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HS2

High Speed Rail (Crewe – Manchester) Environmental Statement

Volume 5: Appendix WR-005-0MA07

Water resources and flood risk

MA07: Davenport Green to Ardwick

Flood risk assessment

M330

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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 Davenport Green to Ardwick area (MA07).

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 Davenport Green to Ardwick area, the relevant hydraulic modelling report (Volume 5: Appendix WR-006-00009) should be referred to as well as the Water resources assessment (Volume 5: Appendix WR-003-0MA07).

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-004-0MA07)[1]; and
- Water Framework Directive compliance assessment baseline data that 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, MA07 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-004-0MA07. 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 Davenport Green to Ardwick 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 construction 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 available.

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

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: Davenport Green to Ardwick 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 MA07 study area is shown in Figure 1 and Figure 2.

1.3.2 In the Davenport Green to Ardwick area, the study area has been extended to 1.5km from the Proposed Scheme to account for all flood risk receptors where there is the potential for impacts on groundwater, groundwater-surface water interactions and groundwater dependent habitats from construction of the Proposed Scheme. 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)[4] and the risk of flooding from surface water maps (RoFSW)[5].

[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), *Flood map for planning*. Available online at: https://flood-map-for-planning.service.gov.uk.

[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 of the study area (southern extent)

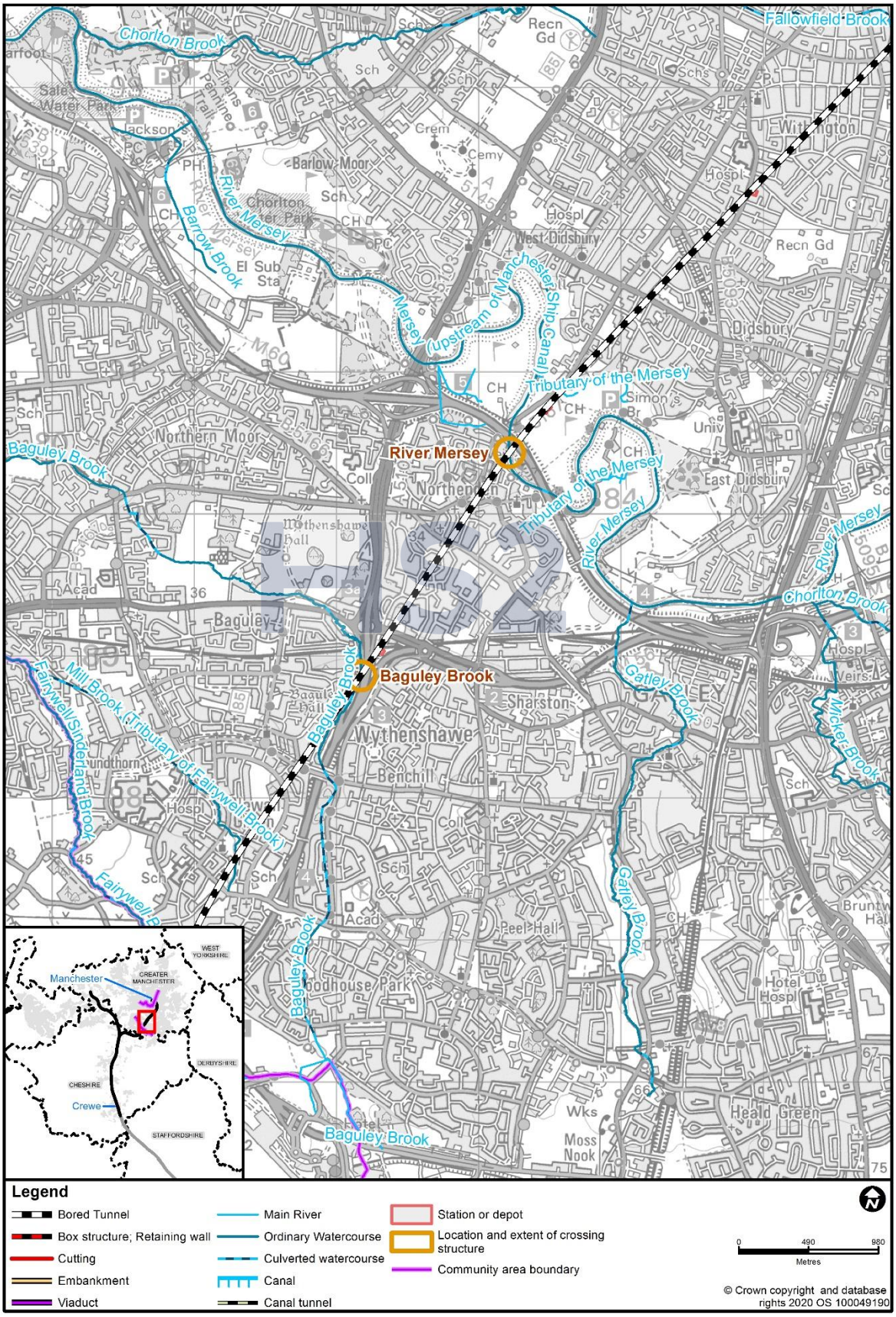
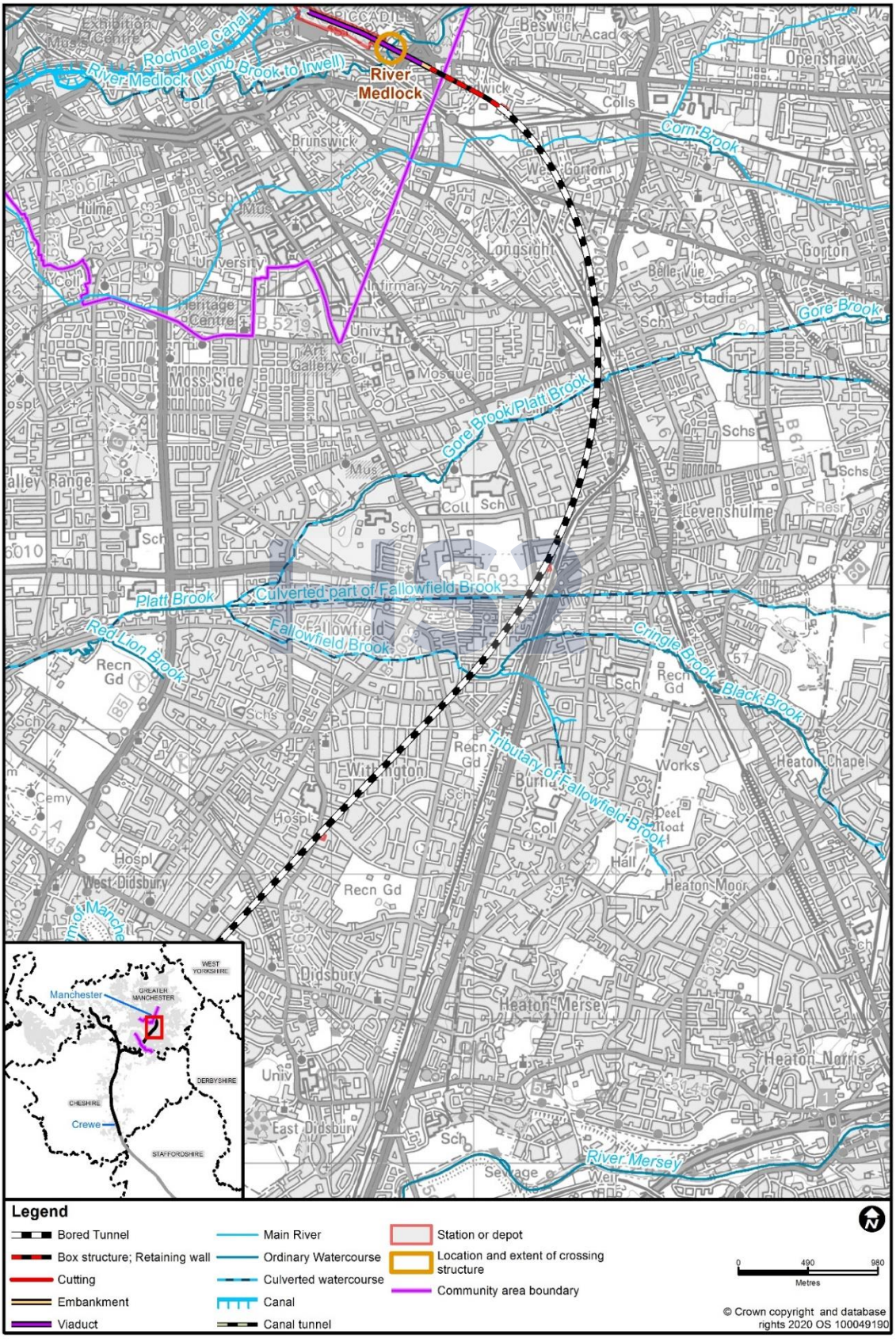


Figure 2: Location of the study area (northern extent)



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[6]. 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). Manchester City Council (MCC) is the LLFA in the Davenport Green to Ardwick area. A series of meetings have been held with MCC and the Environment Agency Greater Manchester, Merseyside and Cheshire (GMMC) local area team 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 – River Mersey (see Volume 5: Appendix WR-006-00009).

2.2.2 The MCC Preliminary Flood Risk Assessment (PFRA)[7] was published in 2011, and the Local Flood Risk Management Strategy (LFRMS)[8] was published in 2014. The LFRMS contains 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)[9]. The Proposed Scheme design has sought to align with these objectives where reasonably practicable.

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[6] Department for communities and local government (2019), *National Planning Policy Framework.*

[7] JBA Consulting (2011), *Manchester City Council Preliminary Flood Risk Assessment.* Available online at: https://www.manchester.gov.uk/egov_downloads/MCC_PFRA.pdf.

[8] Manchester City Council (2014), *Manchester City Council Local Flood Risk Management Strategy.* Available online at: https://secure.manchester.gov.uk/downloads/download/5603/lfrms_documents.

[9] 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.

2.2.3 The Manchester, Salford and Trafford Strategic Flood Risk Assessment (SFRA)[10] covers the Davenport Green to Ardwick 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.

[10] JBA Consulting (2010), *Manchester, Salford and Trafford Strategic Flood Risk Assessment.* Available online at: https://www.trafford.gov.uk/planning/strategic-planning/docs/manchester-salford-and-trafford-councils-level-2-hybrid-sfra-level-1-sfra-march-2010.pdf.

3 Flood risk baseline

3.1 Historical flooding incidents

3.1.1 The PFRA and SFRA published by MCC report incidents of historical flooding from watercourses or surface water sources, particularly from Cringle Brook. The Proposed Scheme in the Davenport Green to Ardwick area is predominantly in bored tunnel with above ground vent shafts.

3.1.2 In January 2021, Storm Christoph caused the River Mersey to rise within a few centimetres of flood defence crest levels at Northenden, triggering the activation of inlet gates at Didsbury flood storage basin and causing water levels within Withington golf course to rise to a peak water level of 28.13mAOD. Analysis of this event and its impact on the hydraulic modelling has been undertaken and will continue to be investigated as part of future work in this area.

3.1.3 A review of the currently available Section 19[11] historical flood reports in the Davenport Green to Ardwick 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. The events are:

- Greater Manchester flood event (December 2015)[12];
- June 2016 flood event - Stockport Metropolitan Borough Council[13];
- Cheadle Hulme flood event (March 2016)[14]; and
- September 2016 flood event – Stockport Metropolitan Borough Council[15].

3.1.4 These reports have been reviewed but contain no information relevant to assessment of flood risk for the Proposed Scheme. The January 2021 event may be the subject of future Section 19 reports.

[11] 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.

[12] Greater Manchester Combined Authority (2015), *Flood investigation report; Greater Manchester*. Available online at: https://www.greatermanchester-ca.gov.uk/media/1261/boxing-day-flood-report.pdf.

[13] Jacobs (2016), *Section 19 investigation report; June 2016 flood events*. Available online at: https://assets.ctfassets.net/ii3xdrqc6nfw/7arSn8BGOQC8O4MUMeSaMk/730eb37e8875aec4c2635eb59d42999b/Flooding_Investigation_Report_-_December_2016.pdf.

[14] Stockport Metropolitan Borough Council (2016), *Flood site information sheet; Dorset Avenue, Cheadle Hulme, 8th February 2016.* Available online at: https://assets.ctfassets.net/ii3xdrqc6nfw/2Hpn1S4Od2skgEiOggO82I/a2f020026ab8daeb2e1ec1df3019918f/Flooding_Investigation_Report_March_2016_-_Dorset_Avenue_-_Cheadle_Hulme.pdf.

[15] Jacobs (2017), *Section 19 investigation report; September 2016 flood events*. Available online at: https://assets.ctfassets.net/ii3xdrqc6nfw/40YlLAtEnm0O8EmKwu2suq/411aaa37df4debc4321549f04bd12652/Flood_Investigation_Report_September_2016.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:

- Baguley Brook;
- River Mersey, including Tributary of River Mersey 2 (also known as Fielden Park Brook);
- Fairywell Brook is located on the boundary between Hulseheath to Manchester Airport (MA06) area and the Davenport Green to Ardwick (MA07) area. The assessment of flood risk associated with this watercourse is covered in the Flood risk assessment report (Volume 5: Appendix WR-005-0MA06); and
- Cringle Brook and Gore Brook – There is no change in flood risk for these watercourses as the Proposed Scheme passes beneath the floodplain in tunnel. Therefore, flood risk assessment for these watercourses has not been considered further.

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 Ordnance Survey (OS) mapping and committed development information[16].

Baguley Brook

3.2.3 The main rivers have mapped flood zones indicated by the Environment Agency Flood map for planning (rivers and sea) dataset. This dataset was used to assess the receptors at potential risk from flooding. As the Proposed Scheme crosses beneath Baguley Brook in tunnel, it does not affect the floodplain other than potentially at the Altrincham Road vent shaft. Therefore, it was determined through the decision tree process that modelling was not required at this location at this stage. Details of the modelling decision tree process are provided in the SMR.

3.2.4 The receptors upstream and downstream of the Proposed Scheme that are at potential risk from the Baguley Brook are listed below and shown in Figure 3. The relative vulnerability to flooding of each receptor (as defined in NPPF and Table 55 of the SMR) is also indicated:

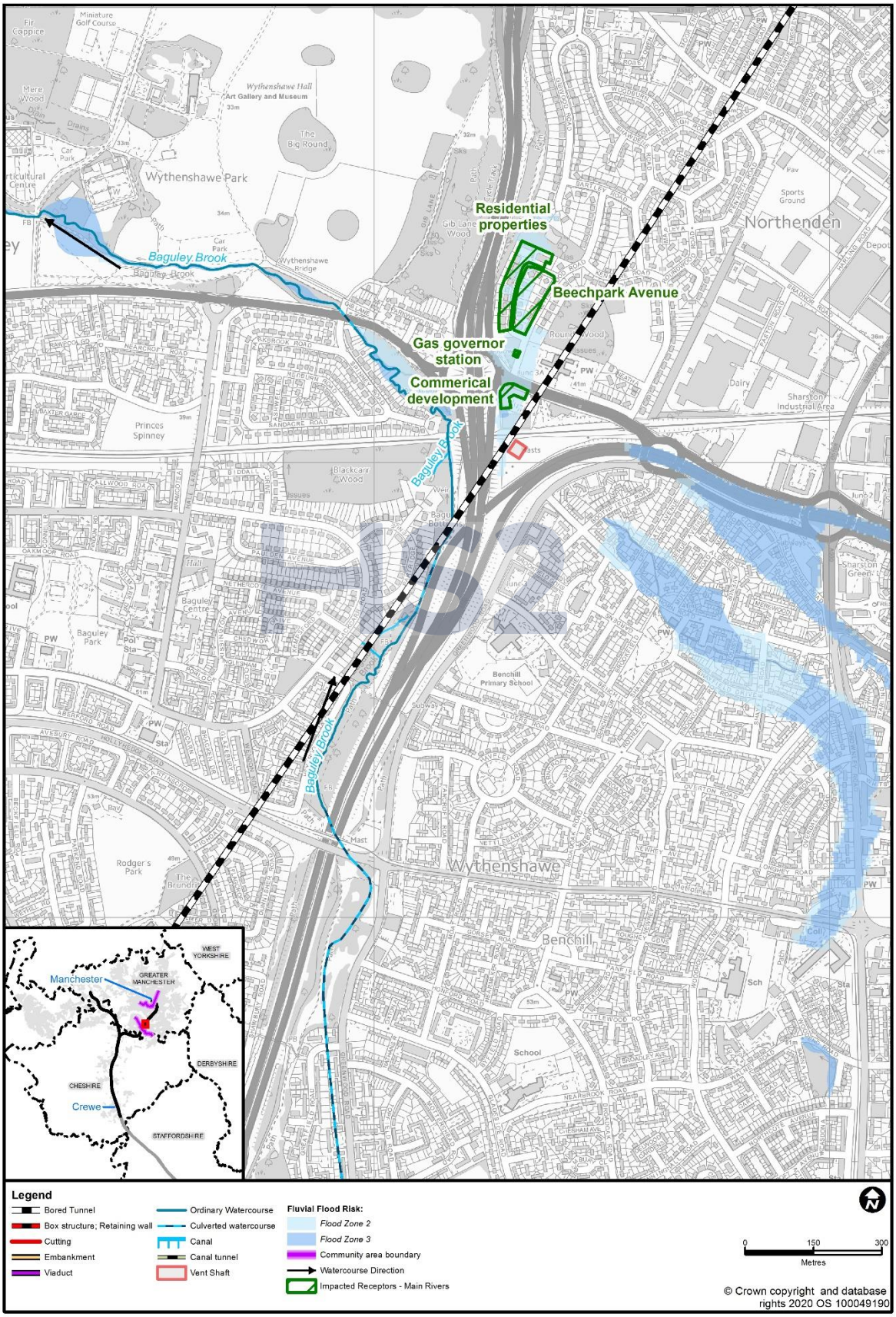
- commercial offices (less vulnerable);
- gas governor station (essential infrastructure);
- residential properties along Beechpark Avenue (more vulnerable); and
- Beechpark Avenue (less vulnerable).

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

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

3.2.6 The Proposed Scheme at Baguley Brook will be in a bored tunnel and a review of the above ground vent shaft at this location has shown it to be outside of the Environment Agency's flood zones. This watercourse will therefore undergo no further assessment at this stage. Should modelling be required during design development, a full survey of the crossing will be undertaken to ensure that the site conditions and flow regimes are adequately understood.

Figure 3: Extent of the Environment Agency's Flood Zones 2 and 3, Baguley Brook



River Mersey

3.2.7 A 1D-2D hydraulic model of the River Mersey and its tributaries has been developed from the existing 2012[17] and 2018[18] Environment Agency models to define the peak flood levels and extents associated with a range of annual probabilities. Further detail is provided in the Hydraulic modelling report – River Mersey. The inundation extents for the 1.0% annual exceedance probability (AEP) plus climate change event are shown in Figure 4.

3.2.8 The receptors upstream and downstream of the Proposed Scheme that are at potential risk from the River Mersey and its tributaries are listed below and shown in Figure 4. The relative vulnerability to flooding of each receptor (as defined in NPPF and Table 55 of the SMR) is also indicated:

- Palatine Road (Didsbury):
  - two secondary electricity substations (essential infrastructure);
  - ten residential properties (more vulnerable);
  - Withington golf course club house (less vulnerable);
  - hotel (less vulnerable);
  - Palatine Road (less vulnerable);
  - two car parks (water compatible);
  - Didsbury flood storage basin (water compatible); and
  - Withington golf course (water compatible).
- area south of Junction 5 of the M60 (Northenden):
  - one residential property (more vulnerable); and
  - cycle track (less vulnerable).
- east of Didsbury flood storage basin (Stenner Lane):
  - four residential properties (more vulnerable);
  - disused building (less vulnerable);
  - Stenner Lane (less vulnerable);
  - allotments (water compatible);
  - Didsbury sports ground and buildings (less vulnerable); and
  - Didsbury golf course (water compatible).
- Ford Lane and Mill Lane area (Northenden):
  - secondary electricity substation (essential infrastructure);
  - 27 residential properties (more vulnerable);
  - disused building (less vulnerable);

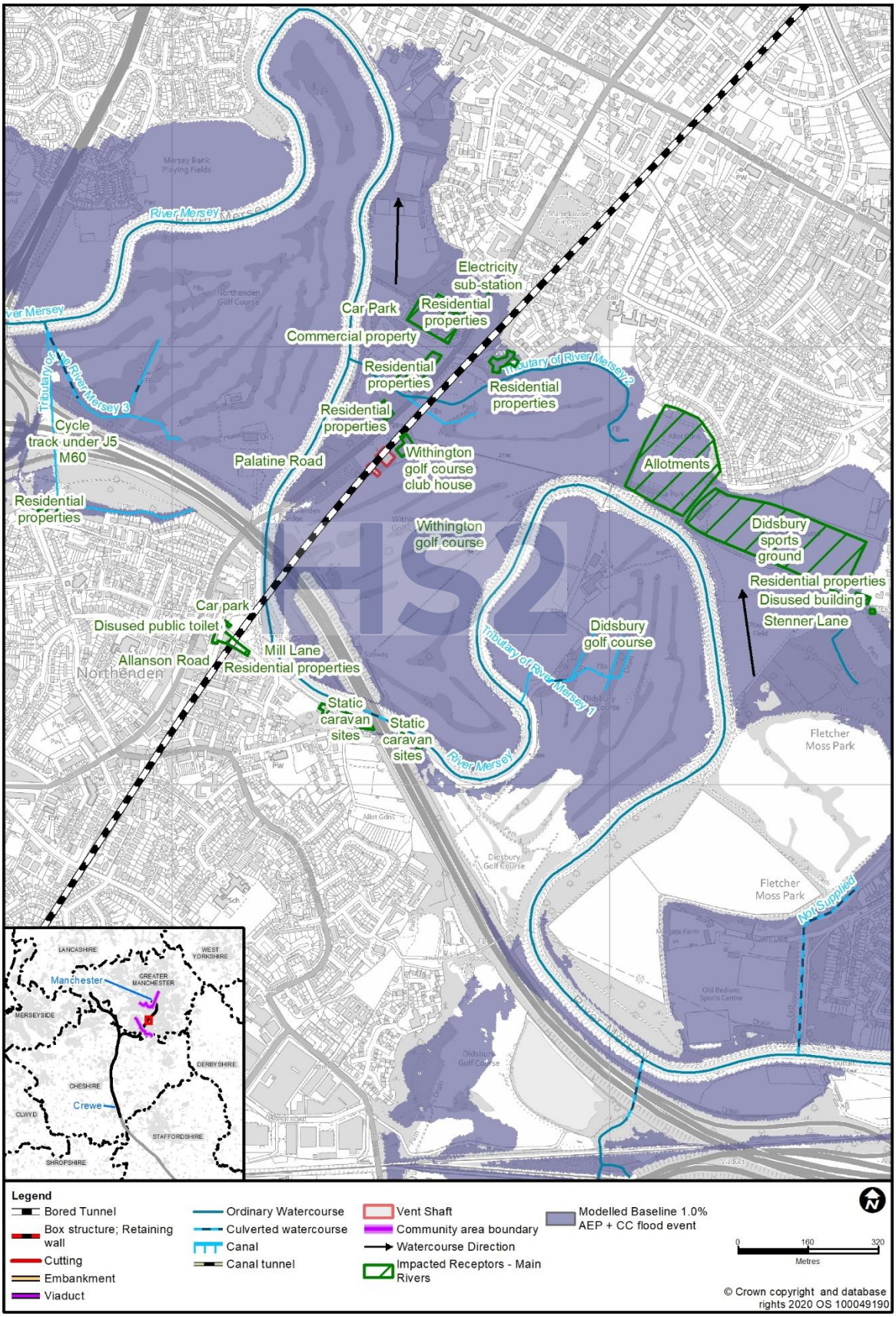
[17] Environment Agency (2012), *Upper Mersey Model update 2011/12*.

[18] JBA Consulting Ltd (2018), *Upper Mersey Model update*.

- Mill Lane (less vulnerable);
- Allanson Road (less vulnerable); and
- car park (water compatible).

3.2.9 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 4: Baseline extent of the modelled 1.0% AEP + CC flood event, River Mersey



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. This dataset indicates where surface water flow paths cross the Proposed Scheme. As presented in Figure 5, the following receptors are at risk from surface water flooding near Rondin Road:

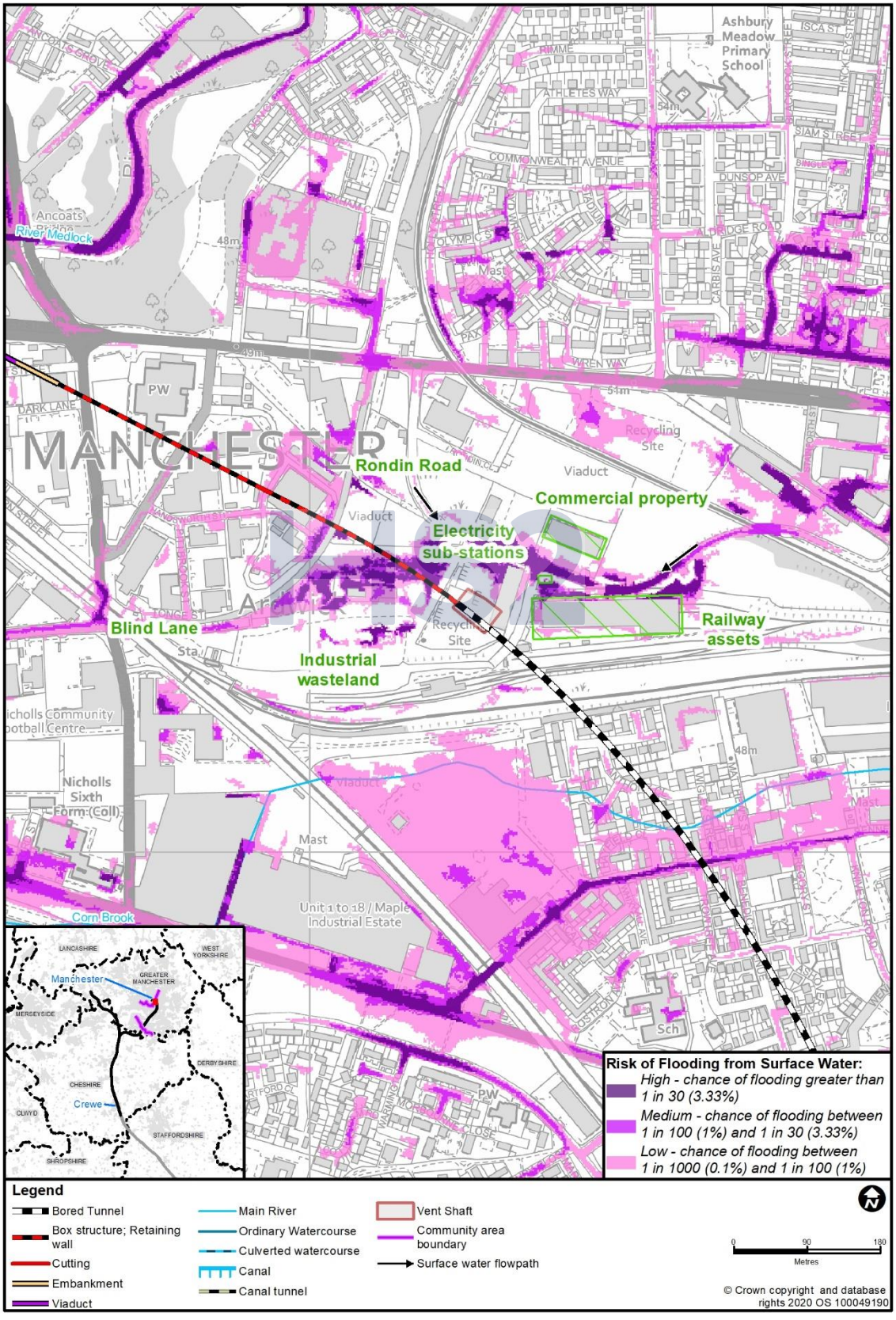
- two secondary electricity substations (essential infrastructure);
- railway assets (train care facility) (less vulnerable);
- commercial property on Rondin Road (to be demolished as part of the Proposed Scheme but assumed to be replaced with planning allocations (MA07/111, MA07/110, MA07/299, MA08/038, MA08/129[19]) for residential and commercial properties in the future (more vulnerable);
- Blind Lane (less vulnerable); and
- industrial wasteland (water compatible).

3.3.2 In line with the SMR, a climate change allowance has been adopted to assess the future flood risk to receptors associated with these surface water flow path crossings 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.

3.3.3 The Proposed Scheme in the Davenport Green to Ardwick area is predominately in a bored tunnel. Other flow paths that cross the Proposed Scheme have therefore been excluded from the assessment as they are not affected by the Proposed Scheme in the tunnel.

[19] Planning data, Volume 5: Appendix CT-004-00000.

Figure 5: Extent of the Environment Agency's RoFSW dataset, surface water flow path near Rondin Road



3.4 Risks associated with groundwater

3.4.1 The British Geological 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 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 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 6) indicates that there is potential for groundwater flooding to occur at surface at the following locations:

- Baguley;
- Newall Green;
- Woodhouse Park;
- Moss Nook;
- Tributary of Cringle Brook 1;
- West Gorton; and
- Ardwick.

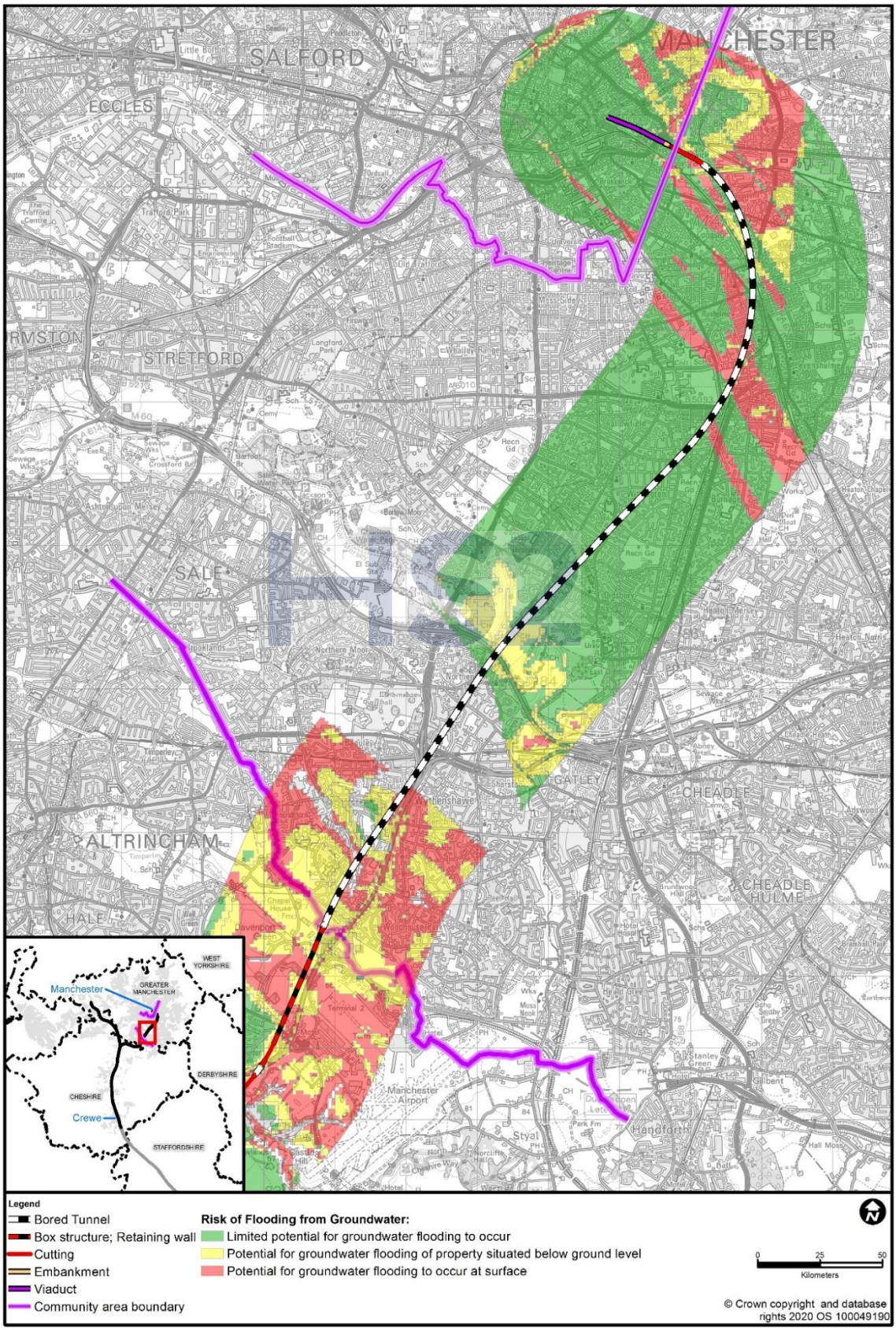
3.4.4 The gap in the mapped dataset (Figure 6) around Didsbury is attributed to the bedrock geology. The Tarporley Siltstone Formation present in this area is not considered to hold a significant quantity of groundwater hence is not 'geologically susceptible' to groundwater flooding. The susceptibility to groundwater flooding is related to the nature of the bedrock (mudstones) and superficial deposits (glacial till). The SFRA[10] and LFRMS[8] do not report any historic groundwater flooding incidents within the study area.

3.4.5 The receptors located in these areas that are potentially at risk from groundwater at the surface are listed below. The relative vulnerability to flooding of each receptor (as defined in NPPF and Section 21 of the SMR) is also indicated:

- residential properties and roads (more vulnerable);
- roads (less vulnerable);
- commercial properties (less vulnerable); and
- parks and recreational areas (less vulnerable).

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

Figure 6: Risk of flooding from groundwater throughout the study area



3.5 Risks associated with artificial sources

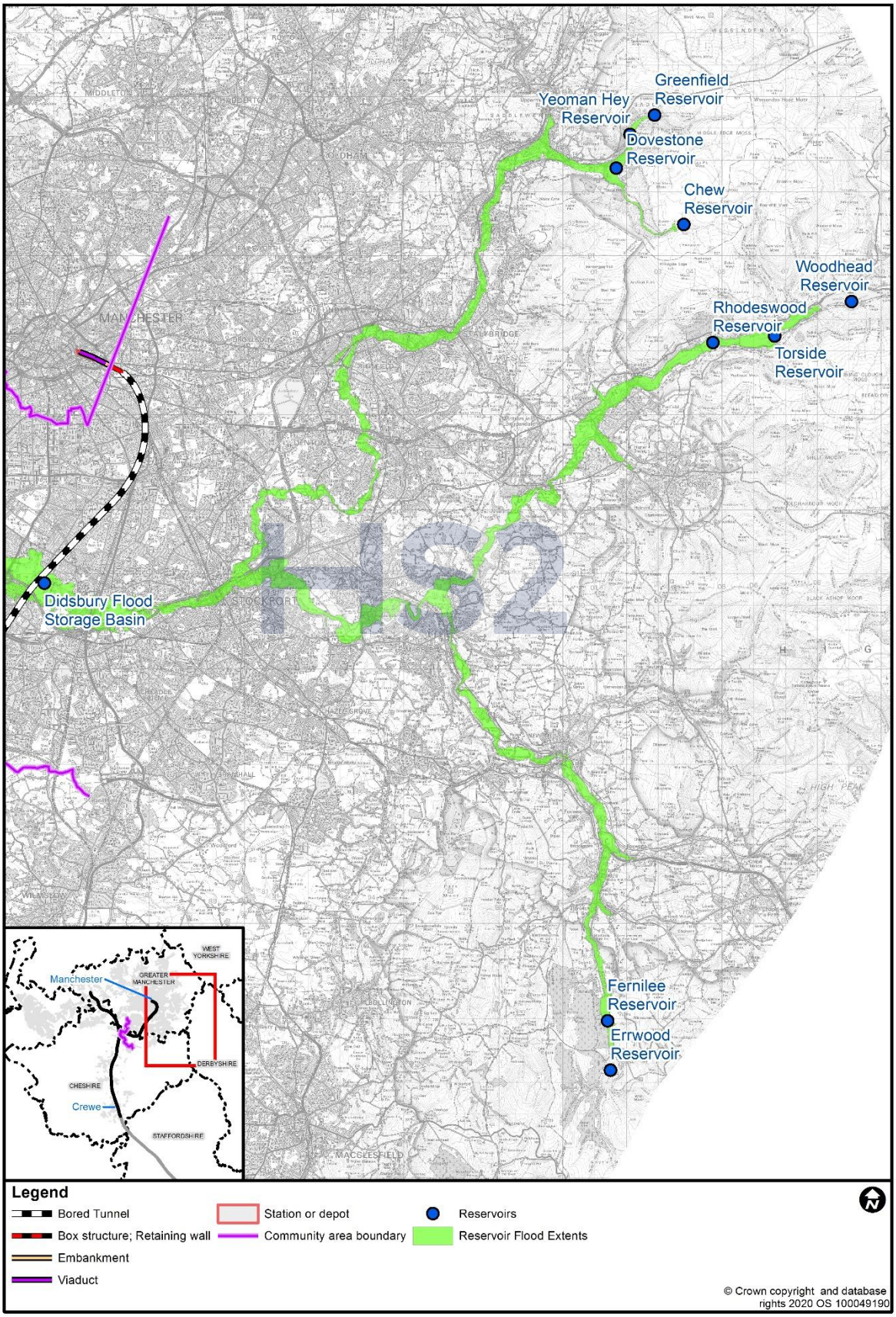
3.5.1 Flooding from artificial water bodies may occur due to failure of an impounding structure, such as a dam or canal embankment. The following features have been identified within the study area that are a potential source of flood risk:

- 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, MA07 Map Book: Map Series CT-05 and CT-06; and
- reservoirs outside of the study area but with potential to affect flood risks of relevance to the Proposed Scheme. These are large raised reservoirs and are shown on the Environment Agency's flood risk from reservoirs mapping and include:
  - Woodhead;
  - Dovestone;
  - Greenfield;
  - Rhodeswood;
  - Yeoman Hey;
  - Fernilee;
  - Errwood;
  - Chew; and
  - Torside.

3.5.2 In addition, the Didsbury flood storage basin is located partly within the land required for the construction of the Proposed Scheme, on the north bank of the River Mersey. The Didsbury flood storage basin has a statutory designation under the 1975 Reservoirs Act, and as such has detailed operational and maintenance requirements. The flood mechanisms in this area reflect the operation of the Didsbury flood storage basin (a flood risk management asset used by the Environment Agency to regulate flows within the River Mersey during flood events). During a flooding event, the basin fills first; once full and the defences become drowned out, floodwaters fill the River Mersey floodplain.

3.5.3 Figure 7 shows the location of artificial sources within the Davenport Green to Ardwick area and a summary of the baseline flood risk from artificial sources is provided in Table 1.

Figure 7: 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
Baguley Brook	Commercial property (hotel) (less vulnerable)	Environment Agency Flood Zones 2 and 3	Essential infrastructure	70% (increase to peak river flow)
	Gas governor (essential infrastructure)			
	Residential properties along Beechpark Avenue (more vulnerable)			
	Beechpark Avenue (less vulnerable)			
River Mersey / Tributary of River Mersey 2 (Fielden Park Brook)	Secondary electricity substations (essential infrastructure)	Environment Agency Flood Zones 2 and 3	Essential infrastructure	70% (increase to peak river flow)
	Residential properties, Palatine Road (more vulnerable)			
	Hotel (less vulnerable)			
	Palatine Road (less vulnerable)			
	Car parks (water compatible)			
River Mersey	Didsbury flood storage basin, Didsbury and Withington golf courses (water compatible)	Environment Agency Flood Zones 2 and 3	Essential infrastructure	70% (increase to peak river flow)
	Allotments (water compatible)			
	Didsbury sports ground and buildings, Didsbury and Withington golf course club houses (less vulnerable)			
	Secondary electricity substation (essential infrastructure)			
	Car park (water compatible)			
	Cycle track (less vulnerable)			

Source / pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment
	Stenner Lane, Mill Lane, Allanson Road (less vulnerable)			
	Disused buildings Stenner Lane and Northenden (less vulnerable)			
	Residential properties Northenden, Stenner Lane, and Palatine Road (more vulnerable)			
	Commercial property on Palatine Road (less vulnerable)			
Surface water flow path at Rondin Road	Two secondary electricity substations (essential infrastructure)	RoFSW 0.1% AEP flood extent	Essential infrastructure	40% (increase in peak rainfall intensity)
	Railway assets (train care facility) (less vulnerable)			
	Planning allocations for future commercial and residential properties on Rondin Road (MA07/111, MA07/110, MA07/299, MA08/038, MA08/129)[19] (more vulnerable)			
	Blind Lane (less vulnerable)			
	Industrial wasteland (water compatible)			
Dovestone, Greenfield, Rhodeswood, Yeoman Hey, Fernilee, Errwood, Chew, and Torside reservoirs	Allotments (water compatible)	Environment Agency flood risk from reservoirs data set	Essential infrastructure	N/A
	Didsbury sports ground and buildings, Didsbury and Withington golf course club houses (less vulnerable)			
	Didsbury flood storage basin, Didsbury and Withington golf courses (water compatible)			
	Secondary electricity substations (essential infrastructure)			
	Car parks (water compatible)			
	Cycle track (less vulnerable)			
	Palatine Road, Stenner Lane, Mill Lane, Allanson Road (less vulnerable)			

Source / pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment
	Disused buildings Stenner Lane and Northenden (less vulnerable)			
	Residential properties Northenden, Stenner Lane, and Palatine Road (more vulnerable)			
	Commercial property on Palatine Road (less vulnerable)			
	Residential properties Longsight (more vulnerable)			
	Roads and commercial properties Longsight (less vulnerable)			
	Residential properties West Gorton (more vulnerable)			
	Roads and commercial properties West Gorton (less vulnerable)			
Groundwater flooding	Commercial properties (less vulnerable)	BGS susceptibility to groundwater flooding data set	More vulnerable	N/A
	Parks and recreational areas (less vulnerable)			
	Residential properties and roads (more vulnerable)			
	Roads (less vulnerable)			

4 Flood risk impacts and effects

4.1 Main rivers and ordinary watercourses

River Mersey

4.1.1 The Proposed Scheme within the Davenport Green to Ardwick area includes vent shafts for the bored tunnel. The Palatine Road vent shaft and associated raised satellite construction compound are located within the Didsbury flood storage basin (a flood risk management asset used by the Environment Agency to regulate flows within the River Mersey during flood events), which forms part of the River Mersey floodplain. During a flooding event, the defended Didsbury flood storage basin fills first. Once full and the defences become drowned out, floodwaters then fill the River Mersey floodplain.

4.1.2 The Palatine Road vent shaft and raised satellite compound will be located on the north side of Didsbury flood storage basin. The raised satellite construction compound will be elevated to the 1 in 100 year peak flood level with an allowance of 600mm freeboard. The vent shaft is designed to be elevated to above the 1 in 1000 year peak flood level with an allowance of 300mm freeboard.

4.1.3 The permanent Palatine Road vent shaft operational compound will be located on the same site as the satellite construction compound, however the land required for the operational compound could be smaller than the construction compound. On a precautionary basis this assessment assumes that material used to raise the land for the construction satellite compound will not be removed at the end of construction period and will form the permanent works at this site. The size of the permanent raised operational compound will be reviewed during design development with the aim of reducing the area of raised land as far as reasonably practicable.

4.1.4 The raised compound and vent shaft would displace floodwater whilst the Didsbury flood storage basin fills, and once the defences are overwhelmed, it would displace floodwater in the River Mersey floodplain. Hydraulic modelling of the River Mersey at Palatine Road has been used in the design and assessment of the Proposed Scheme. The modelling has been used to determine the likely impact of the vent shaft and compound on the peak flood levels in the 1.0% AEP plus an allowance for climate change event (CC). Details of the hydraulic modelling are reported in the Hydraulic modelling report – River Mersey.

4.1.5 The initial model was based on the 2012 Environment Agency 1D Flood Modeller Pro model. This 1D model was updated to a linked 1D-2D model by including a small 1km^2 area of 2D grid cells around Palatine Road, including the Didsbury flood storage basin. This area of 2D grid cells was included to allow for an improved understanding of the effect of the vent shaft and compound on flow conveyance routes.

4.1.6 In late January 2021, Storm Christoph caused extensive flooding in the River Mersey area, which reached a peak on 21 January 2021. Verification of the linked 1D-2D model using this flood event showed that it did not accurately represent the mechanisms of flooding in this complex area and highlighted some anomalies in the level of flood defences. Further detailed engagement with the Environment Agency local area team was therefore undertaken, with the aim of understanding these anomalies and to ensure the best available flood event data was incorporated into the modelling assessment. Following this engagement with the Environment Agency local area team the model was updated to include data from the 2018 Environment Agency model[18], a more extensive 2D area, revised defence levels, and structure parameters as described in the Hydraulic modelling report – River Mersey.

4.1.7 The Environment Agency flow and level gauging data was used to calibrate the model against the Storm Christoph event. Various model parameters were adjusted in order to match the flood levels observed at the Northenden weir (River Mersey level), Stenner Lane (Didsbury flood storage basin level) and Withington golf course (Didsbury flood storage basin level) gauges; further detail is provided in the Hydraulic modelling report – River Mersey.

4.1.8 The Palatine Road vent shaft and its associated raised compound are located within Didsbury flood storage basin. The flood storage basin is a statutory reservoir and therefore volume for volume replacement for any loss of storage volume up to the maximum operating level is required in order to maintain the operational standard of flood protection. The estimated volume of storage lost due to the Proposed Scheme, up to the maximum operating level of the basin (28.65mAOD), is 11,917m^3. Full replacement of this volume within Withington golf course is embedded in the design. The baseline River Mersey hydraulic model was therefore edited to include the Palatine Road vent shaft, its associated compound, and the volume for volume compensation. This allows an assessment of impacts of the Proposed Scheme on the mechanism of flooding to be undertaken. The volume for volume compensation storage is shown in Figure 8.

4.1.9 The impact of the Proposed Scheme on peak flood levels within the modelled area, taking into account the volume for volume compensation embedded in the design, is shown in Figure 9. The detailed modelling shows that the presence of the Proposed Scheme will result in localised changes to the conveyance of water during peak flood events. The River Mersey Hydraulic modelling report provides further information and detailed flood mapping that identifies each receptor potentially impacted by these changes in conveyance.

4.1.10 The presence of the Proposed Scheme leads to new flooding at a range of local receptors in the Northenden area around Ford Lane and Mill Lane including:

- a major impact on peak flood levels on a very high value secondary electricity substation. This results in a major adverse effect, which is significant;
- major impacts on peak flood levels on 22 high value residential properties. These result in major adverse effects, which are significant;

- a major impact on peak flood levels on a moderate value commercial property. This results in a moderate adverse effect, which is significant;
- major impacts on peak flood levels along Mill Lane and Allanson Road (moderate value receptors). These result in moderate adverse effects on these roads, which are significant; and
- a major impact on peak flood levels on a low value car park. This results in a minor adverse effect, which is not significant.

4.1.11 The presence of the Proposed Scheme will also lead to increases in peak flood levels to the following local receptors which are already at risk of flooding:

- Ford Lane Northenden:
  - moderate impacts on peak flood levels at four high value residential receptors. These result in moderate adverse effects, which are significant.
- Palatine Road area:
  - a moderate increase in peak flood levels at one secondary electricity substation adjacent to Brookside, Palatine Road (very high value). This results in a major adverse effect, which is significant;
  - a minor increase in peak flood levels at another secondary electricity substation adjacent to 208 Palatine Road (very high value). This results in a moderate adverse effect, which is significant;
  - a major increase in peak flood levels at four high value residential properties. This results in major adverse effects to these properties, which are significant;
  - a moderate increase in peak flood level at two high value residential properties near Palatine Road. This results in moderate adverse effects, which are significant;
  - a major increase in peak flood level at one commercial property. This major impact on a moderate value receptor results in a moderate adverse effect, which is significant;
  - a minor increase in peak flood level at three high value residential properties. These minor impacts result in moderate adverse effects, which are significant;
  - a major increase in peak flood level along part of Palatine Road (to the northeast of the proposed vent shaft site). This major impact results in a moderate adverse effect, which is significant;
  - a moderate increase in peak flood level along Palatine Road (further to the north-east in the vicinity of the hotel). This moderate impact results in a moderate adverse effect which is significant;
  - a minor increase in peak flood level at a moderate value commercial property. This minor impact results in a minor adverse effect which is not significant;
  - a minor decrease in peak flood level to two car parks, low value receptors. These are assessed as minor impacts resulting in negligible effects, which are not significant;

  - a moderate decrease in peak flood level to one residential property near Palatine Road. This moderate impact on a high value receptor results in a moderate beneficial effect, which is significant;
  - a major decrease in peak flood level along Palatine Road (directly adjacent to the Proposed shaft site) This moderate impact on a moderate value receptor results in a moderate beneficial effect, which is significant; and
  - a minor increase in peak flood level along Palatine Road (to the southwest of the Proposed shaft site). This minor impact is assessed to result in a minor adverse effect, which is not significant.
- area south of Junction 5 of the M60 (Northenden):
  - a minor increase in peak flood level at one high value residential property. This minor impact results in a moderate effect, which is significant; and
  - a minor increase in flood risk along a cycle path which passes beneath Junction 5 of the M60 (low value receptor). This minor impact on a low value receptor results in a minor adverse effect, which is not significant.
- east of Didsbury flood storage basin (Stenner Lane):
  - a moderate increase in peak flood level to four residential receptors (high value). These moderate impacts result in moderate adverse effects, which are significant;
  - a moderate increase in peak flood level to one commercial receptor (moderate value). This moderate impact results in a moderate adverse effect, which is significant;
  - a moderate increase in peak flood level along part of Stenner Lane. This is assessed to result in a moderate adverse effect on this road, which is significant;
  - a major increase in peak flood level to the allotments (low value). This results in a minor adverse effect, which is not significant; and
  - a moderate increase in peak flood level to Didsbury Sports Ground (low value). This results in a minor adverse effect, which is not significant.

4.1.12 The provision of volume for volume compensation storage in the reservoir has been embedded into the design and is therefore included in all options as part of the Proposed Scheme. Mitigation measures will be required to reduce the impact of the Proposed Scheme on peak flood levels at the receptors in Northenden, Stenner Lane and along Palatine Road. Additional modelling is underway and will continue during the passage of the hybrid Bill, to identify avoidance and mitigation measures to reduce the impact of the Proposed Scheme on peak flood levels in Northenden, Stenner Lane and along Palatine Road as far as reasonably practicable. The options under investigation are discussed further in Section 5.

4.1.13 Providing additional level for level compensation in Didsbury golf course for loss of flood storage up to the 1.0% AEP + CC peak flood level has also been tested using the model. However, this only provided 1mm of betterment at one receptor confirming that the simulated changes in flood level are predominantly driven by changes to the pattern of flood

conveyance caused by the Palatine Road vent shaft and not loss of floodplain storage volume.

4.1.14 Further topographical survey, other surveys as required, hydraulic modelling, design and mitigation measures refinement will be undertaken during design development and will, as far as reasonably practical, ensure no impacts on peak flood levels. The preferred mitigation measures will be selected in consultation with the other design disciplines, the Environment Agency, and other stakeholders to ensure all constraints and opportunities are considered.

Figure 8: Reservoir volume compensation storage

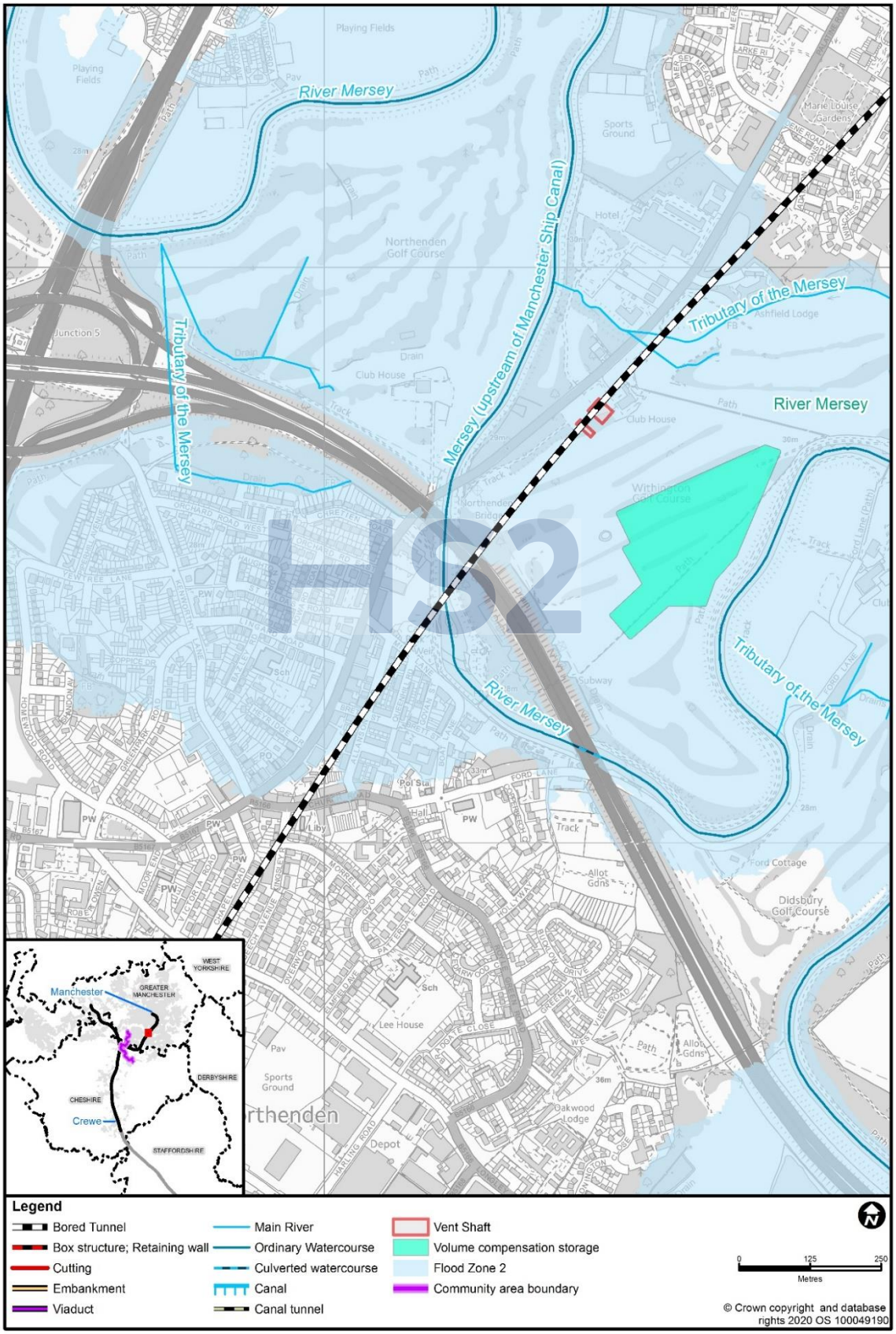
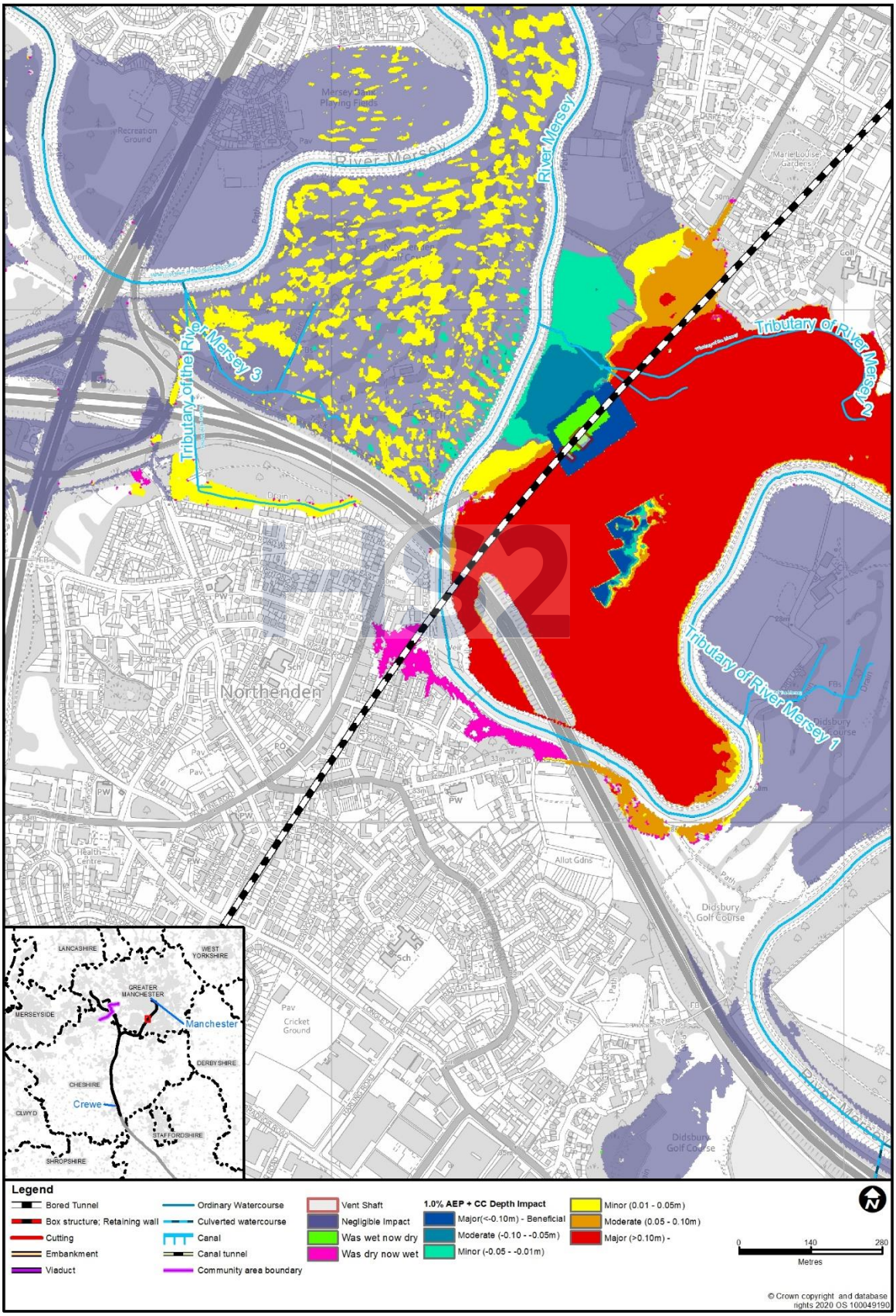


Figure 9: Palatine Road impact map for the 1.0% AEP + CC flood event



Construction compounds

4.1.15 The Palatine Road vent shaft satellite compound will occupy land required for the construction of the Proposed Scheme. The satellite compound is located in Flood Zone 3 and is partially within the Didsbury flood storage basin and at risk of flooding from the River Mersey. The risk of flooding to the compound will be managed by elevating it above the baseline 1 in 100 year peak flood level, the impact of this land raising has been included in the impact assessment discussed in Section 4.1.

4.1.16 There is a main construction compound between Chancellor Lane and Ashton Old Road in Ardwick that is at risk of flooding from a surface water flow path across the eastern part of the site. The risk of flooding to this compound 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 site will be registered with the Environment Agency Flood Warning and Flood Alert service, if applicable.

4.2 Surface water

4.2.1 As outlined previously the RoFSW 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 The surface water flow regime in the Manchester tunnel north portal area, around the Rondin Road flow path, will be altered from the baseline due to the demolition of buildings and construction of the portal and Ardwick South cutting retaining walls. To convey this surface water flow path, a local drainage solution is proposed. A land drainage ditch will convey flows from the north side of the Proposed Scheme, around the tunnel headhouse, and will connect to the existing flow route on the south side of the Proposed Scheme. The surface water flow path will be maintained, and therefore, the risk from surface water arising from the Proposed Scheme is considered negligible and not significant. The land drainage ditch will provide additional storage up to the 1 in 100 year plus climate change peak design flow and therefore the risk from surface water flooding to the Proposed Scheme is considered negligible and not significant.

4.2.3 There are possible interactions between the above ground vent shafts as part of the Proposed Scheme and the Environment Agency's RoFSW surface water flow paths. Any impacts to surface water flood levels due to the Proposed Scheme are considered to be negligible and not significant.

4.2.4 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 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. Other below ground features that could cause changes to the local groundwater levels, such as drained cuttings, are not assumed to increase groundwater flood risk as the drainage design will take account of groundwater flows entering the cutting.

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 of the Proposed Scheme has been undertaken to understand where it is likely to interact with groundwater. The high-level assessment identified where elements of the Proposed Scheme 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. Further details of this assessment are set out in the Water resources assessment (Volume 5: Appendix WR-003-0MA07).

4.3.3 In the vicinity of the Proposed Scheme, the BGS susceptibility to groundwater flooding data set shows potential for groundwater flooding at surface and in basements, particularly in the Ardwick area. There is the potential for the groundwater level to rise north of the Proposed Scheme. The Ardwick South cutting retaining walls, Ardwick box structure and Ardwick North cutting retaining walls could result in an increased risk of groundwater flooding in this area. It is likely that the industrial properties (moderate value receptors) located in these areas will be demolished as part of the Proposed Scheme. There are planning allocations for future development of this land (MA07/111, MA07/110, MA07/299, MA08/038, MA08/129)[19] for residential, commercial and industrial property (high to moderate value receptors). On a precautionary basis, pending further investigation, the potential impact is considered moderate affecting these moderate value future receptors, resulting in moderate adverse effects, which are significant.

4.3.4 Mitigation measures to address groundwater flood risk may therefore be required, associated with Ardwick South cutting, Ardwick box structure and Ardwick North cutting. Further site and ground investigations are required to assess the groundwater flood risk. If required, mitigation measures may include the requirement for land drainage around retaining wall structures and will be designed during design development in consultation with the Environment Agency and the LLFA.

4.3.5 The Manchester tunnel will be partially constructed through the Appleby Group Principal Aquifer, the Warwickshire Group Secondary A Aquifer and the Cumbrian Coast Group Secondary B Aquifer. The construction of the tunnel will create an extended cylinder of no flow in these aquifers and may have minor localised impacts on groundwater flow. This leads to a permanent moderate effect which is significant for the Appleby Group, and a permanent minor effect which is not significant for the Warwickshire Group and the Cumbrian Coast Group. Further details of groundwater level changes are set out in the Water resources assessment (Volume 5: Appendix WR-002-0MA07).

4.4 Artificial sources

4.4.1 The Palatine Road vent shaft is located partially within the Environment Agency Didsbury flood storage basin. The impact on the Didsbury flood storage basin and receptors along Palatine Road is discussed in Section 4.1.

4.4.2 Woodhead, Dovestone, Greenfield, Rhodeswood, Yeoman Hey, Fernilee, Errwood, Chew and Torside reservoirs are shown on the Environment Agency's flood risk from reservoirs mapping dataset[21]. This dataset indicates that, in the event of a failure of these reservoirs, the River Mersey floodplain area would be affected by the resulting flood. These large reservoirs are subject to the requirements of the Reservoirs Act 1975[21], 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. The Proposed Scheme does not encroach into any of the reservoir locations and therefore does not affect the structure or operation of the reservoirs.

4.4.3 Major water supply pipelines and sewerage (foul and surface water) infrastructure has been identified and is accounted for on the Volume 2, MA07 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.

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

[21] 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.

4.5 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 lower 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[22].

[22] 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 Detailed modelling, including the volume for volume compensation, has shown that during an extreme flood event when the capacity of the flood storage basin is exceeded and water begins to overtop Palatine Road, the raised ground surrounding the Palatine Road vent shaft changes the pattern of flood conveyance in the local area. This leads to increases in peak flood level to several high value receptors. Mitigation is therefore required.

5.1.2 The next stage of the design development process will involve incorporation of topographical survey information into the existing hydraulic models to improve how they represent the existing watercourses. The design of the vent shaft and raised compound will be refined during the passage of the hybrid Bill to avoid adverse impacts on peak water levels during a 1% AEP + CC flood event as far as reasonably practicable.

5.1.3 Additional flood risk management measures will be developed during the passage of the hybrid Bill to reduce any residual impacts on peak flood levels as far as reasonably practicable.

5.1.4 The avoidance and mitigation options that could reduce flood impacts include:

- refinement of the design to reduce the flood risk effects, including review of the vent shaft compound size and elevation;
- measures to control conveyances of flood flows, such as the provision of flood walls or bunds, along:
  - the boundary of Withington golf course to the north of the Palatine Road vent shaft;
  - the Fielden Park Brook;
  - around essential infrastructure;
  - around Junction 5 of the M60 motorway; and
  - changes to flood defences along the western bank of the River Mersey at Northenden.
- additional capacity in the bottom outlet structures from the Didsbury flood storage basin into the River Mersey;
- an increased conveyance of Fielden Park Brook (Tributary of River Mersey 2) beneath Palatine Road; and
- increasing the level of flood protection in the Northenden area, around Ford Lane.

5.1.5 The potential for groundwater level rise north of the Ardwick South cutting, Ardwick box structure and Ardwick North cutting could result in moderate impacts on groundwater flood risk. Additional mitigation measures for the management of groundwater flood risk will be required. Further site and ground investigations are required to assess the groundwater flood risk. If required, mitigation measures may include the requirement for land drainage around retaining wall structures and will be designed during design development in consultation with the Environment Agency and the LLFA.

6 Summary of significant flood risk effects

6.1.1 The Proposed Scheme will potentially result in significant effects on flood risk from groundwater due to the Manchester tunnel creating an extended cylinder of no flow within the Appleby Group Principal Aquifer. Further assessment is required to finalise the mitigation measures required to remove the significant effects on flood risk.

6.1.2 The preliminary assessment work carried out to date, has identified mitigation measures to ensure no significant effects on receptors around Ford Lane and Mill Lane area (Northenden) and at the secondary electricity substations near Palatine Road (Didsbury).

6.1.3 However, until such time as other avoidance and mitigation measures have been identified, residual significant effects will remain on some of the receptors in the area near Palatine Road (Didsbury) and all of the receptors in the areas south of Junction 5 of the M60 (Northenden) and east of Didsbury flood storage basin (Stenner Lane).

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: Davenport Green to Ardwick. 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 The Palatine Road vent shaft and associated raised satellite construction compound will occupy land within the Didsbury flood storage basin. The flood storage basin is a statutory reservoir and therefore volume for volume replacement for any loss of storage volume up to the maximum operating level is required in order to maintain the operational standard of flood protection. Full replacement of this volume within Withington golf course is embedded in the design. Detailed modelling shows that the presence of the Proposed Scheme will result in localised changes to the conveyance of water during peak flood events and lead to new flooding to receptors in the Northenden area, and increased peak flood levels to receptors in Northenden, around Palatine Road and Stenner Lane. Additional modelling is underway to identify avoidance and mitigation measures to reduce the impact of the Proposed Scheme on peak flood levels as far as reasonably practicable.

6.2.3 There is the potential for increased groundwater levels north of the Ardwick South cutting, Ardwick box structure and Ardwick North cutting area. Further site and ground investigations are required to assess the risk of groundwater flooding in this area. If required, mitigation measures may include the requirement for land drainage around retaining wall structures and will be designed during design development in consultation with the Environment Agency and the LLFA.

6.2.4 The assessment indicates that the Proposed Scheme currently results in significant adverse effects on flood risk in the Davenport Green to Ardwick area. Further refinement of the mitigation measures is required to remove these significant effects.

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