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HS2

High Speed Rail (Crewe – Manchester) Environmental Statement

Volume 5: Appendix WR-005-0MA05

Water resources and flood risk

MA05: Risley to Bamfurlong

Flood risk assessment

M328

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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 Risley to Bamfurlong area (MA05).

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 Risley to Bamfurlong area, the relevant Hydraulic modelling reports (Volume 5: Appendices WR-006-00003 – Tributaries of Holcroft Lane Brook, WR-006-00004 – Small Brook, WR-006-00005 – Carr Brook and WR-006-00006 – Hey Brook) as well as the Water resources assessment (Volume 5: Appendix WR-003-0MA05) 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-004-0MA05)[1]; and
- Water Framework Directive compliance assessment baseline data (BID WR-002-00001)[2].

1.1.6 Maps referred to throughout this assessment are contained in the Volume 2, MA05 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)[3] 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-004-0MA05. 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.

[3] 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.

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 Risley to Bamfurlong 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 the site compounds will be managed through the draft Code of Construction Practice (CoCP) (see Volume 5: Appendix CT-002-00000). As far as practicable, site compounds have been located outside of Flood Zone 3. However, where this is not possible, 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.

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. 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 survey data have been obtained. Floodplain geometry was, however, updated using Light Detection and Ranging (LiDAR) data.

1.2.8 The hydraulic modelling 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 of hydraulic structures and flood risk mitigation measures.

1.2.9 The Volume 2, Community Area report for the Risley to Bamfurlong 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 MA05 study area is shown in Figure 1 and Figure 2.

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[4], 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)[5].

[4] 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.

[5] 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 (southern extent)

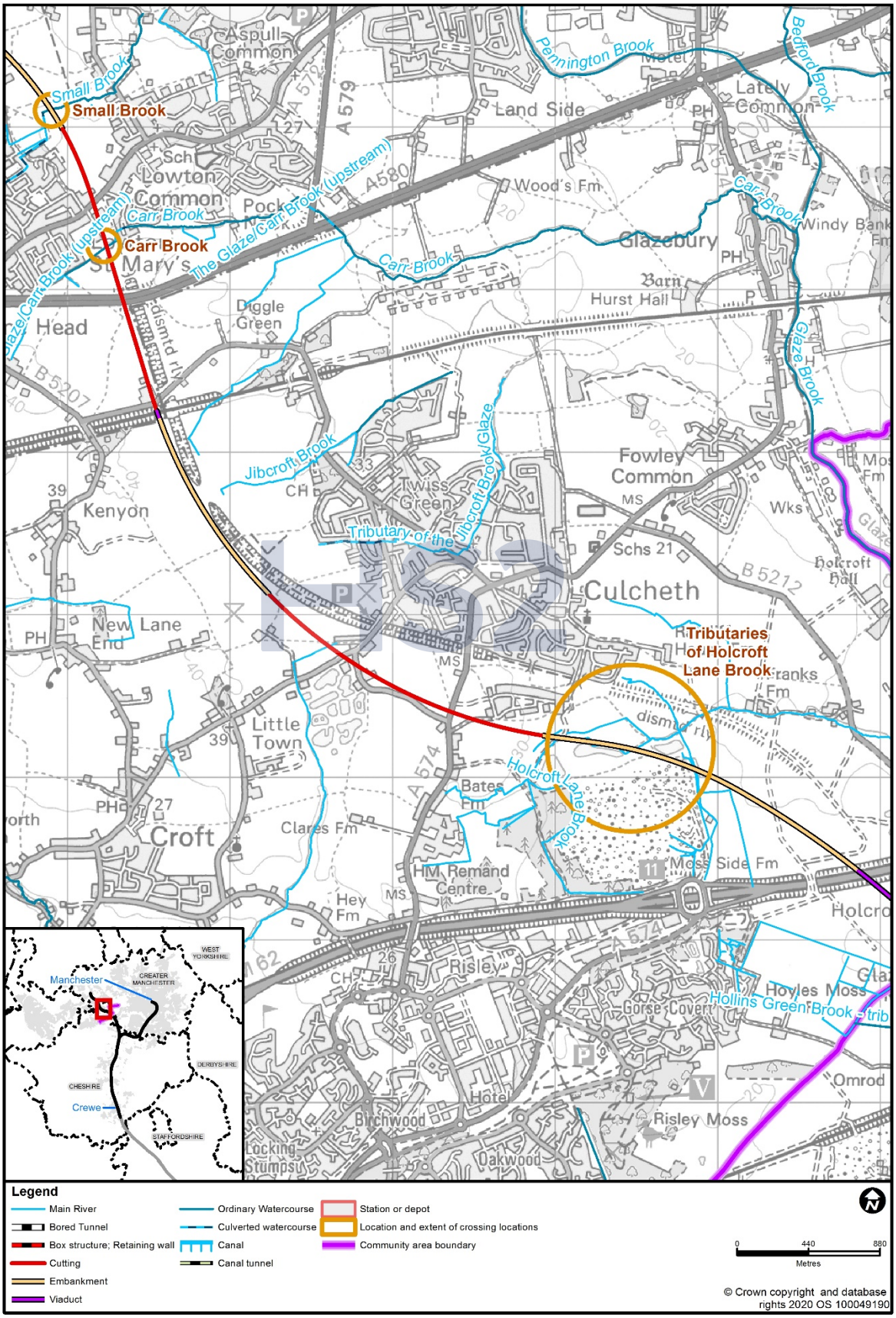
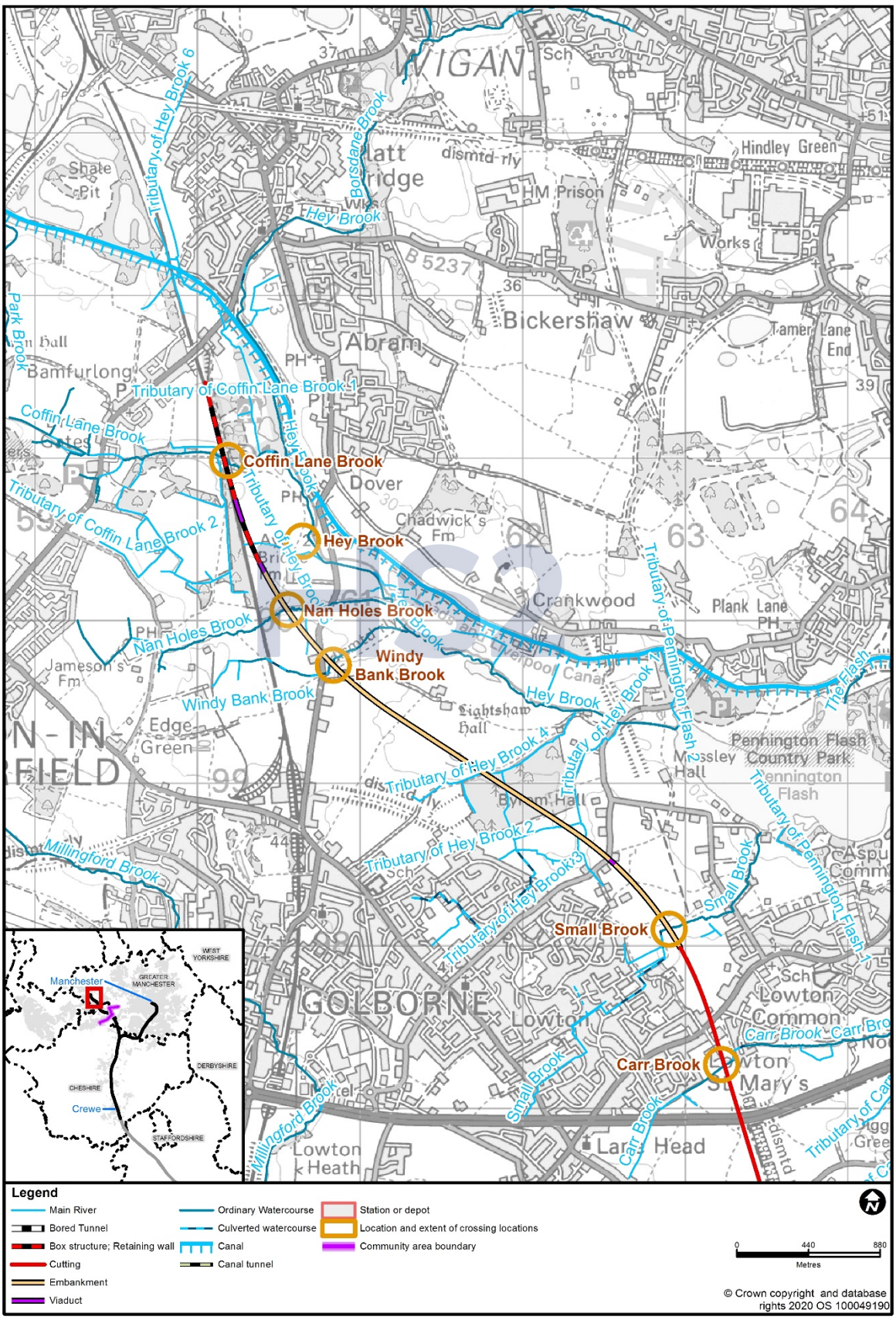


Figure 2: Location and extent of the study area (northern extent)



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 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 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 Wigan Metropolitan Borough Council (WMBC) are the LLFA in the Risley to Bamfurlong area. A meeting has been held with WBC 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 relevant Hydraulic modelling reports (Volume 5: Appendices WR-006-00003, WR-006-00004, WR-006-00005 and WR-006-00006).

2.2.2 The WBC Preliminary Flood Risk Assessment (PFRA)[6] was published in 2017, the WMBC PFRA[7] was published in 2011, the WBC Local Flood Risk Management Strategy (LFRMS)[8] was published in 2017, and the WMBC LFRMS[9], was published in 2014. The LFRMS contain a number of policies related to sustainable development, access to, and maintenance of,

[6] 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.

[7] JBA Consulting (2011), *Wigan Preliminary Flood Risk Assessment.* Available online at: https://www.wigan.gov.uk/Docs/PDF/Resident/Crime-Emergencies/Flood-Risk-Assessment.pdf.

[8] Cheshire West and Chester County Council (2016), *Cheshire West and Chester Local Flood Risk Management Strategy.* Available online at: https://moderngov.cheshireeast.gov.uk/ecminutes/documents/s59547/Local%20Flood%20Risk%20Management%20Strategy%20-%20app%202.pdf.

[9] Wigan Council (2014), *Wigan Local Flood Risk Management Strategy.* Available online at: https://www.wigan.gov.uk/Docs/PDF/Resident/Crime-Emergencies/Flood-Risk-Management-Strategy.pdf.

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 WBC have produced a Strategic Flood Risk Assessment (SFRA)[11], and WMBC have produced a SFRA[12] that cover the Risley to Bamfurlong area. The key flood risk objectives outlined in the SFRAs 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 crossings. The CRT has also provided information on dimensions for existing culverts, where applicable.

[10] Department for Environment, Food and Rural Affairs and Environment Agency (2015), *North-West River Basin Management Plan*. Available online at: https://www.gov.uk/government/publications/north-west-river-basin-district-river-basin-management-plan.

[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), *Wigan Strategic Flood Risk.* Available online at: https://www.wigan.gov.uk/Docs/PDF/Council/Strategies-Plans-and-Policies/Planning/Environment/FloodRiskAssessmentReport1411kb.pdf.

3 Flood risk baseline

3.1 Historical flooding incidents

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

3.1.2 A review of the Section 19[13] historical flood reports in the Risley to Bamfurlong area shows that since the PFRA and SFRA have been published, there have been two historical flood events for which investigations under Section 19 of the Flood and Water Management Act have been undertaken; the Stone Pit Lane event (December 2015)[14] and the Greater Manchester event (December 2015)[15]. Both events occurred within 1km of the Proposed Scheme.

3.1.3 The Stone Pit Lane flood event occurred on 26th December 2015 at Stone Pit Lane, Croft, approximately 1km west of the Proposed Scheme. WBC is aware that two residential properties and one business were impacted, as well as Stone Pit Lane being severely affected by the flooding. The flood was thought to be caused by a blocked culvert as a result of tree debris. The blockages were removed, and floodwaters drained away quickly.

3.1.4 The Greater Manchester flood event occurred on 26th December 2015 affecting many areas within Greater Manchester. Flooding affected residential properties, business units and infrastructure in Abram, approximately 1.2km east of the Proposed Scheme. The flood event was caused by prolonged rainfall over 36 hours.

3.1.5 Other Section 19 reports show historical 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:

- Cromwell Avenue, Callands;
- borough-wide rainfall event: Barnes Avenue, Fearnhead;
- Hawkley Hall, Wigan;
- Eleanor Street; and
- Beresford Street.

[13] *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.

[14] Warrington Borough Council (2016), *S19. (1) Flood Investigation Report. Stone Pit Lane, Croft*. Available online at: https://www.warrington.gov.uk/sites/default/files/2019-10/s19_report_-_stone_pit_lane.pdf.

[15] Greater Manchester Lead Local Flood Authorities, *Flood Investigation Report, Greater Manchester, 26 December 2015*. Available online at: https://www.greatermanchester-ca.gov.uk/media/1261/boxing-day-flood-report.pdf.

3.2 Risks associated with main rivers and ordinary watercourses

3.2.1 The key flood risk from main rivers and ordinary watercourses is that associated with the following:

- main rivers
  - Holcroft Lane Brook;
  - Small Brook;
  - Hey Brook;
  - Nan Holes Brook; and
  - Coffin Lane Brook.
- ordinary watercourses
  - Carr Brook;
  - Tributary of Holcroft Lane Brook 2;
  - Tributary of Holcroft Lane Brook 3;
  - Tributary of Holcroft Lane Brook 4; and
  - Windy Bank Brook.

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. Further details of these allocations can be found in Volume 5: Appendix CT-004-00000, Planning data.

Holcroft Lane Brook and its tributaries

3.2.3 A 2D hydraulic model of Tributaries of Holcroft Lane Brook 2, 3 and 4 has been developed to define the peak flood levels and extents associated with a range of annual probabilities, and details are reported in Hydraulic modelling report Volume 5: Appendix WR-006-00003. The inundation extents for the 1 in 100 (1.0%) annual exceedance probability (AEP) plus climate change (CC) flood are shown in Figure 3.

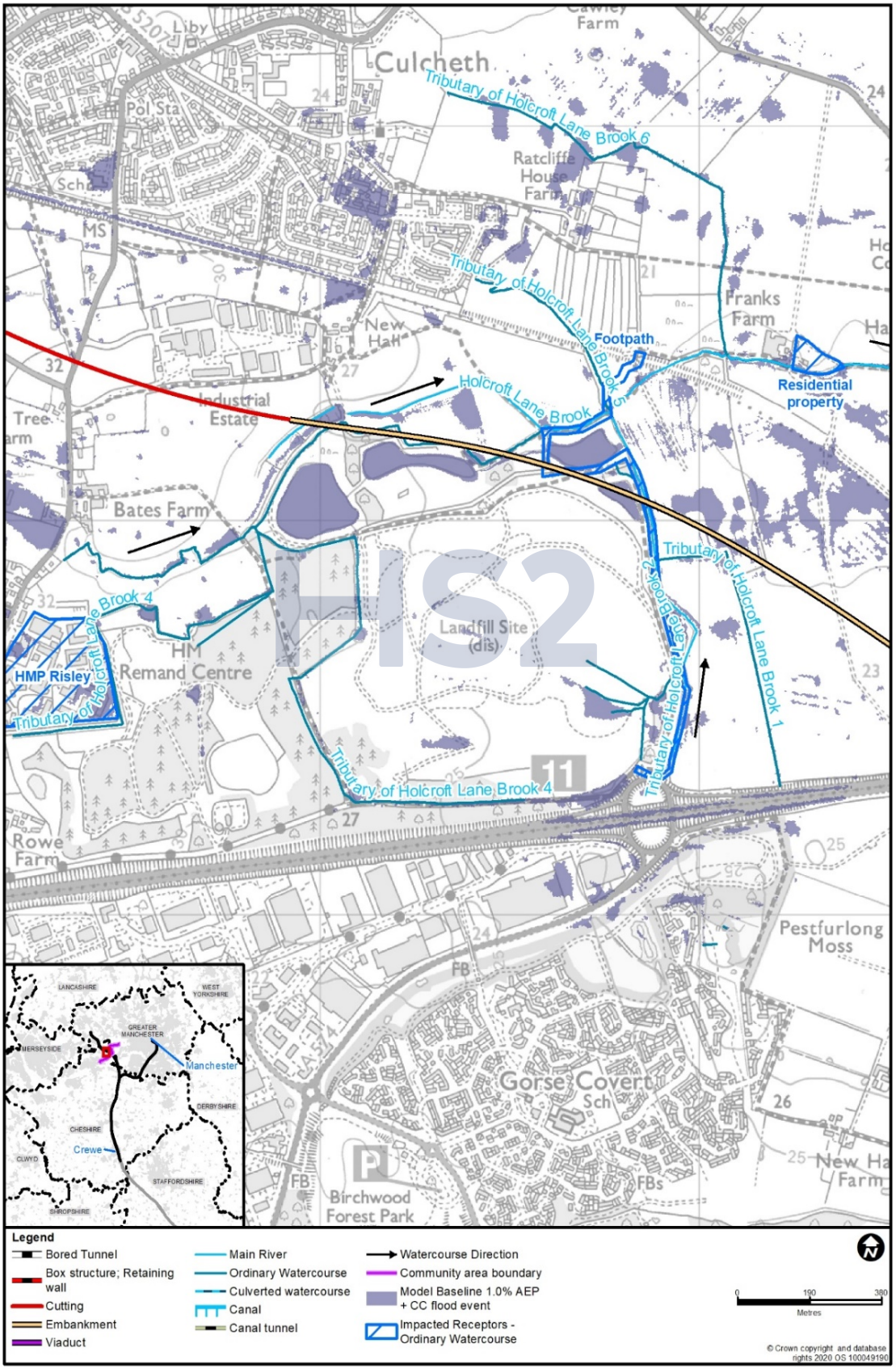
3.2.4 The receptors that are at potential risk from these watercourses are listed below. The relative vulnerability to flooding of each receptor (as defined in NPPF) is also indicated:

- Croft footpath 13 (less vulnerable);
- Her Majesty's Prison (HMP) Risley (more vulnerable); and
- residential property (more vulnerable).

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. 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 3: Baseline extent of the modelled 1.0% AEP + CC flood event, Holcroft Lane Brook and its tributaries



Carr Brook

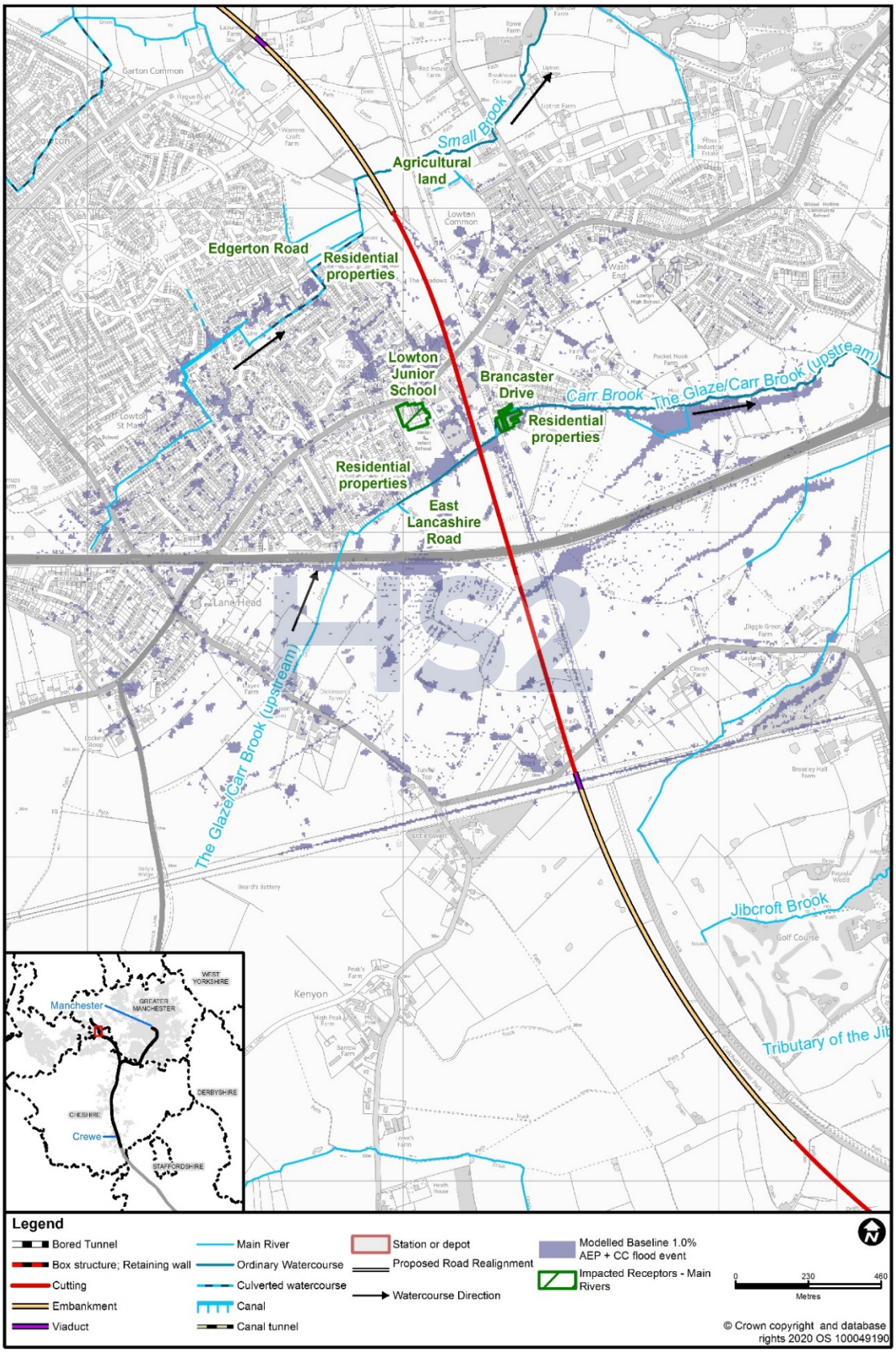
3.2.6 A 2D hydraulic model of Carr Brook has been developed to define the peak flood levels and extents associated with a range of annual probabilities, and details are reported in the Hydraulic modelling report Volume 5: Appendix WR-006-00005. The inundation extents for the 1.0% AEP + CC flood are shown in Figure 4.

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:

- residential properties downstream of the crossing along Brancaster Drive (more vulnerable);
- Brancaster Drive (less vulnerable);
- residential properties upstream of the crossing along Cedar Avenue, Maple Avenue, Beech Avenue and Kings Avenue (more vulnerable);
- Lowton Junior and Infants School (more vulnerable);
- A580 East Lancashire Road (less vulnerable); and
- planning allocation for dwellings (MA05/092) (more vulnerable).

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. 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 4: Baseline extent of the modelled 1.0% AEP + CC flood event, Carr Brook



Small Brook

3.2.9 A 2D hydraulic model of Small Brook has been developed to define the peak flood levels and extents associated with a range of annual probabilities, and details are reported in the Hydraulic modelling report Volume 5: Appendix WR-006-00004. The inundation extents for the 1.0% AEP + CC flood are shown in Figure 5.

3.2.10 The 2D hydraulic model has an inflow boundary at the upstream extent of Small Brook to account for the flows from the upstream urban catchment, as well as direct rainfall hyetographs to account for the rainfall falling directly onto the 2D model domain. The hydraulic model includes the representation of key structures that may influence the flow regime. Two culverts along Small Brook have been included in the model, represented as pipes.

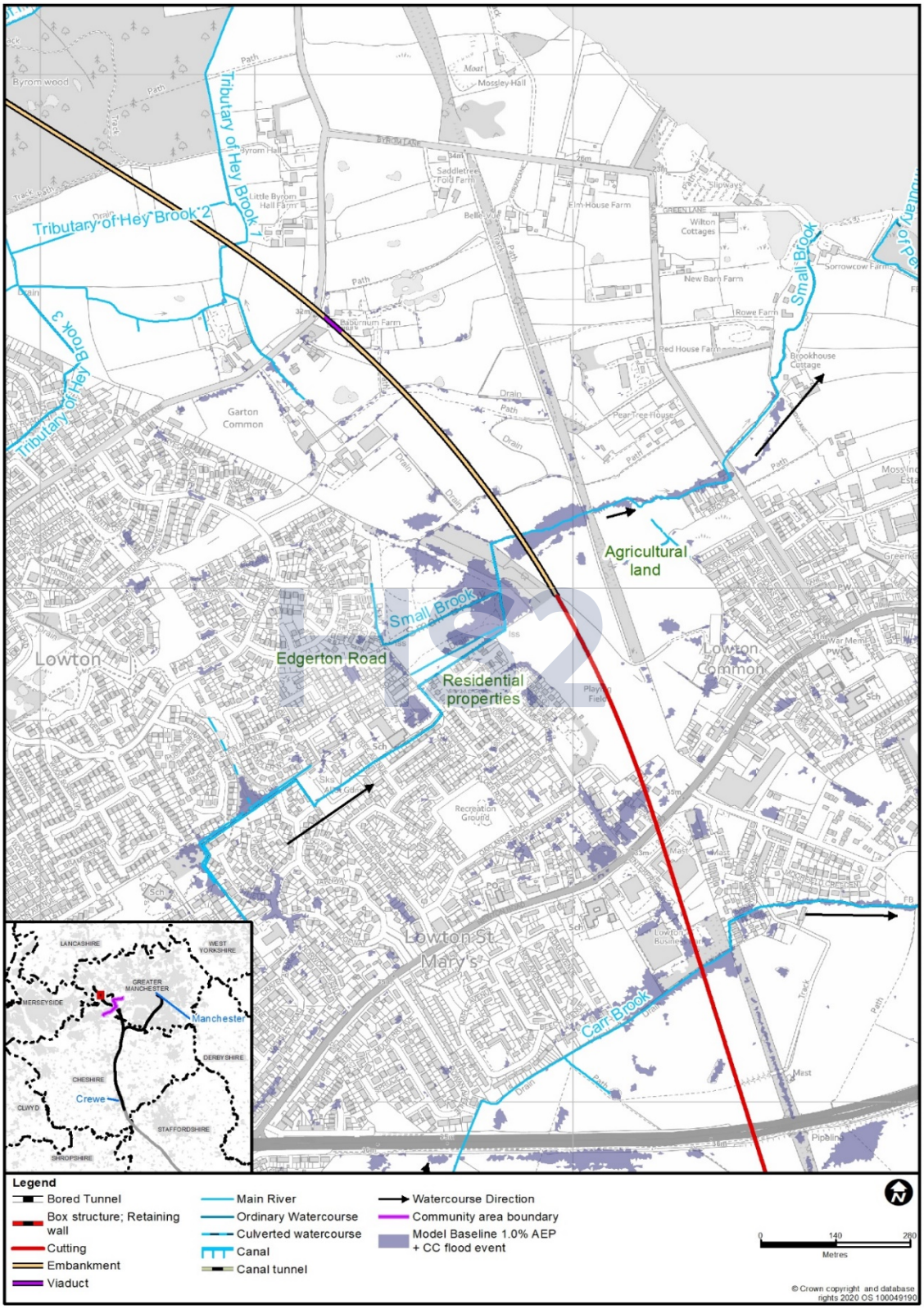
3.2.11 The receptors that are at potential risk from this watercourse are listed below. The relative vulnerability to flooding of each receptor (as defined in NPPF and Table 55 of the SMR) is also indicated:

- agricultural land (less vulnerable[16]);
- footpath and roads at Pennington Flash Country Park (less vulnerable);
- Edgerton Road (less vulnerable); and
- residential properties along Elmridge Court and Cherry Tree Road (more vulnerable).

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.

[16] 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 Volume 2, Community Area report: Risley to Bamfurlong (MA05), Section 4.

Figure 5: Baseline extent of the modelled 1.0% AEP + CC flood event, Small Brook



Hey Brook

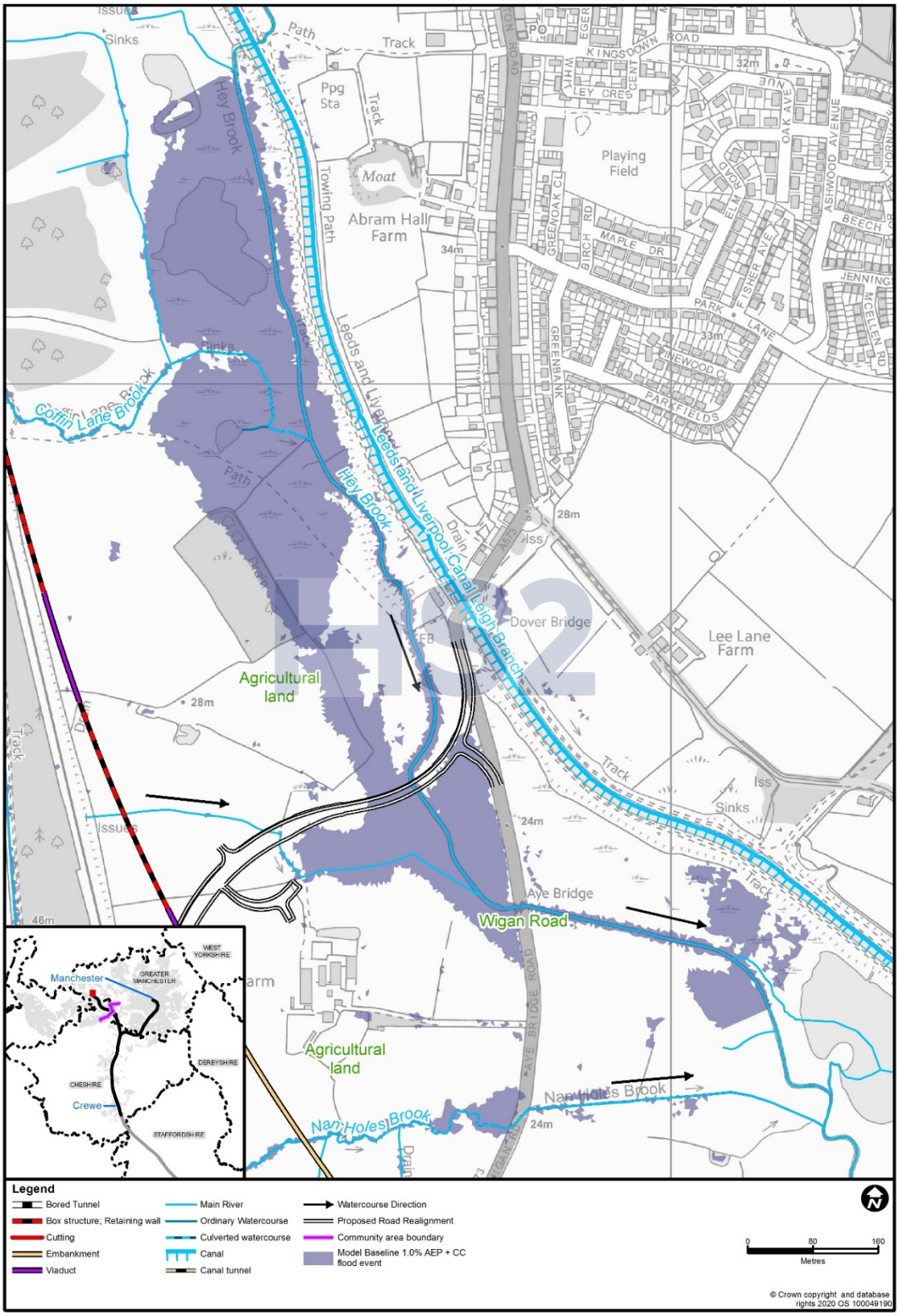
3.2.13 A 2D hydraulic model of Hey Brook has been developed to define the peak flood levels and extents associated with a range of annual probabilities, and details are reported in the Hydraulic modelling report Volume 5: Appendix WR-006-00006. The inundation extents for the 1.0% AEP + CC flood are shown in Figure 6.

3.2.14 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:

- A573 Wigan Road (less vulnerable); and
- agricultural land (less vulnerable[16]).

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 greater than or equal to 5km^2 in size 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 6: Baseline extent of the modelled 1.0% AEP + CC flood event, Hey Brook



Nan Holes Brook

3.2.16 A 2D hydraulic model of Nan Holes Brook has been developed to define the peak flood levels and extents associated with a range of annual probabilities. The inundation extents for the 1.0% AEP + CC flood are shown in Figure 7.

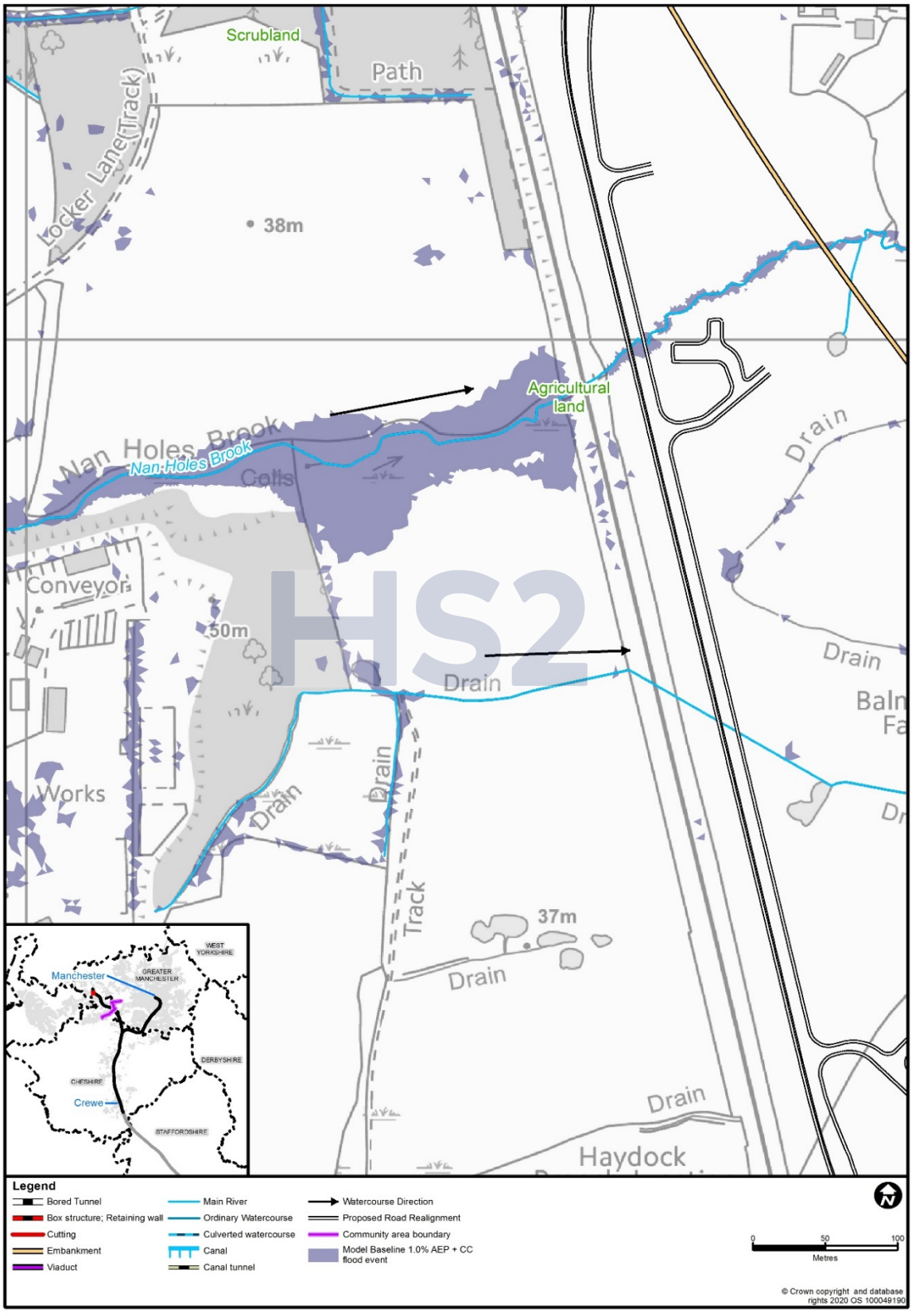
3.2.17 Nan Holes Brook is a tributary of Hey Brook. The modelling of Nan Holes Brook has been carried out separately from the modelling of Hey Brook. This is considered appropriate due to the fact that Nan Holes Brook is approximately 8m higher than Hey Brook at the point where it is crossed by the Proposed Scheme. The Proposed Scheme crossing of Nan Holes Brook is also outside of the Flood Zone 2 for Hey Brook. Therefore, flooding in the Hey Brook is unlikely to cause any backing up on the Nan Holes Brook at the Proposed Scheme crossing, and the channel can freely discharge.

3.2.18 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:

- A573 Wigan Road (less vulnerable); and
- agricultural land (less vulnerable[16]).

3.2.19 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 7: Baseline extent of the modelled 1.0% AEP + CC flood event, Nan Holes Brook



Coffin Lane Brook

3.2.20 A 2D hydraulic model of Coffin Lane Brook has been developed to define the peak flood levels and extents associated with a range of annual probabilities. The inundation extents for the 1.0% AEP + CC flood are shown in Figure 8.

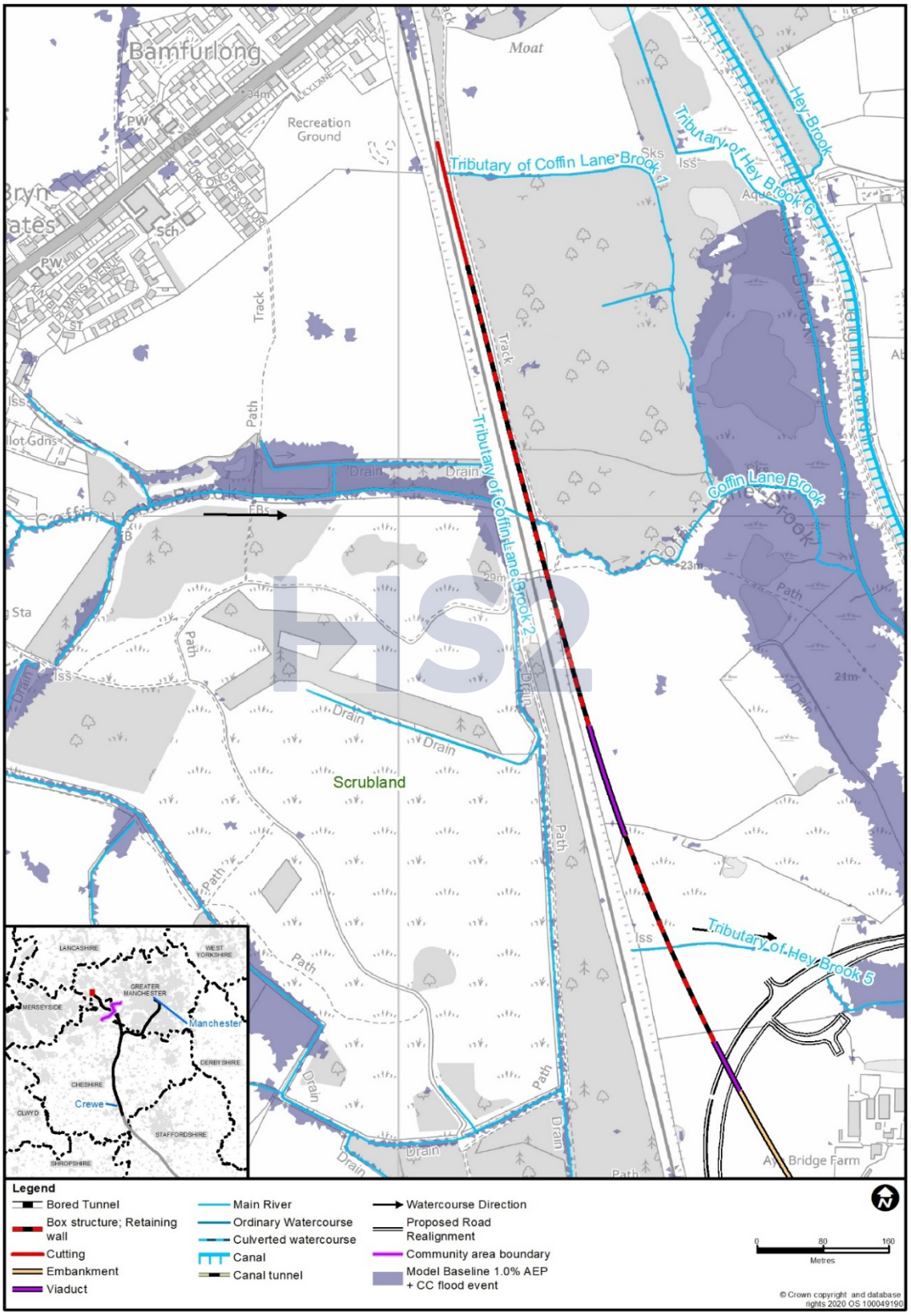
3.2.21 Coffin Lane Brook is a tributary of Hey Brook. The modelling of Coffin Lane Brook has been carried out separately from the modelling of Hey Brook. This is considered appropriate due to the fact that Coffin Lane Brook is approximately 5m higher than Hey Brook at the point where it is crossed by the Proposed Scheme. The Proposed Scheme crossing of Coffin Lane Brook is also outside of the Flood Zone 2 for Hey Brook. Therefore, flooding in the Hey Brook is unlikely to cause any backing up on the Coffin Lane Brook at the Proposed Scheme crossing, and the channel can freely discharge.

3.2.22 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:

- A58 Bolton Road (essential infrastructure); and
- scrubland (water compatible) west of the A58 Bolton Road.

3.2.23 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 8: Baseline extent of the modelled 1.0% AEP + CC flood event, Coffin Lane Brook



Other watercourses

3.2.24 Windy Bank Brook is the only other ordinary watercourse located within the Risley to Bamfurlong area. This ordinary watercourse does 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.

3.2.25 Figure 9 indicates the receptors at risk for the surface water flow paths associated with this watercourse. Agricultural land (less vulnerable) and the A573 Wigan Road (less vulnerable) are the receptors at risk from Windy Bank Brook.

3.2.26 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.

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%) annual exceedance probability (AEP) flood event. This dataset indicates where surface water flow paths cross the Proposed Scheme. Four surface water flow paths have been identified in the study area.

3.3.2 As indicated in Figure 10, Glaziers Lane, Wigshaw Lane (less vulnerable) and a residential property (more vulnerable) are the receptors at risk from a surface water flow path at Glaziers Lane.

3.3.3 As indicated in Figure 11, residential properties in Lowton St Mary (more vulnerable), Newton Road and Hesketh Meadow Land (less vulnerable) are at risk from surface water at Lowton St Mary. There is also a dry valley from the A580 East Lancashire Road discharging to Carr Brook shown in Figure 11.

3.3.4 As indicated in Figure 12, residential properties in Slag Lane (less vulnerable) and residential properties along Garton Common (more vulnerable), are at risk from surface water at Garton Common.

3.3.5 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. 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 9: Extent of the Environment Agency's RoFSW dataset, Windy Bank Brook

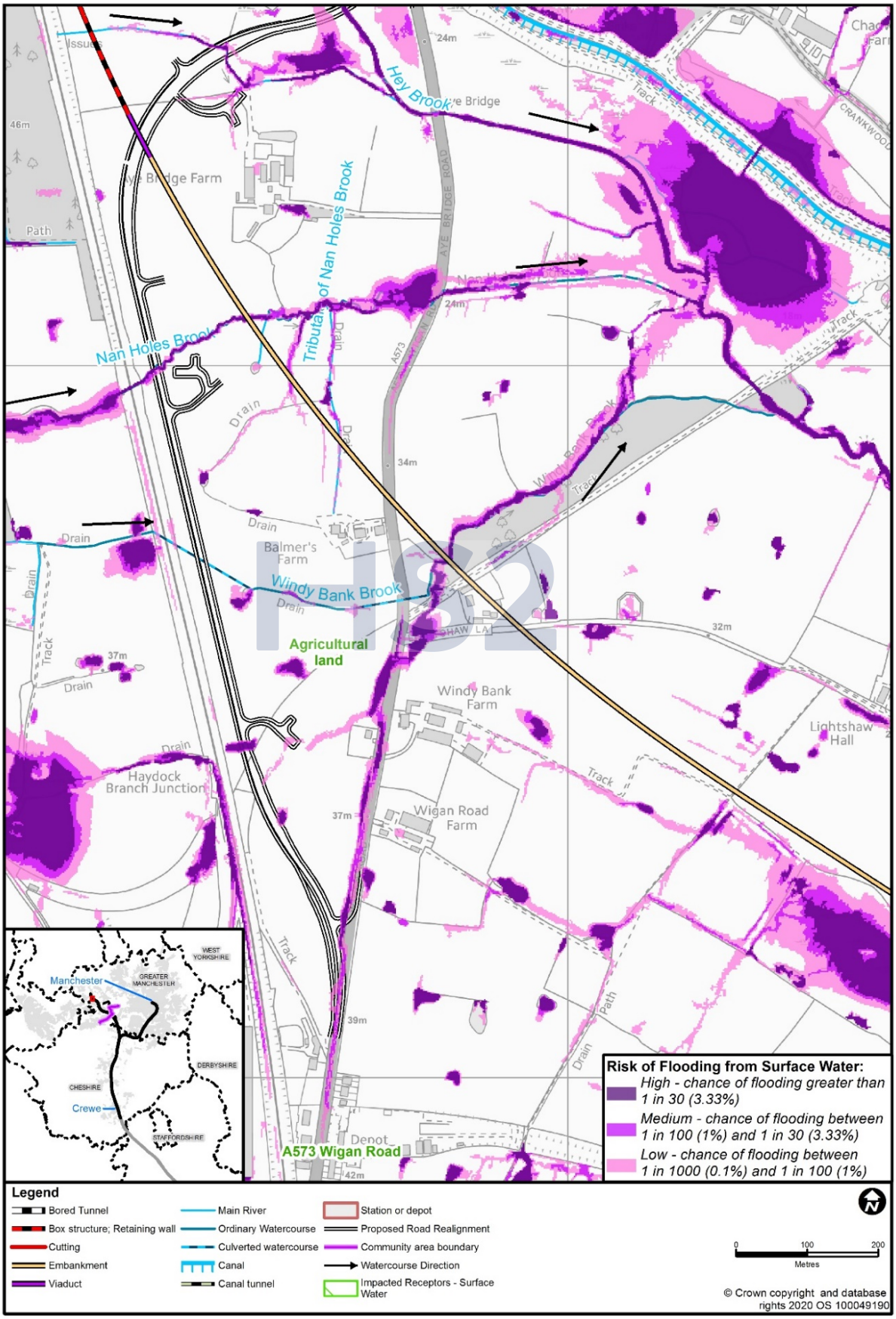


Figure 10: Extent of the Environment Agency's RoFSW dataset, surface water flow path Glazier Lane

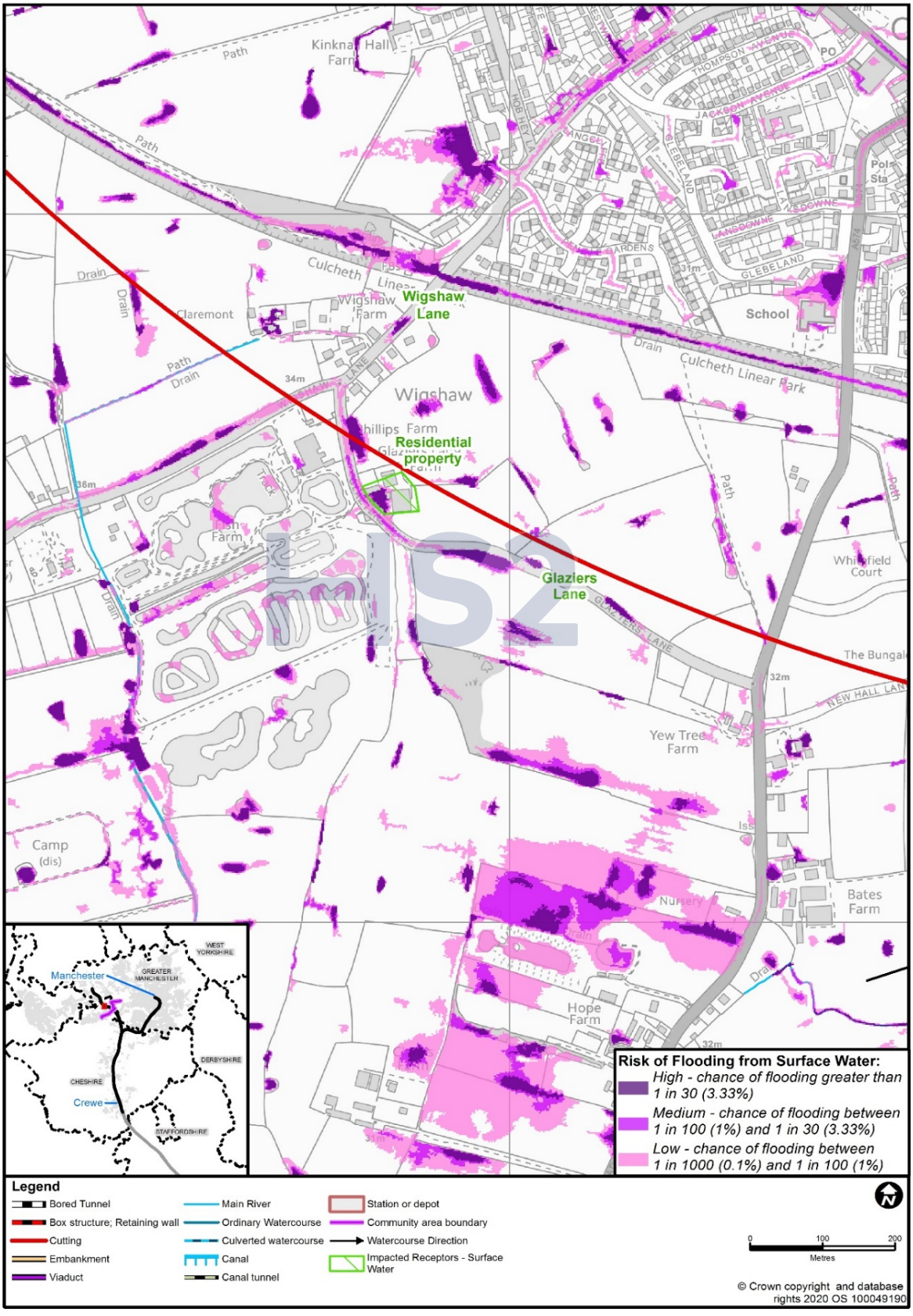


Figure 11: Extent of the Environment Agency's RoFSW dataset, surface water flow path at Lowton St Mary

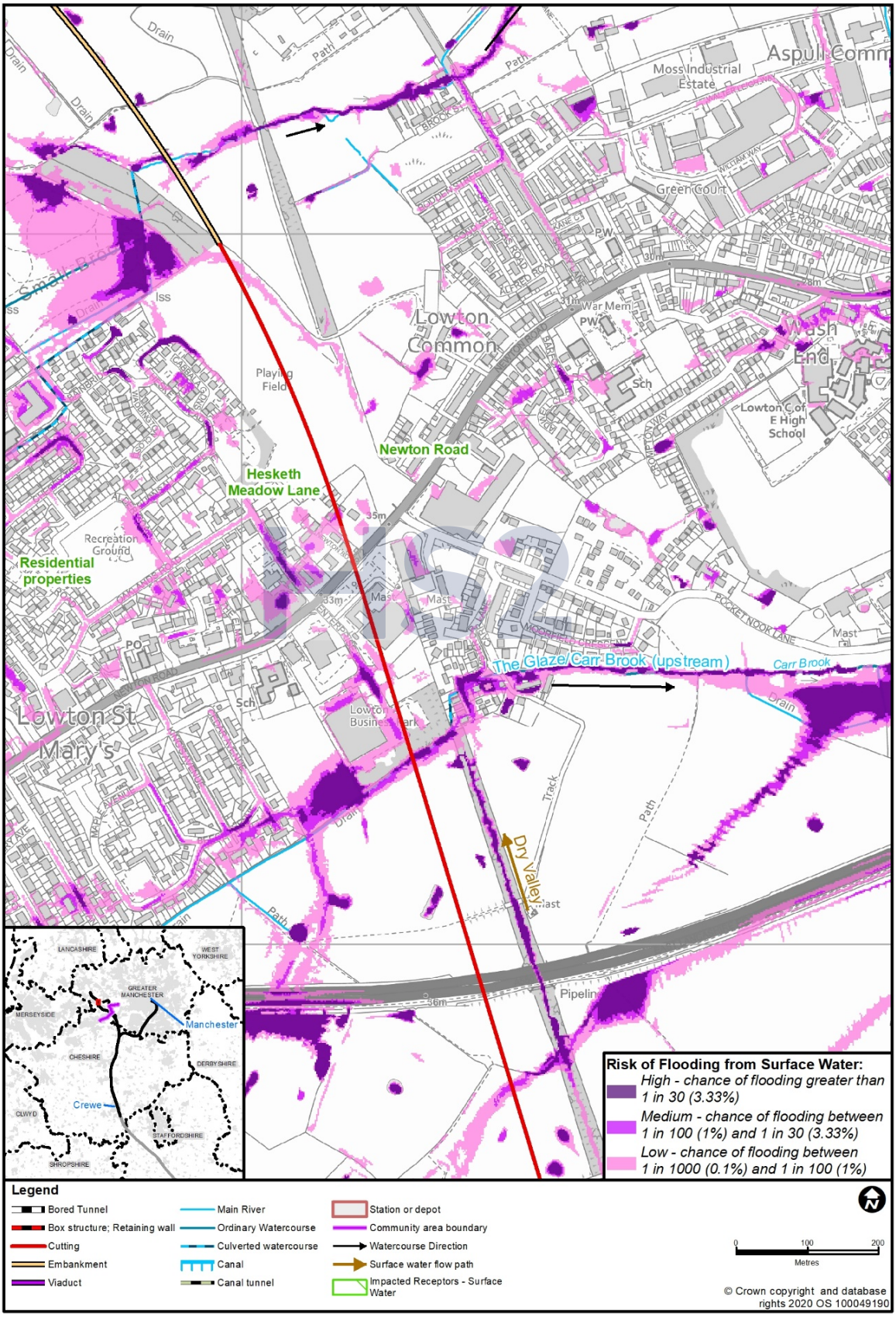
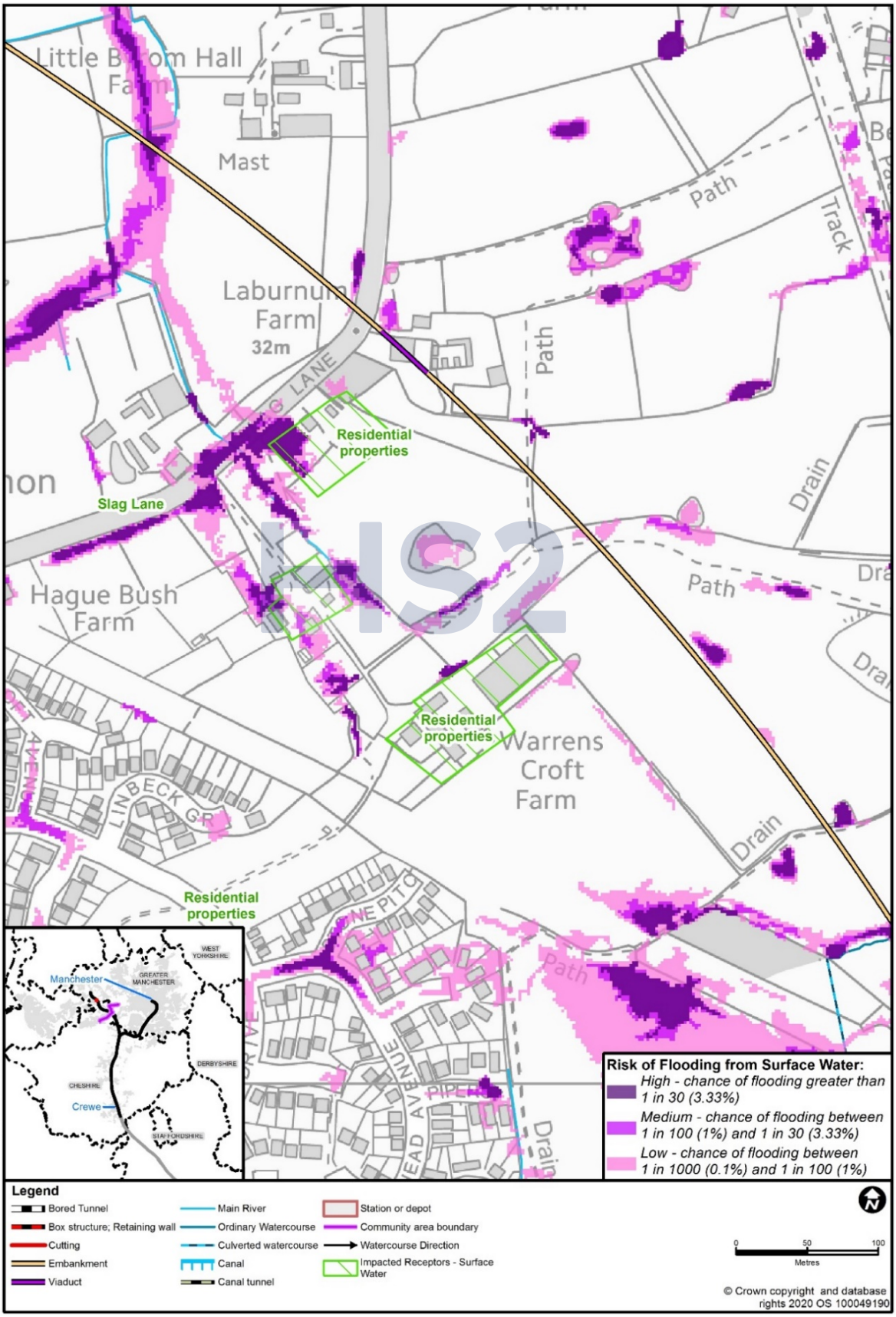


Figure 12: Extent of the Environment Agency's RoFSW dataset, surface water flow path at Garton Common



3.4 Risks associated with groundwater

3.4.1 The BGS susceptibility to groundwater flooding[17] 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 susceptibility to groundwater flooding, 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.

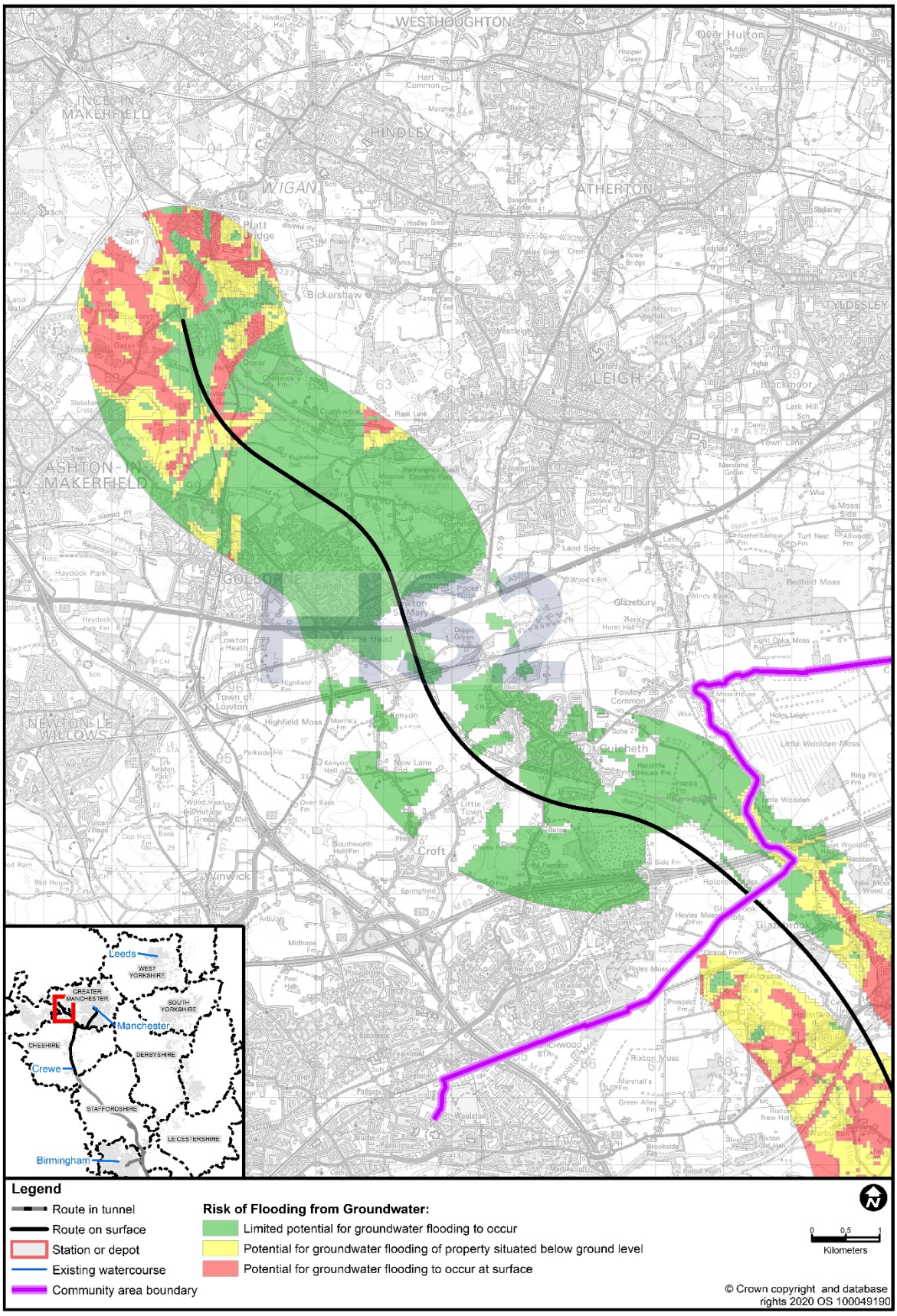
3.4.3 The BGS susceptibility to groundwater flooding dataset (presented in Figure 13) indicates that there is potential for groundwater flooding to occur at surface at the following locations:

- around Windy Bank Brook;
- south of Abram; and
- Byrn Gates.

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

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

Figure 13: 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. No impounding features have been identified within the study area that are a potential source of flood risk.

3.5.2 Major water supply pipelines and sewerage (foul and surface water) infrastructure has 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, MA05 Map Book: Map Series CT-05 and CT-06.

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
Tributaries of Holcroft Lane Brook 2, 3 and 4	Croft Footpath 13 (less vulnerable)	1.0% AEP + CC flood extent	More vulnerable	40% (increase in peak rainfall intensity)
	HMP Risley (more vulnerable)			
	Residential property (more vulnerable)			
Hey Brook	A573 Wigan Road (less vulnerable)	1.0% AEP + CC flood extent	Less vulnerable	70% (increase to peak river flow)
	Agricultural land (less vulnerable)			
Carr Brook	Residential properties downstream along Brancaster Drive (more vulnerable)	1.0% AEP + CC flood extent	More vulnerable	40% (increase in peak rainfall intensity)
	Brancaster Drive (less vulnerable)			
	Residential properties upstream along Cedar Avenue, Maple Avenue, Beech Avenue, and Kings Avenue (more vulnerable)			
	Lowton Junior and Infant School (less vulnerable)			
	A580 East Lancashire Road (less vulnerable)			

Source / pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment
	Allocation for future development of dwellings (MA05/092) (high value receptors)			
Small Brook	Agricultural land (less vulnerable)	1.0% AEP + CC flood extent	More vulnerable	40% (increase in peak rainfall intensity)
	Footpath and roads at Pennington Flash Country Park (less vulnerable)			
	Egerton Road (less vulnerable)			
	Residential properties along Elmridge Court and Cherry Tree Road (more vulnerable)			
Nan Holes Brook	A573 Wigan Road (less vulnerable)	1.0% AEP + CC flood extent	Less vulnerable	40% (increase in peak rainfall intensity)
	Agricultural land (less vulnerable)			
Coffin Lane Brook	A58 Bolton Road (essential infrastructure)	1.0% AEP + CC flood extent	Essential infrastructure	40% (increase in peak rainfall intensity)
	Scrubland (water compatible)			
Windy Bank Brook	A573 Wigan Road (less vulnerable)	RoFSW 0.1% AEP flood extent	Less vulnerable	40% (increase in peak rainfall intensity)
	Agricultural land (less vulnerable)			
Surface water flow path at Glaziers Lane Farm	Glaziers Lane (less vulnerable)	RoFSW 0.1% AEP flood extent	More vulnerable	40% (increase in peak rainfall intensity)
	Wigshaw Lane (less vulnerable)			
	Residential property (more vulnerable)			
Surface water flow path in Lowton St Mary	Residential properties (more vulnerable)	RoFSW 0.1% AEP flood extent	More vulnerable	40% (increase in peak rainfall intensity)
	Newton Road, Hesketh Meadow Lane (less vulnerable)			
Surface flow path north of Garton Common	Slag Lane (less vulnerable)	RoFSW 0.1% AEP flood extent	More vulnerable	40% (increase in peak rainfall intensity)
	Residential properties (more vulnerable)			
Groundwater	Agricultural land (less vulnerable)	BGS susceptibility to groundwater flooding dataset	Less vulnerable	N/A
	A573 Wigan Road (less vulnerable)			

4 Flood risk impacts and effects

4.1 Rivers and ordinary watercourses

Culverts and channel realignments

4.1.1 The Proposed Scheme within the Risley to Bamfurlong area crosses a number of watercourses via culverts. Hydraulic modelling of some of these main rivers has been used in the design and assessment of the Proposed Scheme to determine the likely impact on local peak flood levels. This was undertaken at Tributaries of Holcroft Lane Brook 2, 3 and 4, Carr Brook, Small Brook, Nan Holes Brook and Coffin Lane Brook. At Hey Brook, a realignment of the A573 Wigan Road was modelled. The hydraulic modelling of these watercourses has been used in the design and assessment of the Proposed Scheme to determine the likely impact on local peak flood levels.

4.1.2 Figure 14 and Figure 15 show the location of proposed culverts. The models have been used to:

- define the 1.0% AEP storm event plus climate change event; and
- select a cross sectional area with the capacity to convey the 1.0% AEP + CC 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.

4.1.3 The details of the culvert design applied to the watercourses are provided in Table 2.

Table 2: Details of culvert design at modelled watercourse crossings

Watercourse/ location	Structure name	Estimated 1.0% AEP peak flow (m^3/s)	Climate change allowance (increase in peak rainfall intensity)	Estimated 1.0% AEP + CC river flow (m^3/s)	Culvert dimensions of opening (m)	Culvert capacity (m^3/s)18
Tributary of Holcroft Lane Brook 2 and 3	Footpath Croft 13/1 Accommodation underbridge	Bridge structure (6m wide 6.1m high) over Tributary of Holcroft Lane Brook 2 and 3				
Tributary of Holcroft Lane Brook 4	Holcroft Lane Brook culvert	Culvert structure (5m wide by 3.8m high) over Tributary of Holcroft Lane Brook 4				

[18] 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.

Watercourse/ location	Structure name	Estimated 1.0% AEP peak flow (m^3/s)	Climate change allowance (increase in peak rainfall intensity)	Estimated 1.0% AEP + CC river flow (m^3/s)	Culvert dimensions of opening (m)	Culvert capacity (m^3/s)18
Small Brook	Footpath Golborne 63/10 and Small Brook culvert	Bridge structure (7m wide by 4m high) over Small Brook				
Hey Brook	A573 Wigan Road	The proposed bridge structure over Hey Brook for the A573 Wigan Road realignment has not been modelled at this stage as the bridge soffit is designed to be above the required freeboard allowance.				
Nan Holes Brook	Nan Holes Brook culvert	0.39	40%	1.65	5m wide x 3m high	7.80
Nan Holes Brook - offline	Nan Holes Brook Offline Culvert	0.39	40%	1.65	5m wide x 3m high	7.34
Coffin Lane Brook	Coffin Lane Brook culvert	1.71	40%	1.93	1.7m wide x 1.7m high	8.59

4.1.4 The following calculation procedure has been undertaken to size offline culverts:

- use of the Revitalised Rainfall-Runoff Model version 2.2 (ReFH2)[19] 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 cross sectional area 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.

4.1.5 The details of the culvert design applied to the watercourses are provided in Table 3.

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

Table 3: Details of culvert design at watercourses

Watercourse /location	Structure name	Esimated 1.0% AEP peak flow (m^3/s)	Climate change allowance (increase in peak rainfall intensity)	Estimated 1.0% AEP + CC river flow (m^3/s)	Culvert dimensions of opening (m)	Culvert capacity (m^3/s)
Tributary of Holcroft Lane Brook 2 and 3	Holcroft Lane Brook Offline Culvert	0.1	40%	0.1	2 circular culverts 1.35m diameter	2.82

4.1.6 There are a number of additional offline unnamed culverts beneath access roads listed in Table 4. The unnamed culverts will be sized during design development following the calculation procedure outlined in this section.

Table 4: Unnamed culverts

Watercourse	Location
Tributary of Holcroft Lane Brook 1	Unnamed culvert north of M62 Motorway
Tributary of Holcroft Lane Brook 2	Unnamed culvert west of Culcheth South embankment
Tributary of Holcroft Lane Brook 3	Unnamed culvert north of M62 Motorway
Tributary of Holcroft Lane Brook 4	Unnamed culvert west of Culcheth South embankment

4.1.7 Details of all the hydraulic modelling assessments undertaken for these watercourses can be found in the supporting Hydraulic modelling reports Volume 5: Appendices WR-006-00003, WR-006-00004, WR-006-00005, and WR-006-00006. The results of these assessments are reported below for each watercourse in turn.

Figure 14: Proposed culverts (southern extent)

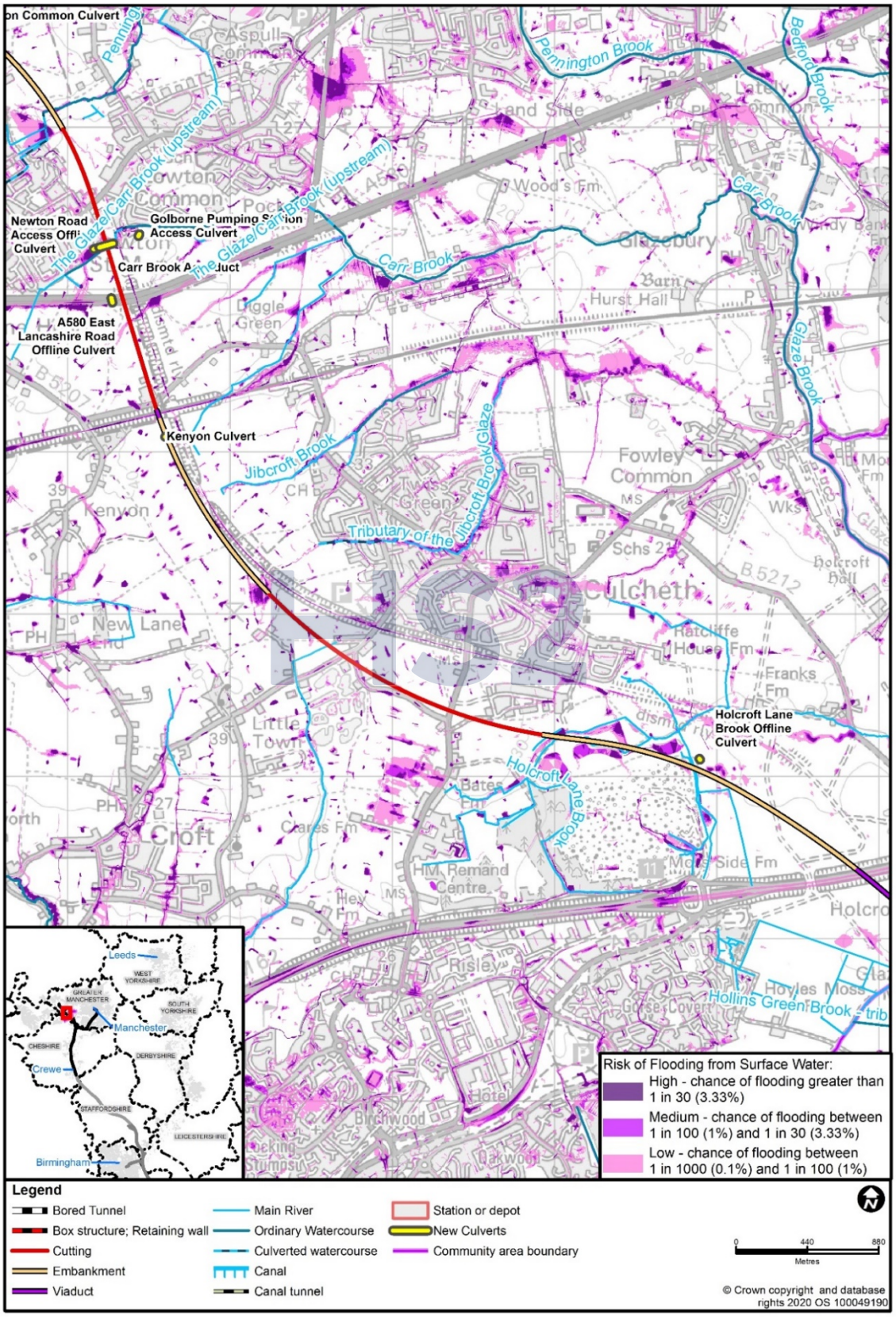
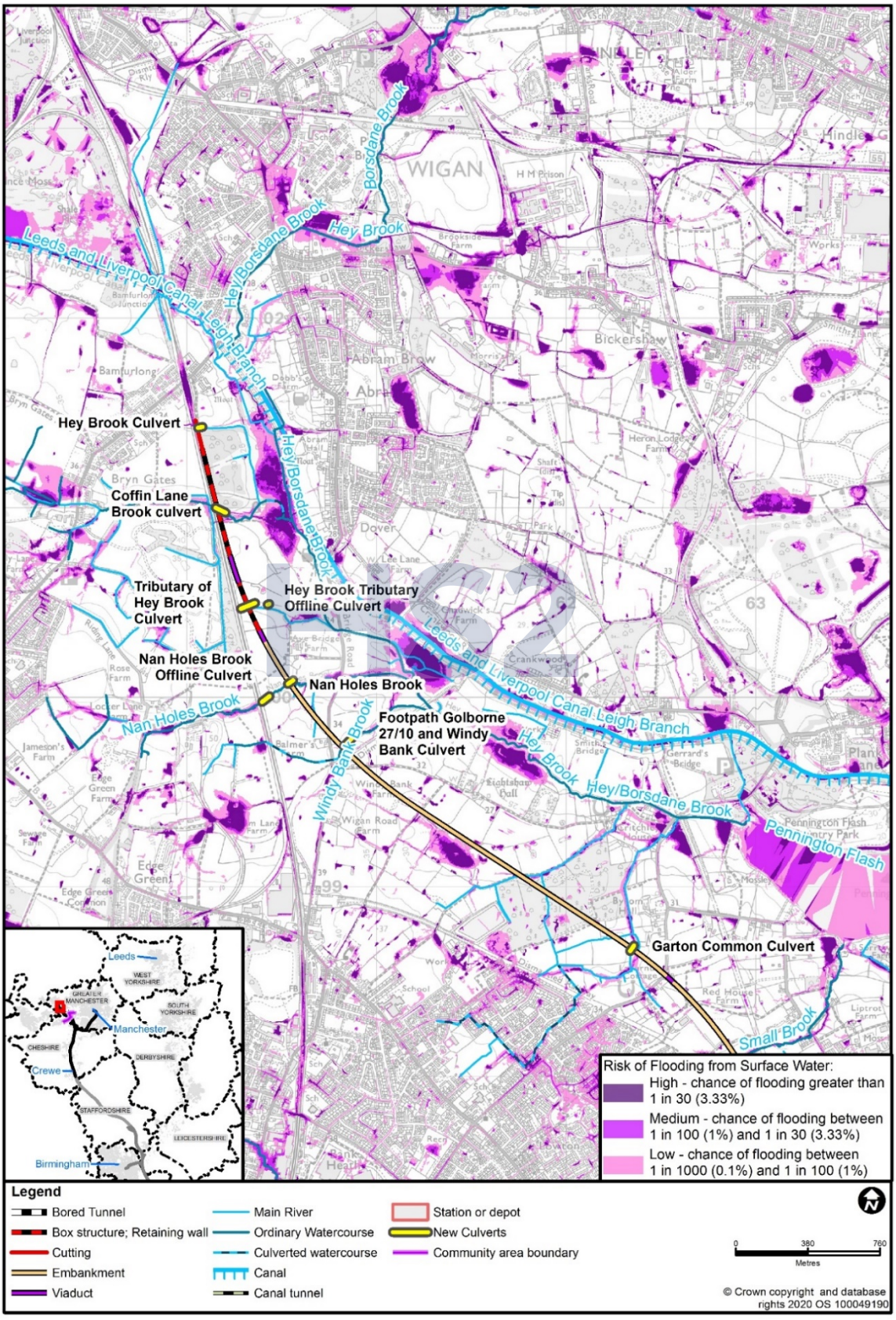


Figure 15: Proposed culverts (northern extent)



Tributaries of Holcroft Lane Brook 2, 3 and 4

4.1.8 The Proposed Scheme crosses the Tributaries of Holcroft Lane Brook 2,3 and 4 on the Culcheth South embankment. The embankment is approximately 40m wide and 8m high and 30m wide and 6m high at the two crossing points respectively. The baseline model of tributaries of Holcroft Lane Brook 2, 3 and 4 has been edited to include the elements in Table 2. The Proposed Scheme embankment has been modelled as a raised impermeable area, covering the footprint of the Proposed Scheme embankment for the purposes of impounding overland flows. At crossing locations, openings in the Proposed Scheme embankment walls were incorporated. The modelling of the crossings as open areas, instead of as culverts, is considered acceptable as the crossings are high composite structures (no surcharge conditions) that allow footway and/or vehicular access.

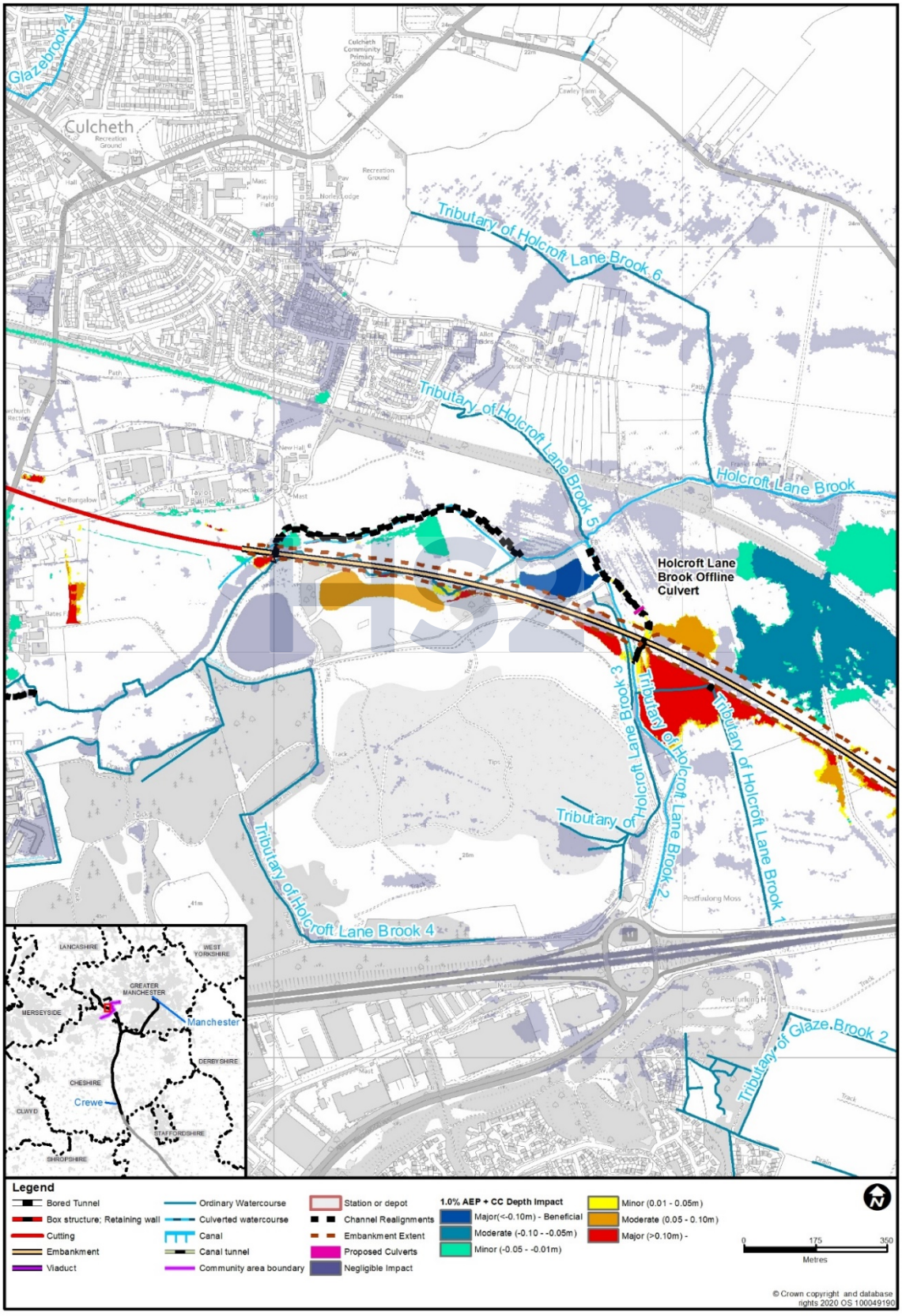
4.1.9 Approximately 600m of Tributary of Holcroft Lane Brook 4 falls beneath the Proposed Scheme and its embankments. It is proposed to divert this 600m section of Tributary of Holcroft Lane Brook 4 and allow the watercourse to cross the Proposed Scheme through Holcroft Lane Brook culvert and discharge into the realigned Holcroft Lane Brook. The diverted section of Tributary of Holcroft Lane Brook 4 downstream of the Proposed Scheme crossing will be approximately 50m in length and will join the Holcroft Lane Brook realignment. The Holcroft Lane Brook realignment will have a wider channel section than the existing watercourse to provide replacement floodplain storage (RFS) as a mitigation measure to attenuate flows and ensure no increase in flood risk, as shown in Figure 16. The realignments have not been included in the hydraulic modelling at this stage but will be included during design development stage. A localised realignment is proposed by the outlet of the Proposed Scheme crossing of Tributary of Holcroft Lane Brook 2 and 3. This is to ensure that the channel crosses at a ninety-degree angle to the Proposed Scheme alignment. Downstream of the crossing the realigned tributary passes through the Holcroft Lane Brook offline culvert and discharges into the Holcroft Lane Brook.

4.1.10 The modelled impact of the Proposed Scheme on peak flood levels is shown in Figure 16. This indicates the potential for:

- an approximate increase in peak flood levels of 200mm, 400m upstream of the crossing at Tributary of Holcroft Lane Brook 2 and 3;
- decreases in peak flood level of approximately 300mm, 140m west of the watercourse, at Tributary of Holcroft Lane Brook 2 and 3, adjacent to the Proposed Scheme embankment;
- increases in peak flood level of approximately 700mm, 50m east of the watercourse at Tributary of Holcroft Lane Brook 2 and 3;
- an approximate increase in peak water level of 160mm immediately adjacent to the Proposed Scheme at Tributary of Holcroft Lane Brook 4; and
- decreases in peak flood level greater than 100mm immediately downstream of the Proposed Scheme and east of Tributary of Holcroft Lane Brook 2 and 3.

4.1.11 The increases in peak water level at Tributaries of Holcroft Lane Brook 2, 3 and 4 are classified as major adverse impacts, affecting agricultural land, a moderate value receptor (as set out in the SMR), resulting in moderate adverse effects, which are significant.

Figure 16: Tributaries of Holcroft Lane Brook 2, 3 and 4 impact map for the 1.0% AEP + CC flood event



4.1.12 Model results indicate that the current proposed design achieves the freeboard requirements for both the top of rail level and Proposed Scheme watercourse crossing soffits.

4.1.13 RFS has been identified on a volume for volume basis as a precautionary measure to address the loss of floodplain storage caused by the embankment, culverts and channel realignments (Figure 22). This RFS has not been included in the hydraulic analysis at this stage. The RFS will be refined during design development and ensure that there is no net loss of floodplain storage and therefore no impact on flood risk elsewhere due to the proposed crossing.

Carr Brook

4.1.14 Carr Brook crosses the Proposed Scheme on an aqueduct over the Lowton cutting that is approximately 9m deep at this location. The baseline Carr Brook model has been edited to include the elements in Table 2. A cutting for the Proposed Scheme has been modelled as a void with an impermeable wall preventing flood waters from entering the cutting of the Proposed Scheme.

4.1.15 Upstream of the Proposed Scheme crossing, cut-off ditches have been included in the model to direct overland runoff towards the inlet of the aqueduct. There is a watercourse realignment immediately downstream of the Proposed Scheme crossing. This realignment comprises a naturalised channel running to the south of the Brancaster Drive residential estate, and by-passes the culverted section of Carr Brook running at the rear of properties on Brancaster Drive. The existing culvert at the rear of properties on Brancaster Drive has not been modelled in the baseline model as no 1D survey was available.

4.1.16 The modelled impact of the Proposed Scheme on peak flood levels for the 1.0% + CC AEP event is shown in Figure 17. This indicates the potential for decreases in peak flood levels of up to 300mm downstream of the Proposed Scheme. Downstream towards Pocket Nook, there is a negligible change in peak flow rate and water levels due to the proposed scheme.

4.1.17 Peak flood levels upstream and downstream of the aqueduct are reduced by up to 200mm compared to the baseline are modelled at:

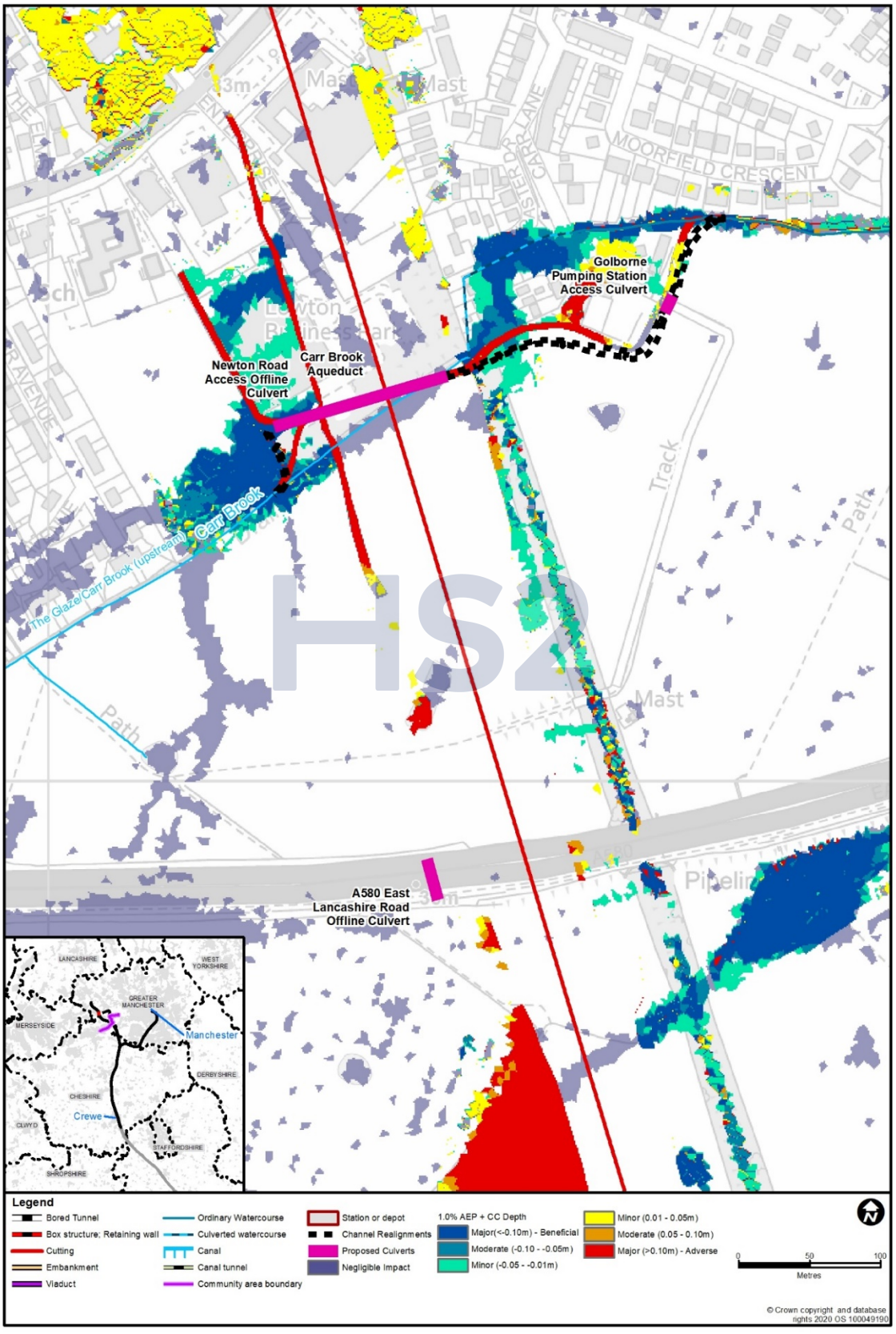
- residential properties along Brancaster Drive (high value receptors);
- Brancaster Drive (moderate value receptor); and
- allocation of land for future development of dwellings (MA05/092[13]) (high value receptor) (values are based on definitions set out in the SMR).

4.1.18 These are all considered to result in major beneficial effects, which are significant.

4.1.19 Flood risk management measures have been embedded into the design at Carr Brook. These measures comprise the realignment of Carr Brook to a naturalised channel south of Brancaster Drive to bypass the culverted section of Carr Brook at the rear of properties on Brancaster Drive. These measures will mitigate flood risk posed by the Proposed Scheme, resulting in a negligible impact and a negligible effect, which is not significant. In some areas

there is a major beneficial impact on some high value receptors, leading to a major beneficial effect which is significant.

Figure 17: Carr Brook impact map for the 1.0% AEP + CC flood event



Small Brook

4.1.20 The Proposed Scheme crosses Small Brook on Lowton South embankment, that is approximately 40m wide and 7m high at this location. The baseline Small Brook model has been edited to include the elements in Table 2. The Proposed Scheme embankment has been modelled as a raised impermeable wall along the Proposed Scheme embankment for the purposes of impeding overland flows. At the Proposed Scheme crossing location, a 7m wide and 4m high opening in the embankment wall was inserted. The modelling of the crossing as open section, instead of as culvert, is considered acceptable as the crossing is a high composite structure allowing footway and vehicular access.

4.1.21 Only localised realignments are proposed at the inlet and outlet of the Proposed Scheme crossing to ensure the channel crosses at a ninety-degree angle to the railway alignment.

4.1.22 The modelled impact of the Proposed Scheme on peak flood levels is shown in Figure 18. This indicates the potential for:

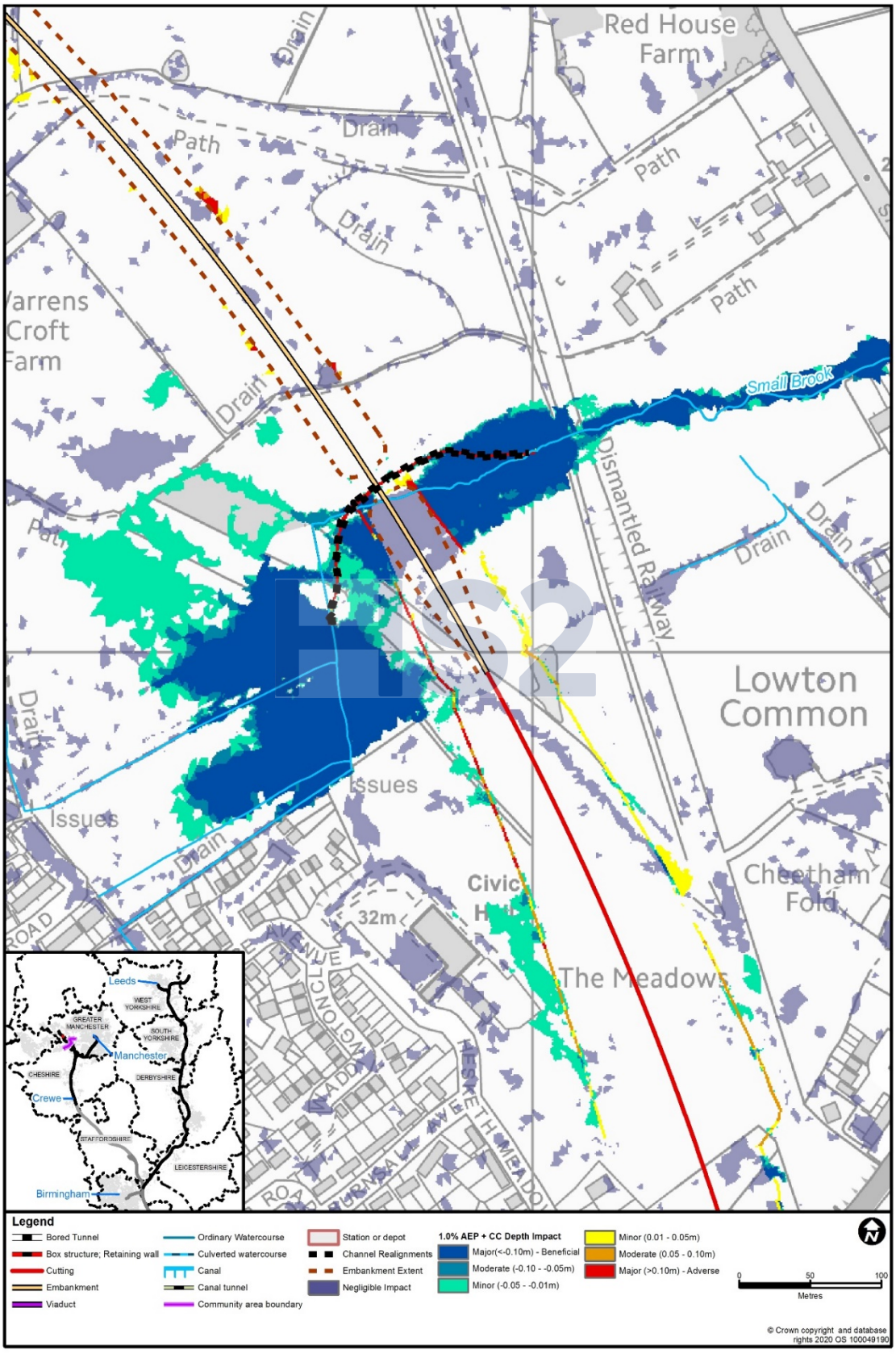
- an increase in peak flood level of up to 90mm upstream of the Proposed Scheme crossing; and
- a decrease in peak flood level of approximately 20mm downstream of the Proposed Scheme crossing.

4.1.23 The increase in peak water level is classified as a moderate adverse impact, affecting agricultural land, a moderate value receptor (as set out in the SMR), resulting in a moderate adverse effect which is significant.

4.1.24 Model results indicate that the current proposed design achieves the freeboard requirements for both the top of rail level and Proposed Scheme watercourse crossing soffits.

4.1.25 RFS has been provided as a mitigation measure on a precautionary basis to address the loss of floodplain storage caused by the embankment, culvert and local channel realignments at Small Brook (Figure 22). This RFS has not been included in the hydraulic analysis at this stage. The RFS will be refined during design development and ensure that there is no net loss of floodplain storage and therefore no impact on flood risk elsewhere due to the proposed crossing.

Figure 18: Small Brook impact map for the 1.0% AEP + CC flood event



Hey Brook

4.1.26 The proposed bridge structure for the A573 Wigan Road realignment crosses the Hey Brook approximately 200m upstream of the existing road crossing. The bridge structure, including the embankment width and piers, has not been modelled at this stage. The bridge soffit is designed to be above the required freeboard allowance to reduce the risk of surcharged conditions.

4.1.27 There are two embankments on both sides of the bridge structure that partially encroach into the floodplain and the Environment Agency flood zones. These have been modelled as raised impermeable walls along the footprint of the embankment.

4.1.28 A bypass channel is included under the proposed A573 Wigan Road realignment bridge. The purpose of the bypass channel is to counteract the localised increase in flood levels as a result of the bridge piers and the partial encroachment of the bridge embankments on the Environment Agency flood zones. This has not been included within the hydraulic modelling as a precautionary hypothesis.

4.1.29 The modelled impact of the Proposed Scheme on peak flood levels for the 1.0% + CC AEP event is shown in Figure 19. This indicates the potential for:

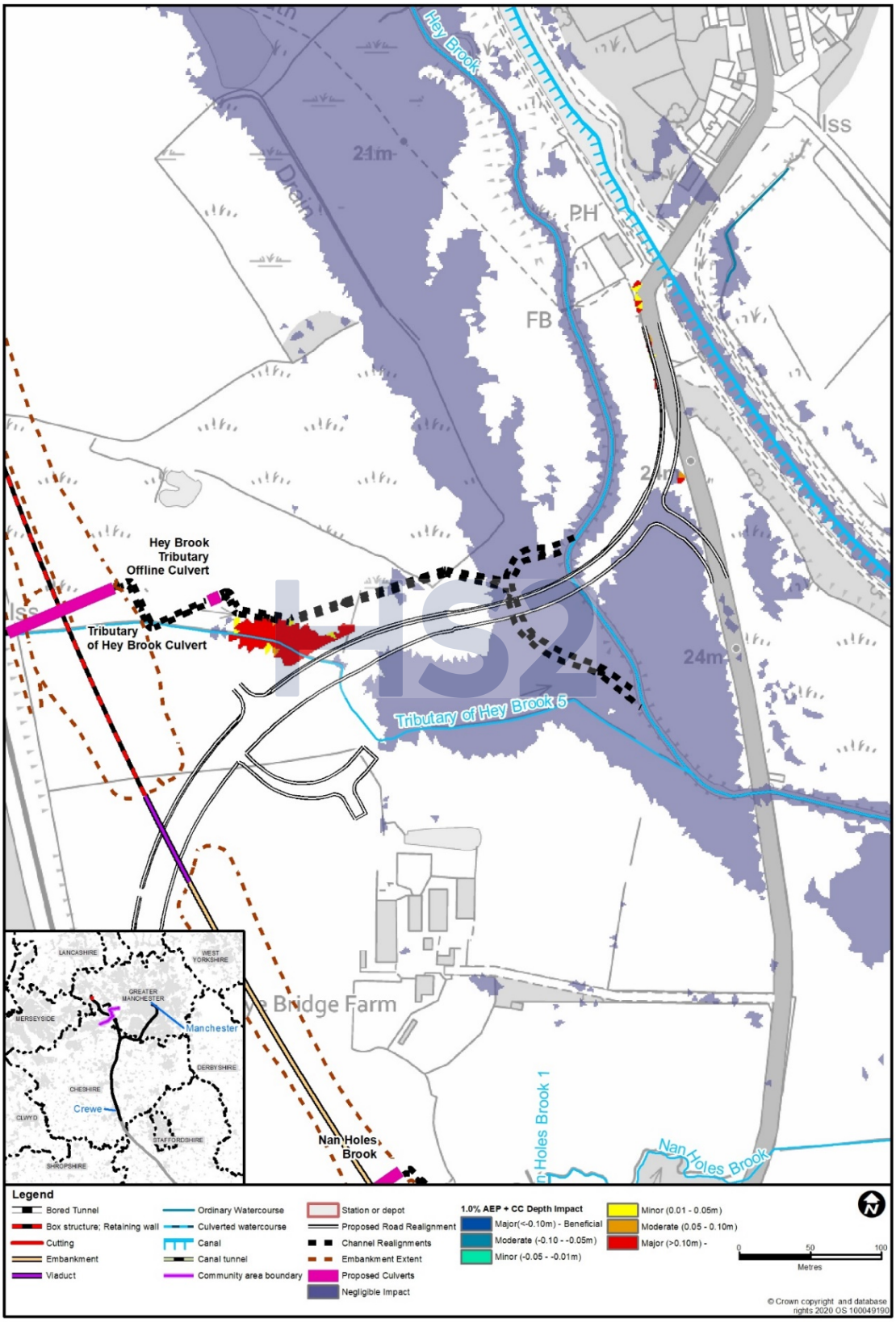
- an increase in peak flood level of approximately 5mm upstream of the proposed highway realignment;
- an increase in peak flood level over 100mm upstream of the proposed highway realignment crossing of the Tributary of Hey Brook 5; and
- a decrease in peak flood level of less than 6mm downstream of the proposed highway realignment.

4.1.30 This increase in peak water level is classified as a major adverse impact, affecting agricultural land, a moderate value receptor (as set out in the SMR), resulting in a moderate adverse effect which is significant.

4.1.31 Model results indicate that the current proposed design achieves the freeboard requirements for the A573 Wigan Road realignment.

4.1.32 RFS has been provided as a mitigation measure on a precautionary basis to address the loss of floodplain storage caused by the road embankment at Hey Brook (Figure 23). This RFS and the bypass channel have not been included in the hydraulic analysis at this stage. The RFS and bypass channel will be refined during design development and ensure that there is no net loss of floodplain storage and therefore no impact on flood risk elsewhere due to the proposed crossing.

Figure 19: Hey Brook impact map for the 1.0% AEP + CC flood event



Nan Holes Brook

4.1.33 The Proposed Scheme crosses Nan Holes Brook on Lowton North embankment, that is approximately 35m wide and 6m high in this location. The baseline Nan Holes Brook model has been edited to include the elements in Table 2. The Proposed Scheme embankment has been represented as a raised impermeable area, covering the footprint of the Proposed Scheme to understand the impact on overland flow routes. As part of the Proposed Scheme, an extension of the West Coast Main Line (WCML) culvert to include the Wigan Road realignment was modelled to be 4m wide and 2m high, and with an extended length of 27m.

4.1.34 The modelled impact of the Proposed Scheme on peak flood levels is shown in Figure 20. This indicates the potential for:

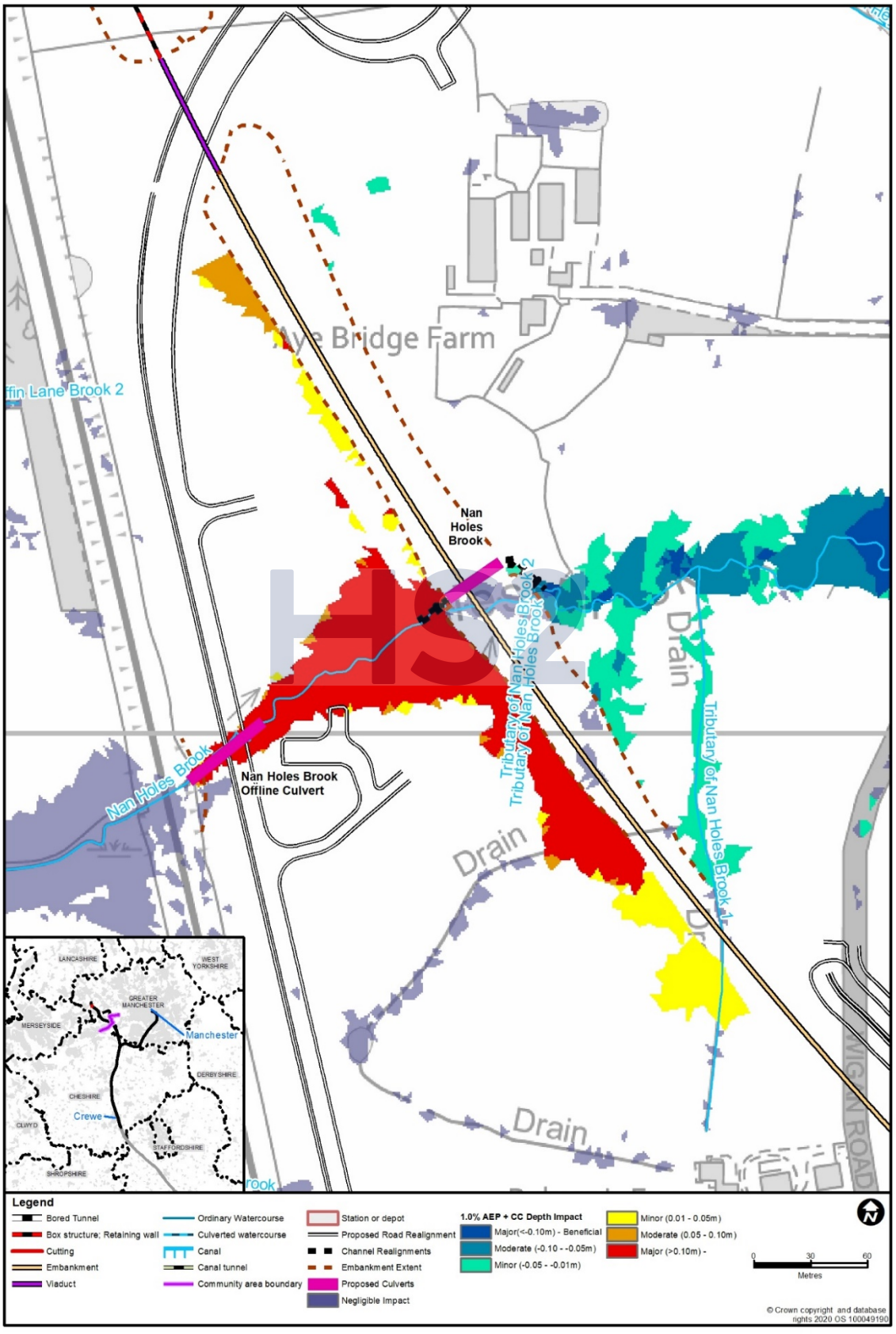
- an increase in peak flood level of up to 130mm upstream of the Proposed Scheme crossing; and
- a decrease in peak flood level of up to 10mm downstream of the Proposed Scheme crossing.

4.1.35 The modelled increase in peak water level is classified as a major adverse impact, affecting agricultural land, a moderate value receptor (as set out in the SMR), resulting in a moderate adverse effect which is significant.

4.1.36 Model results indicate that the current proposed design achieves the freeboard requirements for both the top of rail level and Proposed Scheme watercourse crossing soffits.

4.1.37 RFS has been provided as a mitigation measure on a precautionary basis to address the loss of floodplain storage caused by the road embankment at Hey Brook (Figure 23). This RFS has not been included in the hydraulic analysis at this stage. The RFS will be refined during design development and ensure that there is no net loss of floodplain storage and therefore no impact on flood risk elsewhere due to the proposed crossing.

Figure 20: Nan Holes Brook impact map for the 1.0% AEP + CC flood event



Coffin Lane Brook

4.1.38 The Proposed Scheme will cross Coffin Lane Brook on a retained embankment, that is approximately 55m wide and 7m high at this location. The Proposed Scheme embankment has been modelled as a raised impermeable area, covering the footprint of the Proposed Scheme embankment for the purposes of impounding overland flows. For the Proposed Scheme model, the rectangular culvert under the WCML was extended to incorporate the Proposed Scheme crossing. The culvert dimensions remained as the existing WCML size.

4.1.39 Only localised realignments are proposed at the outlet of the Proposed Scheme crossing to ensure a straight section of channel through the extended culvert at the crossing.

4.1.40 The modelled impact of the Proposed Scheme on peak flood levels for the 1% AEP plus climate change event is shown in Figure 21. In the Proposed Scheme model, the extended WCML/Proposed Scheme culvert discharges to a new location, therefore, an increase in peak flood level of approximately 100mm is modelled here whereas no flooding was shown in the baseline. The increase in peak water level is classified as a major impact, affecting scrubland, a water compatible receptor, resulting in a minor adverse effect which is not significant. On a precautionary basis RFS is provided to mitigate for this increase in peak water level at this location, as shown in Figure 23. This RFS has not been included in the hydraulic analysis at this stage. The RFS will be refined during design development and ensure that there is no net loss of floodplain storage and therefore no impact on flood risk elsewhere due to the proposed crossing. No changes in flood level were indicated upstream of the proposed crossing.

4.1.41 Model results indicate that the current proposed design achieves the freeboard requirements for both the top of rail level and Proposed Scheme watercourse crossing soffits.

Figure 21: Coffin Lane Brook impact map for the 1.0% AEP + CC flood event

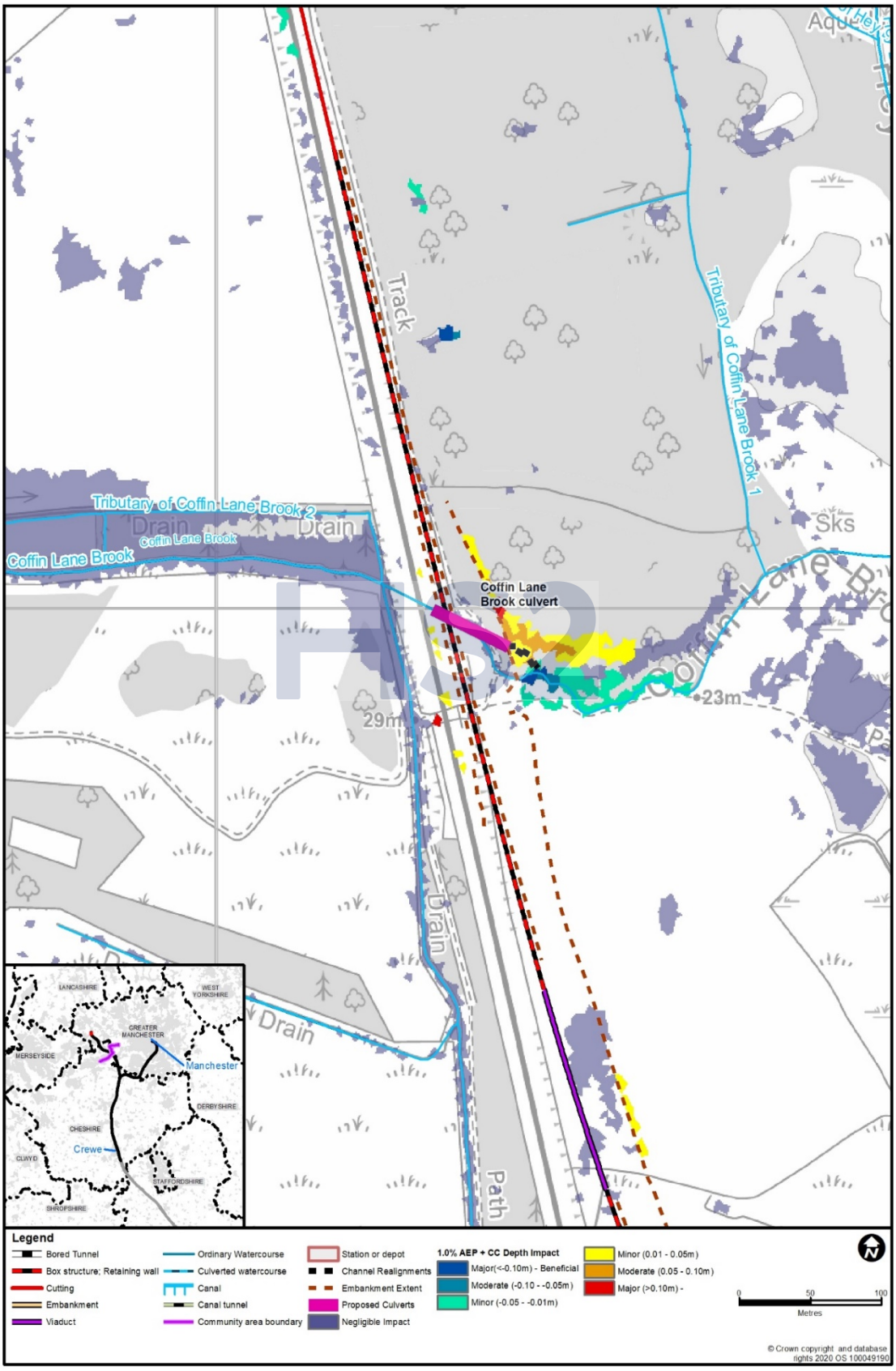


Figure 22: Replacement floodplain storage areas (southern extent)

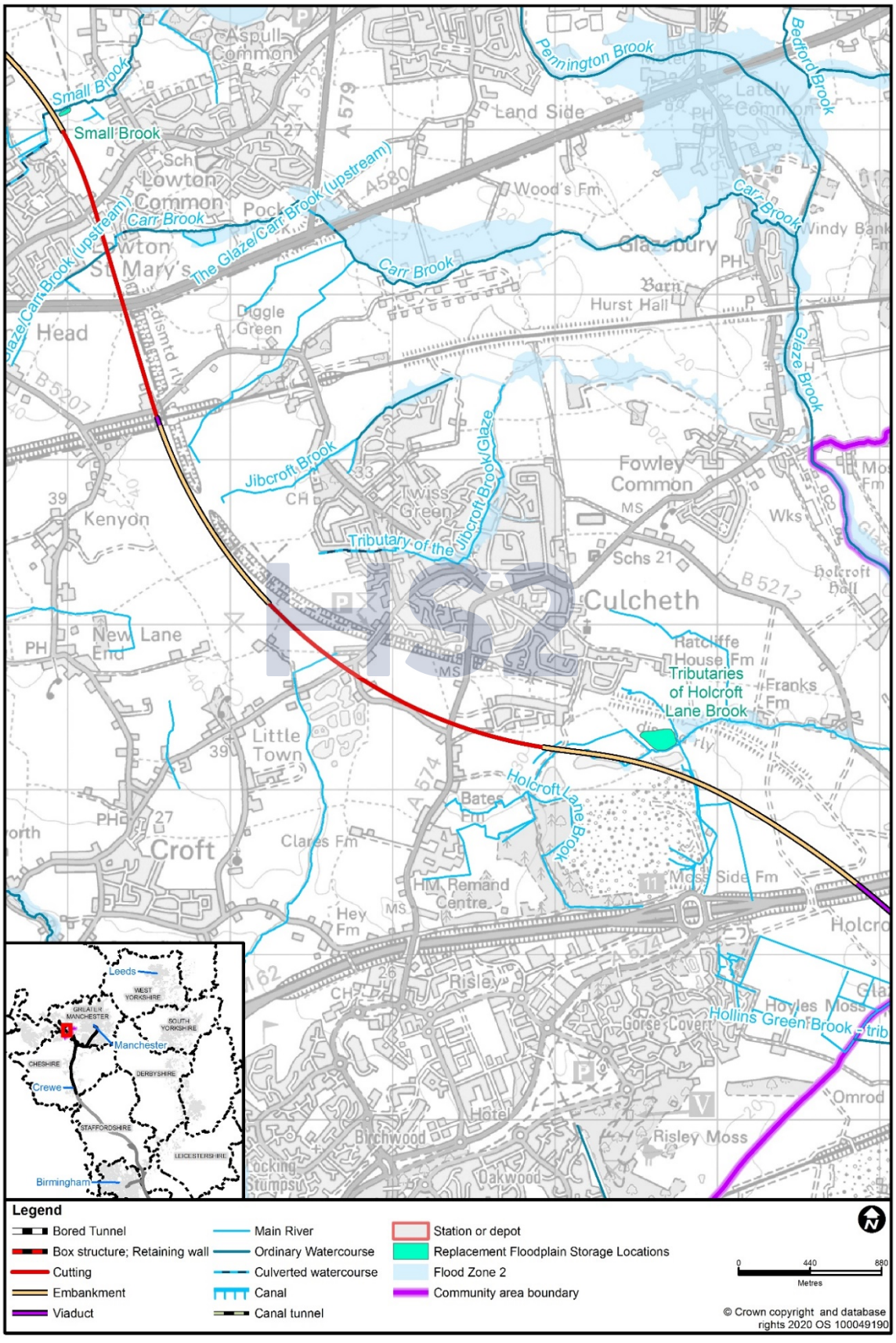
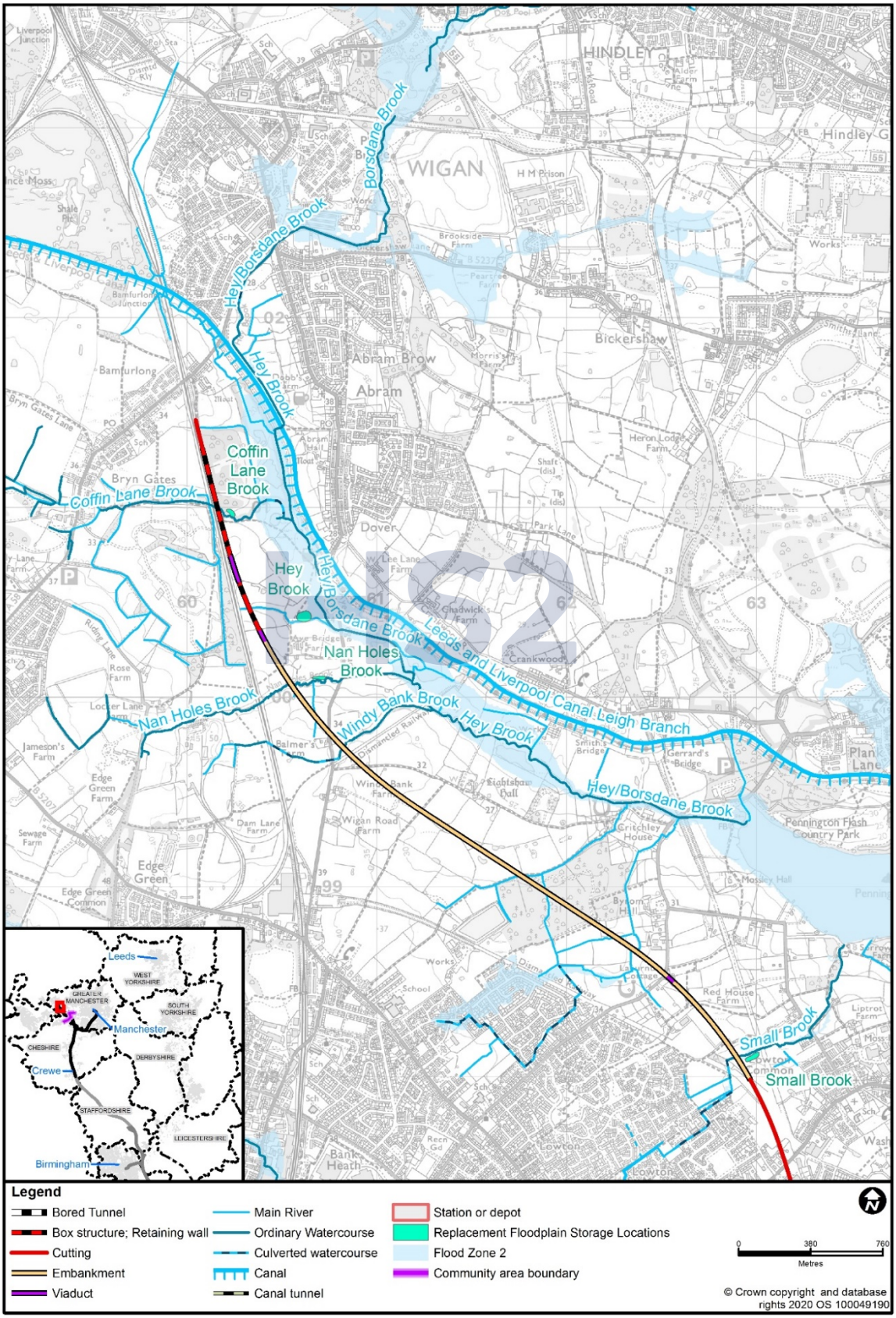


Figure 23: Replacement floodplain storage areas (northern extent)



4.1.42 In addition to the modelled main river crossings, the Proposed Scheme crosses a number of smaller ordinary watercourses that have not been modelled or mapped as part of the Environment Agency's Flood map for planning (rivers and sea) dataset[5]. The RoFSW[5] dataset has therefore been used to indicate the potential flood extent generated and the receptors affected along these ordinary watercourses.

4.1.43 At the locations where these ordinary watercourses cross the Proposed Scheme, or offline features, culverts are required to convey the water under the route.

4.1.44 The following calculation procedure has been undertaken to size the culverts:

- use of the Revitalised Rainfall-Runoff Model version 2.2 (ReFH2)[20] 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 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 cross sectional area 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.

4.1.45 The details of the culvert design applied to the ordinary watercourses are provided in Table 5.

Table 5: Details of culvert design at ordinary watercourse crossings

Watercourse / location	Structure name	Estimated 1.0% AEP peak flow (m^3/s)	Climate change allowance (increase in peak rainfall intensity)	Estimated 1.0% AEP + CC peak flow (m^3/s)	Culvert dimensions of opening (m)	Culvert capacity (m^3/s)[18]
Carr Brook	Carr Brook aqueduct	1.36	40%	1.9	1.5m high x 2.9m wide	5.3
Carr Brook - offline	Golborne pumping station access offline culvert	1.36	40%	1.9	2 box culverts 1.35m high x 1.35m wide	7.08
Carr Brook - offline	Newton Road access offline culvert	1.36	40%	1.9	1.5m high x 2.9m wide	3.53
Tributary of Hey Brook 1	Garton common culvert	3.25	40%	4.88	2.5m high x 2.8m wide	5.8

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

Watercourse / location	Structure name	Estimated 1.0% AEP peak flow (m^3/s)	Climate change allowance (increase in peak rainfall intensity)	Estimated 1.0% AEP + CC peak flow (m^3/s)	Culvert dimensions of opening (m)	Culvert capacity (m^3/s)[18]
Tributary of Hey Brook 5	Hey Brook tributary culvert	0.10	40%	0.10	1.35m high x 1.35m wide	3.33
Tributary of Hey Brook 5 - offline	Hey Brook tributary offline culvert	0.10	40%	0.10	1.35m high x 1.35m wide	3.33
Windy Bank Brook - offline	Footpath Golborne 27/10 and Windy Bank Brook offline culvert	0.24	40%	0.45	3.0m high x 5.0m wide	8.00
Tributary of Coffin Lane Brook 1	Hey Brook culvert	0.24	40%	0.35	1.35m high x 1.35m wide	19.1

4.1.46 There are a number of additional offline unnamed culverts beneath access roads listed in Table 4.

Table 6: Surface water unnamed culverts

Watercourse	Location
Tributary of Carr Brook 1	Unnamed culvert east of HS2 attenuation pond
Tributary of Hey Brook 1	Unnamed culvert west of the highways attenuation pond
Tributary of Hey Brook 4	Unnamed culvert north Byrom Wood
Tributary of Nan Holes Brook 1	Unnamed culvert east of access road
Tributary of Coffin Lane Brook 1	Unnamed culvert east of Hey Brook culvert

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

4.1.48 Each of the watercourse crossings in Table 5 are 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.

Temporary construction compounds and stockpiles

4.1.49 Table 7 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.

4.1.50 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 7: 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
Nan Holes Brook	Satellite compound	Approximately 20% of site at risk of flooding associated with Nan Holes Brook that runs through the centre of the site	Location required due to proximity to Wigan Road. Utilities compounds constraints in the north, east and south	Compound and stockpile layout and drainage to take account of the watercourse either keeping clear with bridging only for access or with more extensive bridging allowing for storage and water flow. Consider locating the compound on one side of the watercourse and the stockpile on the other or lowering the southern area to divert surface water allowing the area on the northern side to be fully utilised.
	Temporary earthworks stockpile	Nan Holes Brook main river runs through the centre of the site	Utilities compound constraint to the south. Satellite compound constraint to the east	
Carr Brook	Stockpile	Stockpile located across a flow path	Main compound constraint to the south	Stockpile can be stopped either side of the flow path or culverted beneath if a continuous bund is required.
	Main compound	Compound located across a flow path	Location required for proximity to the scheme	Flow path may be diverted or reduced due to the road diversion. Utilise edge drainage along the southern boundary of the compound to divert flow path.
	Stockpile	Northern section of stockpile covers a flow path	Road constraint to the north	Flow path may be diverted or reduced due to the road diversion. Reshape the stockpile to remove the area within the flowpath and/or allow for drainage path under the stockpile.
Tributary of Hey Brook 1	Stockpile	Eastern side of the stockpile covers a flow path	Constrained by the Proposed Scheme to the south, watercourse to the east, and road to the north	Shape of stockpile can be adjusted however the southern end is adjacent to permanent works, including an attenuation pond.
	Stockpile	Approximately 30% of the western end of the stockpile is	Proposed Scheme constraint to the north east	Stockpile can be stopped at the edge of the flow path.

Watercourse /location	Construction compound	Risk of flooding from surface water	Location constraints	Potential mitigation
		located in a flow path		
	Satellite compound	Compound covering the upstream end of a surface water flow path towards Hey Brook/Pennington Flash	Location required due to proximity to Slag Lane. Utilities compound constraint to the west	Compound layout and drainage to take account of surface water flow paths. Utilise a pipe beneath the road to maintain flow.
Windy Bank Brook	Stockpile	Approximately 50% of the stockpile located within flow path	Utilities compound constraint to the south	If practical reshape the stockpile and/or allow for drainage path under the stockpile.

4.2 Surface water

4.2.1 As outlined previously the RoFSW[5] 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.

4.2.2 These flow paths have been addressed in the design of the Proposed Scheme by providing culverts and/or channel features to collect and convey surface water from one side of the Proposed Scheme to the other.

4.2.3 The design process outlined in Section 4.1 has also been followed to size these culverts and the associated channels. In this way the existing flow paths are preserved, and the flooding characterises of the local area will remain unchanged.

4.2.4 Details of the culvert and channel design are provided in Table 8. The location of the culverts can be seen in Figure 14 and Figure 15.

Table 8: Details of culvert design at surface water flow paths

Watercourse/ location	Structure/ feature name	Estimated 1.0% AEP peak flow (m^3/s)	Climate change allowance (increase in peak rainfall intensity)	Estimated 1.0% AEP + CC peak flow (m^3/s)	Culvert/channel dimensions (m)	Culvert/ channel capacity (m^3/s)[18]
Highways drain discharging to Tributary of Carr Brook 1	Kenyon culvert	<0.02	40%	0.02	1.35m wide x 1.35m high	5.85
Dry valley discharging to Carr Brook	A580 East Lancashire Road offline culvert	0.76	40%	1.15	1.35m wide x 1.35m high	4.76

4.2.5 By following this design approach, the local flood risk characteristics are preserved and the risk to the receptors is unchanged.

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 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 that 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 Risley to Bamfurlong 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 that 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-003-0MA05).

4.4 Artificial sources

4.4.1 There are no artificial water bodies with potential implications for flood risk within the study area.

4.4.2 Major water supply pipelines and sewerage (foul and surface water) infrastructure have been identified and are shown on the Volume 2, MA05 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.

4.4.3 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[21].

[21] 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 how they represent the existing watercourses. The areas of RFS identified will be incorporated into the models and the design of all the viaducts, bridges and culverts will be developed to mitigate all impacts on peak flood levels 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: Risley to Bamfurlong, (MA06), Section 4.

5.1.2 RFS has been provided on a precautionary basis to address the loss of floodplain storage caused by the culverts and channel realignments either local to the watercourse crossing or elsewhere within the catchment as a result of a cumulative effect at the Tributaries of Holcroft Lane Brook 2, 3 and 4, Small Brook, Nan Holes Brook, Hey Brook and Coffin Lane Brook. The RFS will be refined during design development and ensure that there is no net loss of floodplain storage and therefore no impact on flood risk elsewhere due to the proposed crossing.

5.1.3 Embedded flood risk management measures have been included in the design at Carr Brook. These measures comprise the realignment of Carr Brook to a naturalised channel south of Brancaster Drive and the removal of a culverted section of Carr Brook at the rear of properties on Brancaster Drive. These measures will mitigate flood risk posed by the Proposed Scheme, resulting in a negligible impact and a negligible effect, which is not significant.

5.1.4 Further topographical survey, other surveys as required, hydraulic modelling, including incorporation of the RFS and bypass channels, design development, and refinement of the mitigation measures will be undertaken during design development and will, as far as reasonably practical, ensure no potential effects on flood risk.

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 Due to the flood risk management measures embedded in the design, there are no significant adverse effects on flood risk. At Carr Brook peak flood levels upstream and downstream of the aqueduct are reduced when compared to the baseline, this results in a major beneficial effect, which is significant, of the Proposed Scheme.

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 for the Risley to Bamfurlong area. 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 on a precautionary basis to address the loss of floodplain caused by the embankments, culverts and channel realignments at the Tributaries of Holcroft Lane Brook 2, 3 and 4, Small Brook, Nan Holes Brook, Hey Brook and Coffin Lane Brook. Flood risk management measures embedded in the design at Carr Brook have been provided to ensure no change in flood risk due to the Proposed Scheme at this location. Further assessment and refinement of the models and inclusion of the 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 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 (Volume 5: Appendix WR-007-00000), the Proposed Scheme will not result in any significant adverse effects on flood risk in MA05.

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