In Parliament – Session 2022 - 2023

HS2

High Speed Rail (Crewe – Manchester)

Supplementary Environmental Statement 2 and Additional Provision 2 Environmental Statement

Volume 5: Appendix WR-006-00009

Water resources and flood risk

Hydraulic modelling report - River Mersey

MA07: Davenport Green to Ardwick

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1 Introduction

1.1 Background

1.1.1 This report is an appendix to the water resources and flood risk assessment which forms part of Volume 5 of the Supplementary Environmental Statement 2 (SES2) and Additional Provision 2 Environmental Statement (AP2 ES).

1.1.2 This appendix provides details of changes to the water resources and flood risk assessment since the production of the High Speed Two (HS2) High Speed Rail (Crewe – Manchester) Environmental Statement (ES) published in 2022[1] (the main ES), and the Supplementary Environmental Statement 1 (SES1) and Additional Provision 1 Environmental Statement (AP1 ES) also published in 2022[2].

1.1.3 This appendix presents the results of the hydraulic modelling carried out for the River Mersey. The River Mersey runs through the Davenport Green to Ardwick (MA07) community area.

1.1.4 This appendix should be read in conjunction with the SES2 and AP2 ES:

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

1.1.5 The hydraulic modelling has been used to inform the flood risk assessment for the Davenport Green to Ardwick (MA07) area, see SES2 and AP2 ES Volume 5, Appendix: WR-005-0MA07. The Water resources assessment should also be referred to (see SES2 and AP2 ES Volume 5, Appendix: WR-003-0MA07).

1.1.6 The route of the AP2 revised scheme runs in tunnel beneath the floodplain of the River Mersey at Northenden and Didsbury. The only elements of the AP2 revised scheme that encroach into the floodplain are The Hollies vent shaft, its associated raised compound and access road, which are required to provide a working platform during construction and ventilation and access for emergency services during operation. The AP2 amendment relevant to this report is the Change to Bill powers required for relocation of vent shaft and headhouse from Palatine Road to the Hollies (AP2-007-003).

1.1.7 In order to differentiate between the original scheme and the subsequent changes, the following terms are used:

- 'the original scheme' – the Bill scheme submitted to Parliament in 2022, which was assessed in the main ES;
- 'the SES1 scheme' – the original scheme with any changes described in SES1 that are within the existing powers of the Bill;
- 'the AP1 revised scheme' – the original scheme as amended by SES1 changes and AP1 amendments;
- 'the SES2 scheme' – the original scheme with any changes described in SES1 (submitted in July 2022) and the SES2; and
- 'the AP2 revised scheme' – the original scheme as amended by SES1 and SES2 changes (as relevant) and AP2 amendments.

1.2 Aims

1.2.1 The aims of this study are to:

- update the hydraulic model for the River Mersey in the vicinity of the AP2 revised scheme The Hollies vent shaft (AP2-007-003) and associated compound to simulate peak flood levels, with and without the AP2 revised scheme;
- test options to remove significant effects if any; and
- document the methods used, the results, assumptions and limitations.

[1] High Speed Two Ltd (2022), High Speed Rail (Crewe – Manchester), *Environmental Statement*. Available online at: https://www.gov.uk/government/collections/hs2-phase2b-crewe-manchester-environmental-statement.

[2] High Speed Two Ltd (2022), High Speed Rail (Crewe – Manchester), *Supplementary Environmental Statement 1 and Additional Provision 1 Environmental Statement*. Available online at: https://www.gov.uk/government/collections/hs2-phase-2b-crewe-manchester-supplementary-environmental-statement-1-and-additional-provision-1-environmental-statement.

1.2.2 The hydraulic model has been used to inform the flood protection level required for the vent shaft compound and to calculate the volume of floodplain storage lost as a result of the AP2 revised scheme. The methodology is as detailed in the Water resources and flood risk technical note, Updated guidance on flood risk assessment (see SES2 and AP2 ES Volume 5, Appendix: CT-001-00005).

1.3 Objectives

1.3.1 The objectives of this study were to:

- develop an understanding of existing hydraulic conditions at the AP2 revised scheme vent shaft (AP2-007-003) and associated compound near Palatine Road, including channel and floodplain interaction, hydraulic structures and flow paths, including the operation of inlet and main outlet gates that control water levels within Didsbury flood storage basin, through desk-based study, engagement with the Environment Agency local area team and by conducting a site visit;
- estimate catchment peak flows and hydrographs associated with the following Annual Exceedance Probabilities (AEP): 5.0% AEP, 1.0% AEP, 1.0% AEP + climate change (CC), and 0.1% AEP; and
- using the catchment hydrographs as inflow boundaries and other information available at this stage, develop a hydraulic model to estimate flood levels along the study reach both before and after construction of the AP2 revised scheme.

1.4 Justification of approach

1.4.1 In the main ES, the original scheme model, was based on 2018 Environment Agency model[3] and covered an 8.4km^2 two dimensional (2D) extent. This area extended from the upstream Brinksway gauging station (GS) (located approximately 5km east of the original scheme) to the Riverside Avenue recreation ground (located approximately 1.2km west of the original scheme). This model was calibrated against observed water levels at the Northenden weir, Stenner Lane and Withington Golf Course gauges for the Storm Christoph storm event which occurred in January 2021. Full details on this model and its calibration can be found in the main ES, Volume 5, Appendix: WR-006-00009, Hydraulic modelling report – River Mersey[4].

1.4.2 The original scheme model used the best available data and was improved as a result of internal and external reviews. It incorporated:

- the 1D in-bank cross sections and 1D hydraulic structures from the 2012 Environment Agency 1D Flood Modeller Pro model[5], however with improved structure parameters and a better representation of bank levels (based on the defence data from the 2018 Environment Agency model);
- a 2020 LiDAR data survey for the representation of the 2D extents;
- the catchment flow hydrographs from the Environment Agency 2018 model which have been verified by the Environment Agency; and
- calibrated model parameters based on the January 2021 Storm Christoph event.

1.4.3 A risk-based approach has been adopted, whereby the level of modelling detail supporting the flood risk assessment at a specific site reflects the magnitude of the likely impacts of the AP2 revised scheme on peak flood levels and flood risk management infrastructure, and the sensitivity of nearby receptors to flooding. Since the main ES, the AP2 amendment Vent shaft relocation (AP2-007-003) and its associated compound (which will be raised above flood levels) are proposed to be located within the floodplain to the rear of Britannia Country House Hotel and in the vicinity of Palatine Road. An AP2 revised scheme model has therefore been developed based on the original scheme model summarised above and detailed in Section 4.

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

[4] High Speed Two Ltd (2022), High Speed Rail (Crewe – Manchester), *Environmental Statement, Hydraulic modelling report – River Mersey,* Volume 5, Appendix: WR-006-00009. Available online at: https://www.gov.uk/government/collections/hs2-phase2b-crewe-manchester-environmental-statement.

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

1.5 Scope

1.5.1 The scope of this study was to undertake detailed hydraulic modelling to enable assessment of the impact of the AP2 revised scheme on the local environment. The AP2 revised scheme model aimed to be detailed enough to allow a robust assessment of impacts that have the potential to lead to significant adverse effects on peak flood levels. The AP2 revised scheme model also allowed the identification and preliminary testing of appropriate mitigation measures.

1.5.2 This report focuses on an 8.4km^2 floodplain area which is covered by a 11.5km reach of the River Mersey, extending upstream and downstream of the crossing of the AP2 revised scheme. The AP2 revised scheme crossing comprises of a vent shaft (AP2-007-003) and associated compound which encroach on the floodplain of the River Mersey. A description of the location and type of AP2 revised scheme is provided in Section 2.

1.5.3 The scope of the report includes:

- discussion of all relevant datasets, in terms of their quality and gaps;
- details of the hydrological analysis undertaken, the approach used and the calculation steps;
- details of how the hydrological analysis has been integrated with the hydraulic modelling;
- identification and justification of the hydraulic modelling methodology selected; and
- a description of the hydraulic modelling parameters, assumptions, limitations and uncertainty.

2 Qualitative description of flood response

2.1 Sources of information

2.1.1 The following sources of information were obtained from the Environment Agency:

- flood map for planning (rivers and sea)[6];
- risk of flooding from surface water (RoFSW)[7] map;
- flood defence asset information;
- operational data for the Didsbury flood storage basin and Sale Ees flood storage basin;
- Environment Agency Operational Action Plans for Phase 1 (OAP1), Phase 2 (OAP2) and Phase 3 (OAP3) of the Sales Ees and Didsbury flood storage basins;
- a site location plan for the Didsbury flood storage basin;
- river gauge data for the River Mersey at Brinksway, Northenden Weir, and within the Didsbury flood storage basin for the January 2021 Storm Christoph event;
- gate operation at the inlet to the Didsbury flood storage basin during the Storm Christoph event;
- 2012 Environment Agency 1D model[5]; and
- 2018 Environment Agency 1D-2D model[3].

2.1.2 Additional information from the lead local flood authority (LLFA) and publicly available sources included:

- Manchester City, Salford City and Trafford Councils Level 2 Hybrid Strategic Flood Risk Assessment (SFRA), Final March 2011[8];
- Manchester City Council Preliminary Flood Risk Assessment (2011)[9]; and
- Manchester City Council Local Flood Risk Management Strategy (2014)[10].

2.2 Description of the study area

Study area

2.2.1 Figure 1 shows the River Mersey within the study area and the Environment Agency flood maps, with the wider floodplain shown in Figure 2. The upstream extent of the 1D modelled River Mersey is located at Brinksway GS which is situated approximately 8.5km upstream from the AP2 revised scheme vent shaft relocation (AP2-007-003) and associated compound. The downstream extent of the 1D modelled River Mersey is located 19.1km further downstream from the vent shaft relocation, at the confluence with the Manchester Ship Canal. The upstream and downstream 2D boundaries are sufficiently far upstream and downstream, in order not to impact on peak water levels at the location of the AP2 revised scheme vent shaft relocation.

2.2.2 The AP2 revised scheme model also includes a 2.8km reach of the Fielden Park Brook, a 1.2km reach of the Chorlton Brook, a 1.3km reach of the Old Eea Brook and 2.2km of an overflow channel from the River Mersey just off Stretford Ees.

[6] Environment Agency (2021), *Flood map for planning*. Available online at: https://flood-map-for-planning.service.gov.uk.
[7] Environment Agency (2021), *Long term flood risk information*. Available online at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map.
[8] JBA Consulting (2011), *Manchester City, Salford City and Trafford Councils Level 2 Hybrid SFRA*. Available online at: https://secure.manchester.gov.uk/download/downloads/id/26463/final_mst_level_2_sfra_mar_2011.pdf/.
[9] JBA Consulting (2011), *Manchester City Council Preliminary Flood Risk Assessment*. Available online at: http://webarchive.nationalarchives.gov.uk/20140328165058/http:/cdn.environment-agency.gov.uk/flho1211bvmm-e-e.pdf/.
[10] Manchester City Council (2014), *Local Flood Risk Management Strategy*. Available online at: https://secure.manchester.gov.uk/download/downloads/id/21915/1_local_flood_risk_management_strategy_nt.pdf/.

2.2.3 The vent shaft relocation (AP2-007-003) and associated compound are located at the rear of Britannia Country House Hotel, in the vicinity of Palatine Road, downstream from the Didsbury flood storage basin (see Figure 3). The primary hydraulic mechanisms that can affect the peak water levels at receptors in the vicinity of the AP2 revised scheme vent shaft relocation and associated compound are:

- the release of water from the River Mersey into the Didsbury flood storage basin through the inlet control gates at Milgate Lane;
- the twin flap valves at the outlet of the Fielden Park Brook into the River Mersey;
- the release of water from the Didsbury flood storage basin back into the River Mersey through the outlet control gates beneath the M60 viaduct downstream of Northenden Weir;
- overtopping of the River Mersey flood defences at various locations including Didsbury Golf Club, Withington Golf Course, Northenden, West Didsbury and Northenden Golf Club; and
- spilling of floodwater from Didsbury flood storage basin across Palatine Road in an extreme event, when the basin reaches maximum storage capacity.

Hydrological description

2.2.4 The River Mersey at Didsbury receives runoff from an approximately 600km^2 catchment. The river generates flows from east to west and drops from a bed level of around 34.5m above ordnance datum (AOD) at its source at the confluence of the Rivers Tame and Goyt, to around 6.3m AOD at its confluence with the Manchester Ship Canal (see Figure 3).

2.2.5 Upstream of Didsbury, the Upper Mersey floodplain at Stockport is narrow. However, for much of its length at and downstream of Didsbury the river is accompanied by a wide floodplain, as shown in Figure 2. Much of this floodplain is rural (either undeveloped, agricultural or recreational) but, due to the large size of the catchment and proximity to the large urban hub of Manchester, there are a significant number of properties potentially at flood risk from the River Mersey. The main at-risk communities being Stockport, Didsbury, Northenden, Stretford, Ashton and Flixton.

2.2.6 The catchment geology comprises mostly peat-covered Millstone Grit in the headwaters; Coal Measures, Sherwood Sandstone (around Didsbury) and Boulder Clay in the lower catchment. The catchment is therefore considered to be relatively impermeable (the Flood Estimation Handbook (FEH) SPRHOST[11] value is 40%) and the groundwater contribution to streamflow is modest.

2.2.7 An extensive system of raised flood defences (primarily earth embankments but also some walls), have been built alongside the Upper Mersey and some of its tributaries. In addition, there are flood storage basins at Didsbury and Sale Ees, where sluices allow floodwater to be stored more efficiently than under natural conditions.

2.2.8 The FEH standard annual average rainfall for the catchment is 1,152mm[12].

[11] Standard percentage runoff (%) associated with each HOST soil class (SPRHOST).

[12] Centre for Ecology and Hydrology (2021), *Flood estimation handbook web service*. Available online at: http://fehweb.ceh.ac.uk.

Figure 1: Environment Agency flood zones of the River Mersey around The Hollies vent shaft

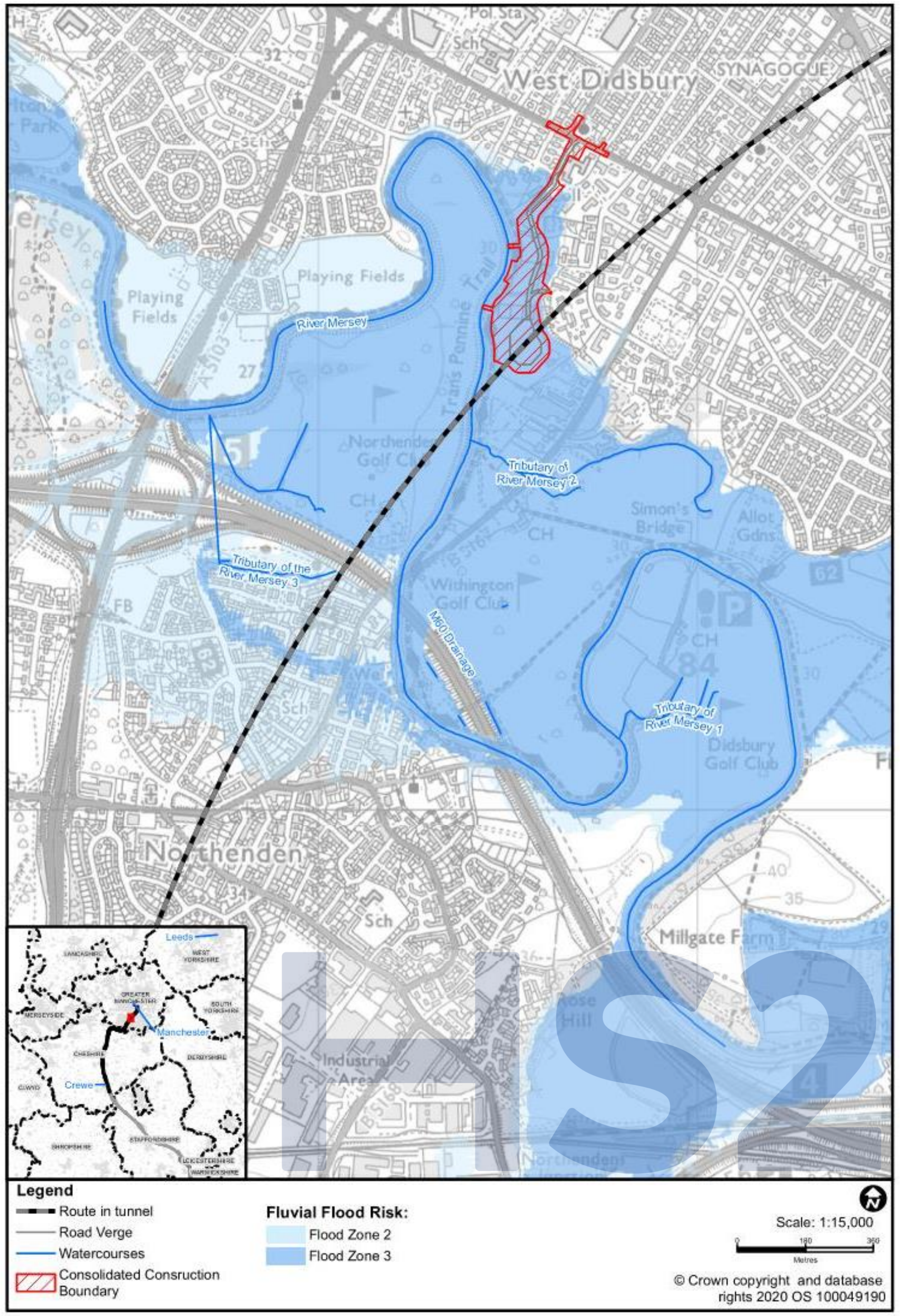


Figure 2: Environment Agency flood zones of the River Mersey

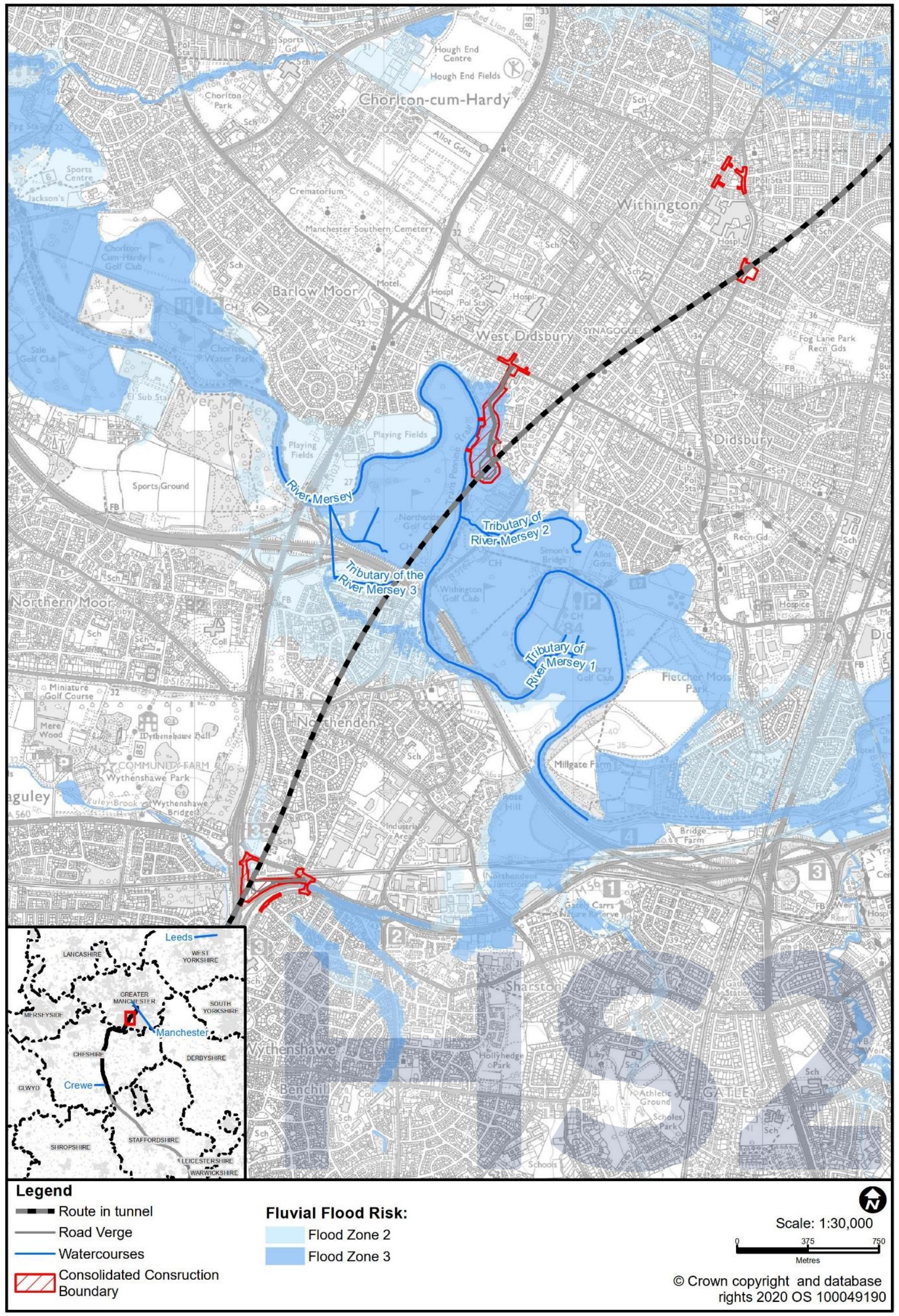
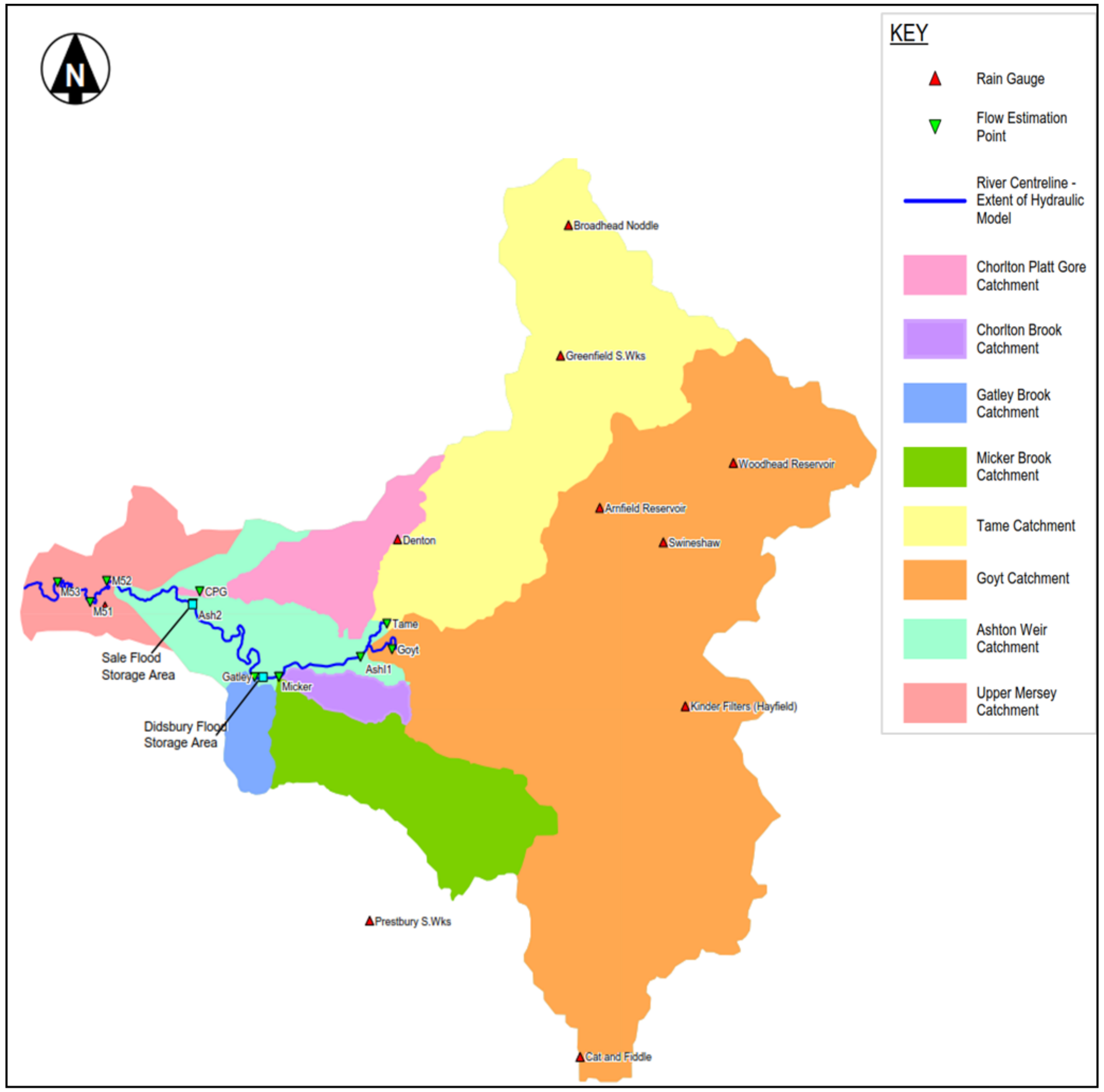


Figure 3: River Mersey catchment areas



Source: Environment Agency (March 2012), Upper Mersey Model update 2011/12

AP2 revised scheme

2.2.9 In the original scheme the vent shaft encroached into the Didsbury flood storage basin, a statutory flood storage reservoir operated by the Environment Agency, requiring a replacement floodplain storage area within Withington Golf Course to mitigate the loss of flood storage. The AP2 revised scheme has relocated the vent shaft (AP2-007-003) to derelict land to the rear of Britannia Country House Hotel which avoids the golf course and the flood storage basin. The AP2 revised scheme relocated vent shaft and its associated raised compound cover an area of approximately 14,000m^2.

2.2.10 Further details on the AP2 revised scheme can be found in SES2 and AP2 ES Volume 2, MA07 Map Book: Map Series CT-06 – Proposed Scheme, map CT-06-360.

Features of note

2.2.11 The Didsbury and Sale Ees flood storage basins protect floodplain communities along the River Mersey and are operated with a set of detailed control rules (as set out in the Environment Agency 2018 model[3]). These two flood storage basins have statutory designations under the 1975 Reservoirs Act, and as such have detailed operational and maintenance requirements. The manual opening and closing of the inlet and outlet control structures are based on a set of river and floodplain water levels, which are monitored by sensors located both inside and outside the storage basins.

2.2.12 The Didsbury flood storage basin inlet gates (at Milgate Lane) only come into operation when the downstream Sale Ees flood storage basin is in operation (i.e. its inlet gate is open) and the water level in the River Mersey at Milgate Lane has exceeded a pre-determined threshold level. The outlet of the Didsbury flood storage basin is operated in accordance with a set of rules designed to keep water levels within the Withington Golf Course below the predetermined water level of 28.65m AOD. This allows for a sufficient freeboard prior to spilling of the Didsbury flood storage basin over Palatine Road at approximately 29.3m AOD, at which point properties along Palatine Road are potentially at risk of flooding. If water levels continue to rise in the River Mersey, then the river defences will overtop into the Didsbury flood storage basin.

2.2.13 During flood events, gates are manually operated at Stenner Lane to protect isolated properties within the Didsbury flood storage basin (Environment Agency, OAP1, OAP2 and OAP3). The Fielden Park Brook rises within the Didsbury flood storage basin. It crosses under Palatine Road and 120m downstream, it discharges into the River Mersey. Fielden Park Brook, therefore, operates as a small secondary high-level outlet from the Didsbury flood storage basin, into the River Mersey. This discharge is not controlled by any rules or remote sensors, but flap valves are in place to prevent backflow from the River Mersey.

2.2.14 Northenden weir on the River Mersey is located between the main inlet and outlet structures of the Didsbury flood storage basin. Water levels are recorded just upstream of the weir as well as at the inlet into the Didsbury flood storage basin, at Stenner Lane and at Withington Golf Course.

2.3 Existing understanding of flood risk

Flood mechanisms

2.3.1 The flooding of the Didsbury flood storage basin is controlled by a set of clearly defined rules at its inlet and main outlet respectively, and the details are provided in the Environment Agency model[3]. For events within its design capacity, it will store flood water in order to protect downstream properties without adversely affecting any property within the local area.

2.3.2 During operation, water levels within the Didsbury flood storage basin increase rapidly. Flooding begins within the area of the reservoir upstream of the allotments at Ford Lane/Stenner Lane and then progresses into the area of the reservoir covered by the Withington Golf Course. When water levels reach the top of the reservoir, in excess of its design standard, flood water first spills over Palatine Road and then into the floodplain area between the river defences, Palatine Road and the raised Britannia Hotel car park which acts as an informal spillway. Once the car park is overtopped then floodwater flows northwards along the long open space floodplain corridor parallel to the river defences and the surrounding development and where the AP2 revised scheme is located. It is important to note that the AP2 revised scheme allows sufficient space for floodwater to inundate the long open space floodplain corridor, to reduce impacts on nearby receptors.

2.3.3 The spilling over Palatine Road is not the only flood mechanism, for more extreme events (for example the 1 in 100 year flood event), the River Mersey overtops its defences along extensive reaches of the river. For these events, where overtopping occurs along the defences, the AP2 revised scheme model predicts that the predominant flow pathway into the Didsbury flood storage basin is the overtopping of the flood defence embankments as opposed to via the Didsbury flood storage basin inlet structure. The predominant flow pathway out of the Didsbury flood storage basin is the spilling over Palatine Road as opposed to via the main outflow structure. In these extreme events, the 430m long stretch of Palatine Road adjacent to the Withington Golf Course behaves therefore like a dam spillway.

Analysis of historical flooding

2.3.4 Prior to the construction of the present flood alleviation scheme in the 1970s, which included the construction of the Didsbury flood storage basin in 1978, there were numerous flood events associated with the River Mersey.

2.3.5 There is anecdotal evidence of flooding in the Palatine Road area, and in 1991 the Britannia Hotel car park flooded by up to 1m[13]. The Didsbury flood storage basin has been operated many times over the last 40 years and most recently in November 2019, during Storm Christoph in January 2021 and during Storm Franklin in February 2022.

[13] Photograph of flooding at the Britannia Hotel car park in December 1991. Available online at: https://www.researchgate.net/figure/Photograph-of-the-Britannia-Hotel-car-park-after-the-flood-of-27-December-1991_fig3_265224458.

Availability of existing hydraulic models

2.3.6 The Environment Agency 2012 Flood Modeller Pro (FMP)[5] and 2018 FMP-TUFLOW hydraulic models[3] were available for the River Mersey. Selected data from these two Environment Agency models were used to build the AP2 revised scheme model for this study, as reported in the main ES. In December 2021, the Environment Agency carried out a stand-alone exercise to review the 2018 model under the conditions of Storm Christoph[14]. This calibration of the model has not been used to update the Environment Agency regional model, but the calibration results of this Environment Agency exercise have been compared and verified against the calibration results of the AP2 revised scheme model (refer to Section 4.3).

2.4 Site visit

2.4.1 Site walkovers have been undertaken with Environment Agency reservoir operational staff to gain an understanding of how the Didsbury flood storage basin is operated.

2.4.2 No additional topographic survey or site visits were required to inform the hydraulic analysis as the existing data available from the Environment Agency was considered sufficient for this stage of the design process. The AP2 revised scheme hydraulic model will be updated during further design development, in accordance with the HS2 Ltd requirements, and a site visit will be undertaken by a hydraulic modeller, if required, to develop a site-specific topographic survey brief.

[14] JBA (2021), *Didsbury Flood Basin Modelling draft report V2.0.*

3 Model approach and justification

3.1 Model conceptualisation

3.1.1 The 1D-2D modelling approach was selected and reported in the main ES, to effectively model the flood mechanisms in the Didsbury area. This model was updated to include the AP2 revised vent shaft and associated compound. The 1D and 2D AP2 revised scheme model extents remain unchanged and are shown in Figure 4.

3.1.2 The 2D domain remains as per the original scheme model and comprises the area around the AP2 revised scheme relocated vent shaft, including the Didsbury flood storage basin. The upstream end of the 2D domain coincides with the 1D upstream end at the Environment Agency's Brinksway GS. Brinksway GS is located 4.4km upstream from the inlet gate into the Didsbury flood storage basin, at Milgate Lane. The downstream end of the 2D domain is located 510m downstream of the Princess Road Bridge at Chorlton Water Park, which is itself located 2.3km downstream of the AP2 revised scheme vent shaft relocation. The 2D domain includes representation of the Fielden Park Brook, via a 2D channel in the 2D domain.

3.1.3 The AP2 revised scheme model continues in 1D beyond the downstream extent of the 2D domain and down to the confluence of the River Mersey with the Manchester Ship Canal (MSC). The 1D representation includes the River Mersey channel as cross section units and also the floodplain in the form of reservoir units which are hydraulically linked to the river and each other via spill units. This 1D representation downstream of the Princess Road Bridge is taken from the Environment Agency 1D 2012 model.

3.2 Software

3.2.1 The latest Flood Modeller Pro (FMP) version 4.5 has been used for modelling the 1D domain and the latest TUFLOW-2018-03-AD-iSP-w64 has been used for the modelling of the 2D domain.

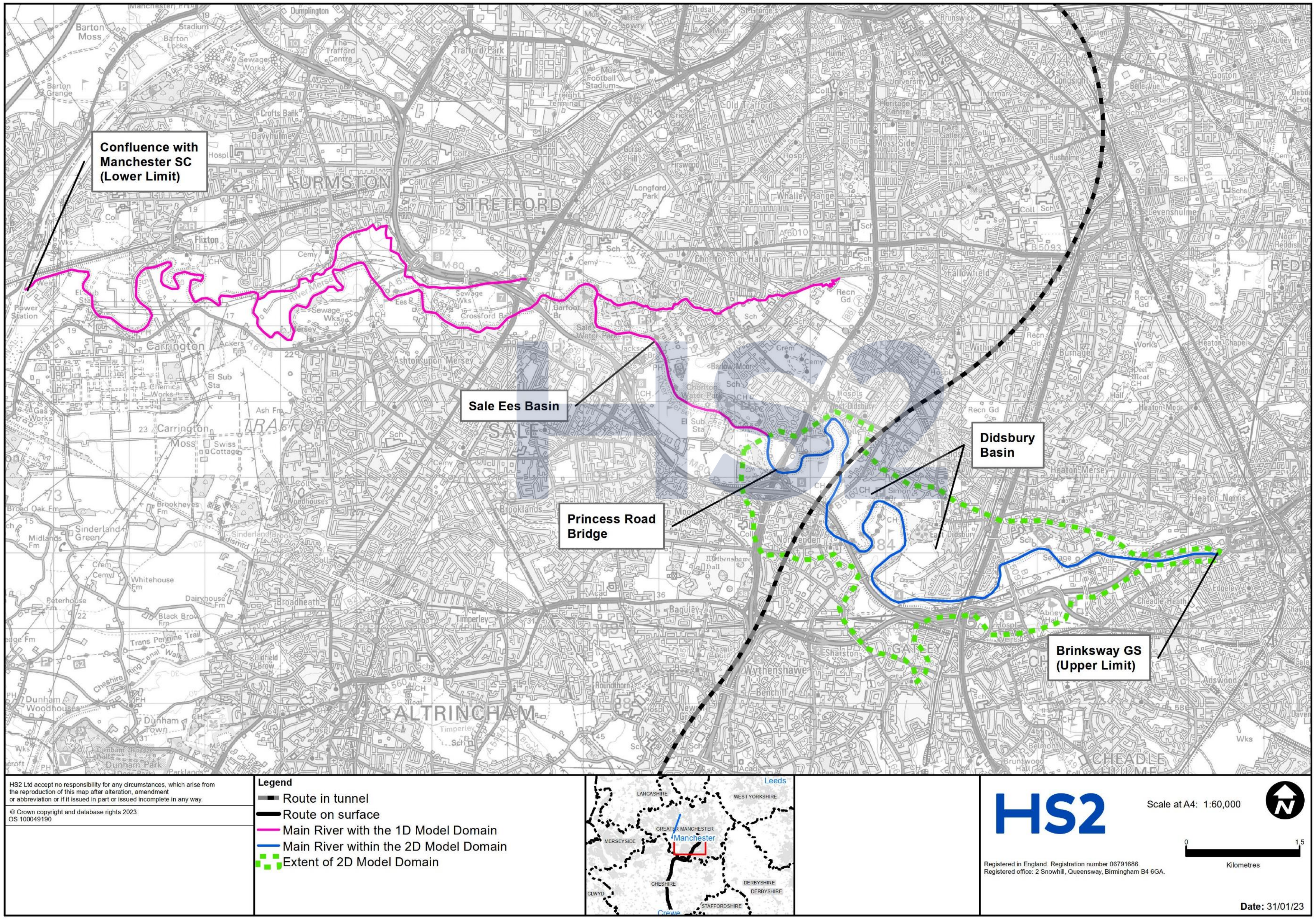
3.3 Topographic survey

3.3.1 No additional topographic survey was commissioned for this study as sufficient information has been made available from the Environment Agency for this stage in the design process.

3.4 Input data

3.4.1 As per the original scheme model, the 1D cross sections are based on the 2012 Environment Agency model however the riverbank levels have been modified based on a 2017 flood defence survey (this information was extracted directly from the 2018 Environment Agency model). The elevation data for the 2D floodplain has been obtained from 1m resolution 2020 Environment Agency LiDAR data. Inflows into the AP2 revised scheme model are based on the 2018 Environment Agency model[3].

Figure 4: Baseline AP2 revised scheme model schematic



4 Technical method and implementation

4.1 Hydrological assessment

4.1.1 As per the original scheme model, reported in the main ES, the AP2 revised scheme model uses the hydrology from 2018 Environment Agency model[3]. This data is based on the ReFH[15] method with the peak river flows adjusted using the FEH statistical method, based on gauge records for the period 1955 to 2012.

4.1.2 A verification of the hydrology was undertaken and reported in the River Mersey hydraulic model of the main ES (Volume 5, Appendix: WR-006-00009[4]). No revision to the hydrology was considered necessary for this AP2 revised scheme.

4.2 Hydraulic model build – baseline model

4.2.1 Figure 4 shows the AP2 revised scheme baseline model schematic. No changes have been made to the baseline model build from that reported in the River Mersey hydraulic model of the main ES (Volume 5, Appendix: WR-006-00009).

4.3 Hydraulic model build – AP2 revised scheme

4.3.1 Figure 5 shows the AP2 revised scheme model schematic. The AP2 revised scheme model has been edited from the original scheme model baseline to include the following design elements.

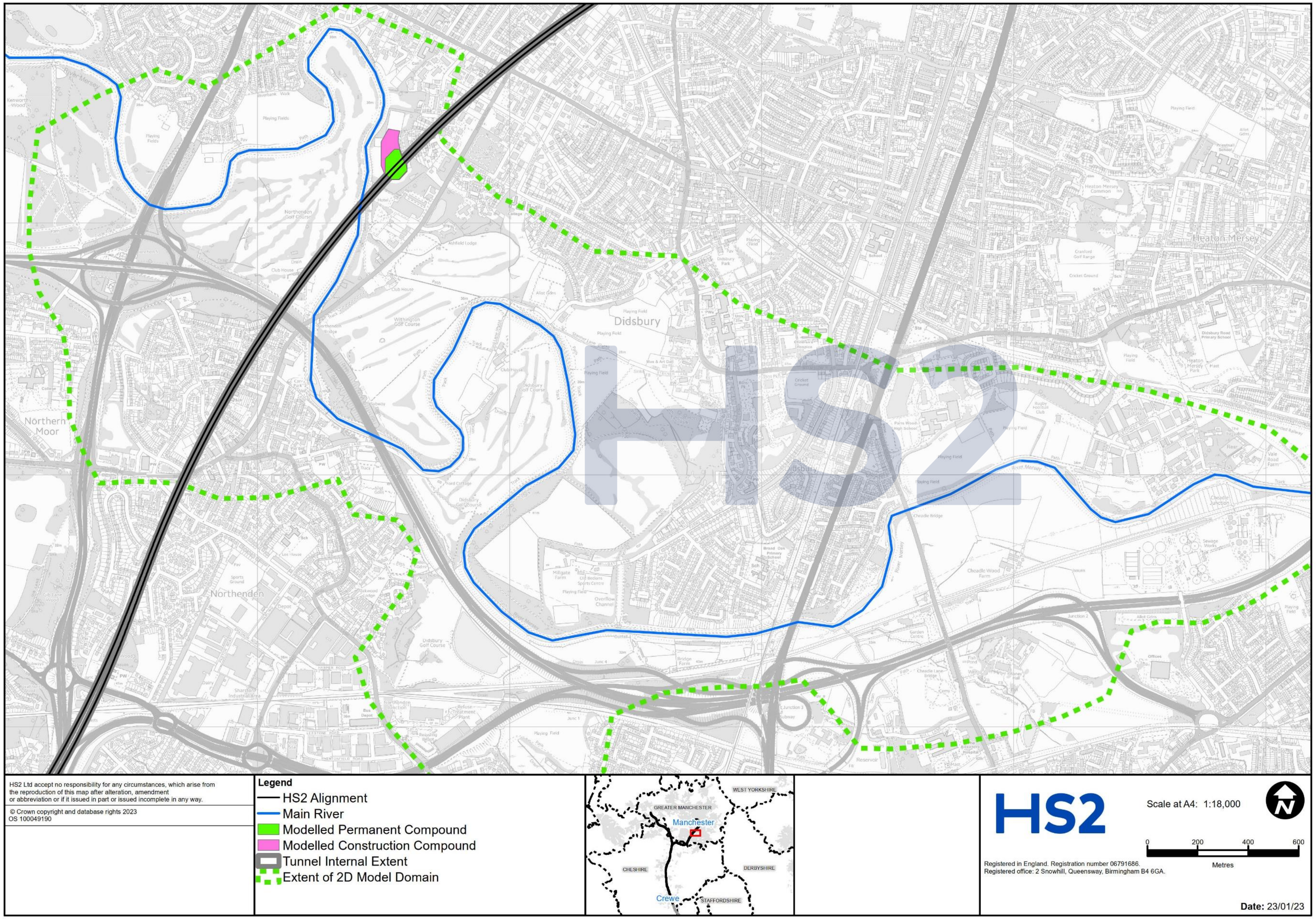
Topographic changes

4.3.2 The raised temporary construction compound, the permanent operational compound, the access roads to the compounds and the shaft have been modelled as raised ground levels using 3D polygons.

4.3.3 Within the land required for the AP2 revised scheme, ground levels around the relocated vent shaft (AP2-007-003) have been raised to a design level of 30.15m AOD which is equal to the 1 in 1,000 year peak water level (29.841m AOD) plus freeboard of approximately 0.3m at this location. Outside the land required for the AP2 revised scheme, within the land required for the construction of the AP2 revised scheme, ground levels have been raised to 29.24m AOD consistent with the 1 in 100 year peak water level of 29.24m AOD at this location.

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

Figure 5: AP2 revised scheme model schematic



Replacement floodplain storage areas

4.3.4 The total volume of floodplain storage lost for the operational site is estimated as 46,600m^3 for the 100 years plus CC event. At this stage no replacement floodplain storage has been provided. Identification and discussion of suitable sites is ongoing with the Environment Agency. Due the highly developed and defended nature of the River Mersey floodplain, opportunities to develop suitable replacement floodplain storage sites are minimal.

Production of flood extents

4.3.5 Maximum flood depth grids have been extracted from the AP2 revised scheme model outputs using a standard TUFLOW utility tool known as TUFLOW–to_GIS. The resulting flood depth grids have been post-processed using 'Raster to Vector' tool in QGIS to generate flood extent regions for the full range of design flood events.

Modelling assumptions made

4.3.6 Key structure sizes and river cross sections are based on the data available within the existing 2012 Environment Agency model which we have assumed for the purposes of this assessment to be correct. This is because the original survey data undertaken in the 1990s was not available.

4.4 Climate change

4.4.1 In July 2021, the Environment Agency published revised guidance for assessing the impact of CC on peak river flows to reflect the UK Climate Projections (UKCP18)[16]. The revised guidance indicates that for essential infrastructure, the Environment Agency's Higher central allowance for the peak river flow should be used. The revised guidance provides peak river flow allowances by management catchment instead of river basin district. The River Mersey is located within the Upper Mersey Management catchment. The Higher central allowance for the Upper Mersey is a 53% uplift in peak flood flow. The Upper end allowance for the Upper Mersey is an 85% increase in peak river flows for the purpose of sensitivity analysis.

[16] Environment Agency (2022), *Flood risk assessments: climate change allowances*. Available online at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

5 Model results

5.1 Baseline model results

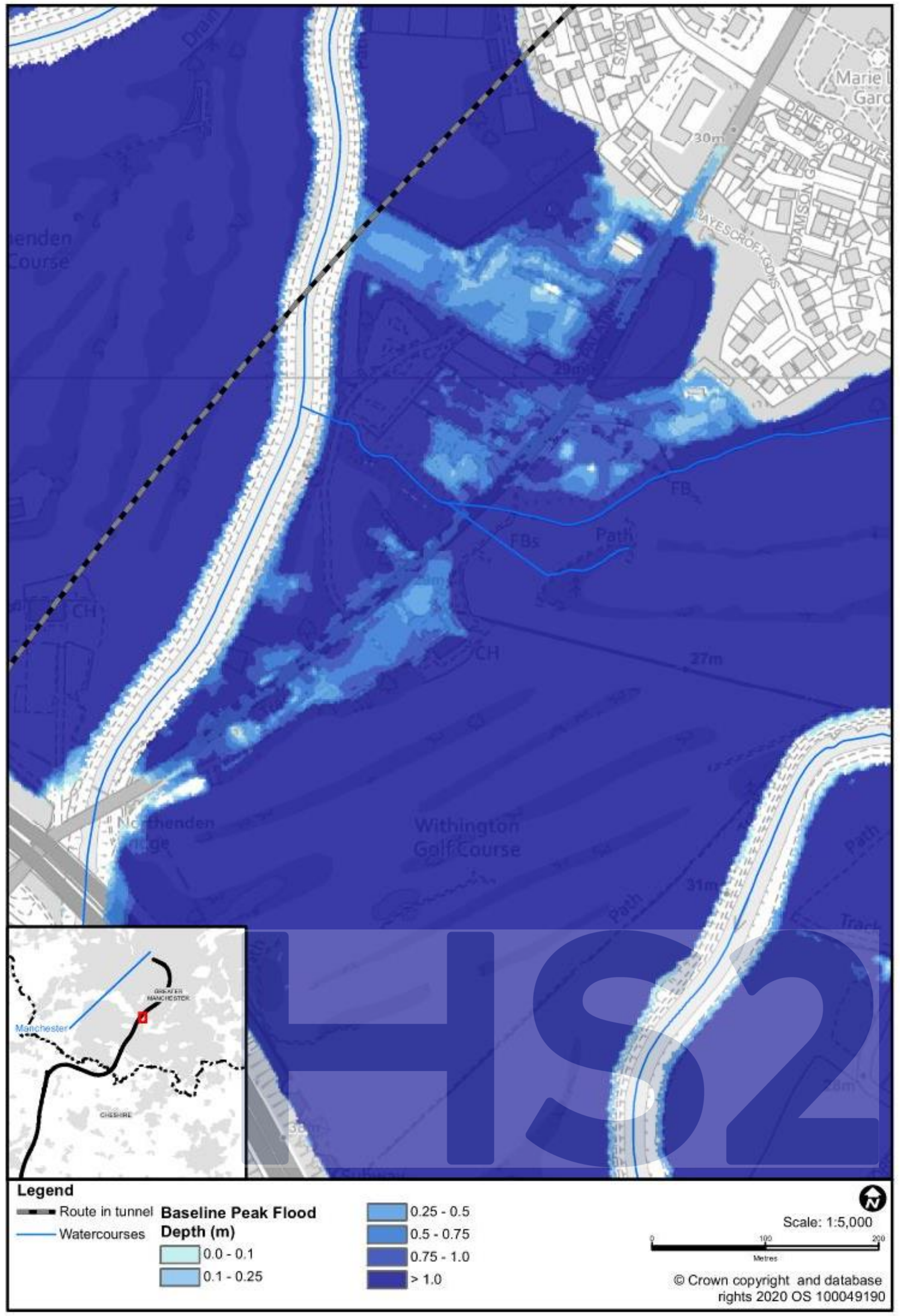
5.1.1 The baseline model has been run for the 5.0% AEP, 2.0% AEP, 1.33% AEP, 1.0% AEP, 0.5% AEP, 0.1% AEP and 1.0% AEP + CC flood events. The 1.0% AEP + CC simulation is based on a 53% increase in peak river flows. Flood event probabilities and peak water levels for the baseline model (not including the AP2 revised scheme) at the proposed shaft and at the Didsbury flood storage basin are provided in Table 1.

Table 1: Peak water levels at the proposed AP2 shaft location

Event probability (% AEP)	Return period (years)	Peak water level (m AOD) at the AP2 revised scheme
5.0	20	27.005
2.0	50	29.131
1.33	75	29.184
1.0	100	29.204
0.5	200	29.257
0.1	1000	29.841
1.0 + CC	100 + CC	29.670

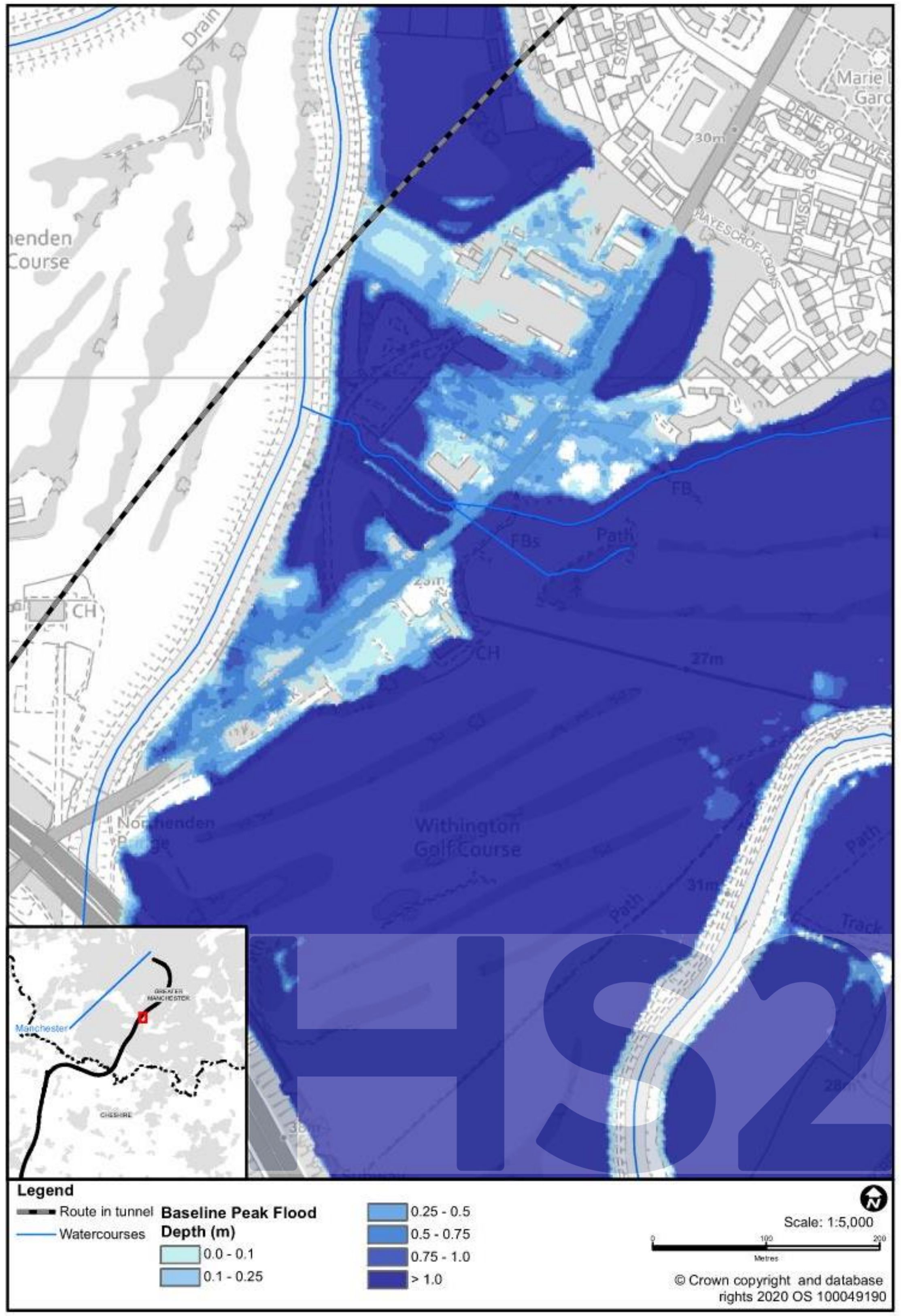
5.1.2 Peak flood depths are provided for the 5.0% AEP and the 1.0% AEP + CC design event in Figure 6 to Figure 13, which include a brief description of the baseline flood risk in those areas. This model uses the planned procedures for the operation of the gates to both the Didsbury flood storage basin and the Sales Ees flood storage basin. In reality these flood gates are operated manually and managed in the field depending on the specific nature of each flood event. This modelling is therefore likely to over represent the flood extents and as such represents a conservative flood risk assessment.

Figure 6: Peak flood depth in the area around The Hollies vent shaft (1% AEP + CC)



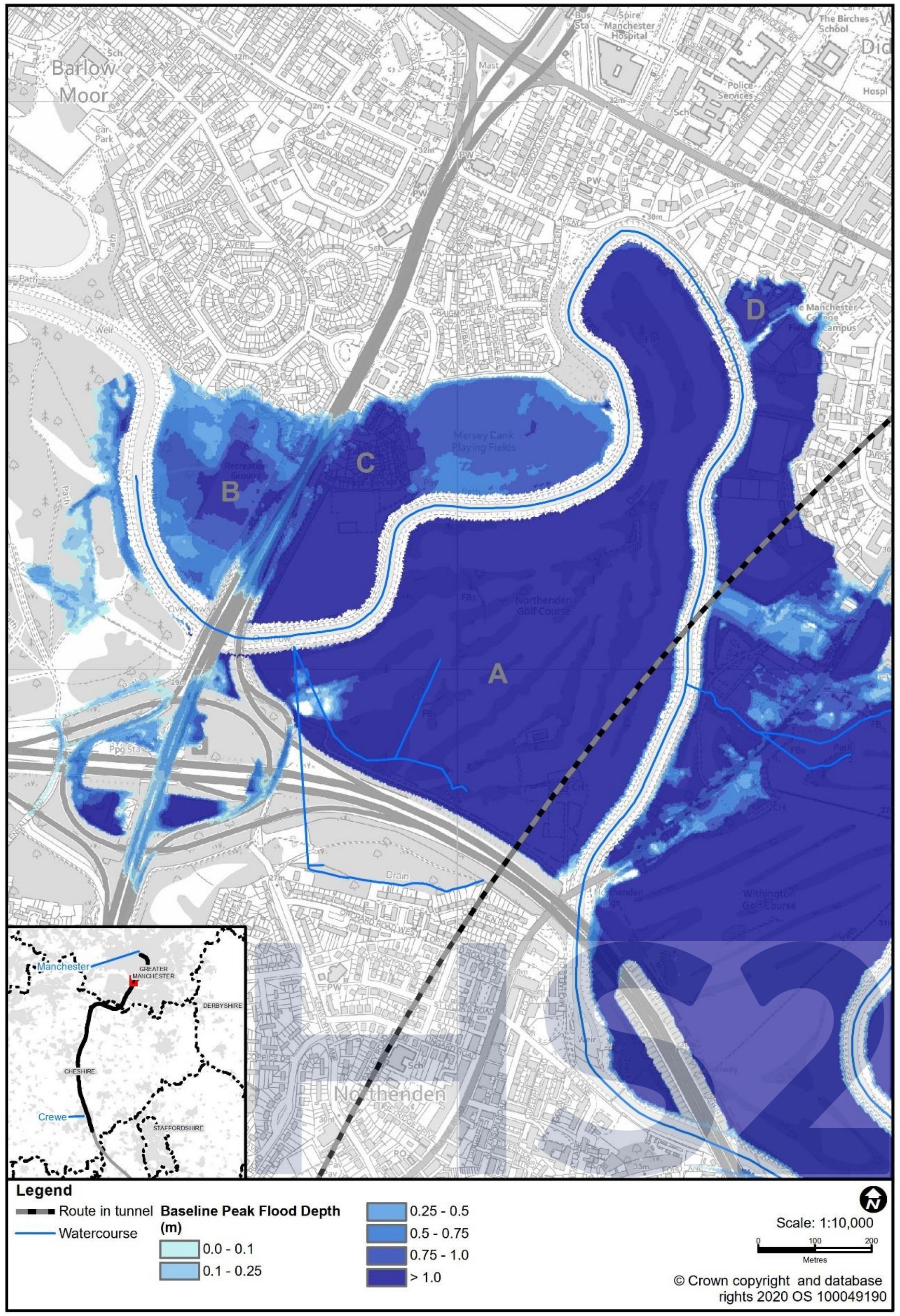
Deep flooding above 1m covers the surrounding floodplain. Most receptors in the areas adjacent to Palatine Road are flooded to depths of between 0.01m and 1m.

Figure 7: Peak flood depth in the area around The Hollies vent shaft (5% AEP)



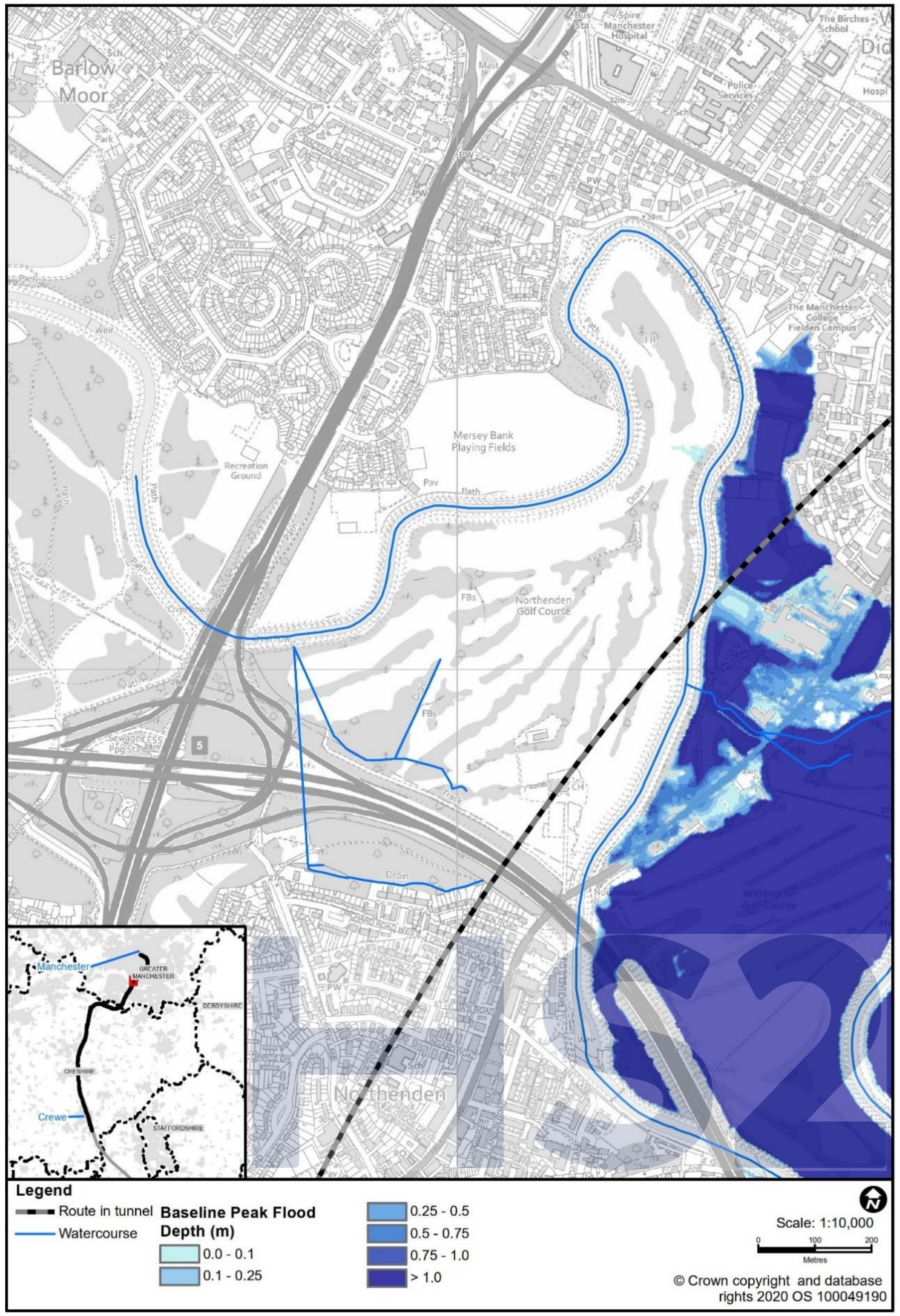
No commercial or residential receptors are flooded. There is shallow flooding of less than 0.25m along parts of Palatine Road. Flooding shown in the area of the AP2 revised scheme occurs via overtopping of Fielden Park Brook.

Figure 8: Peak flood depth downstream of The Hollies vent shaft (1% AEP + CC)



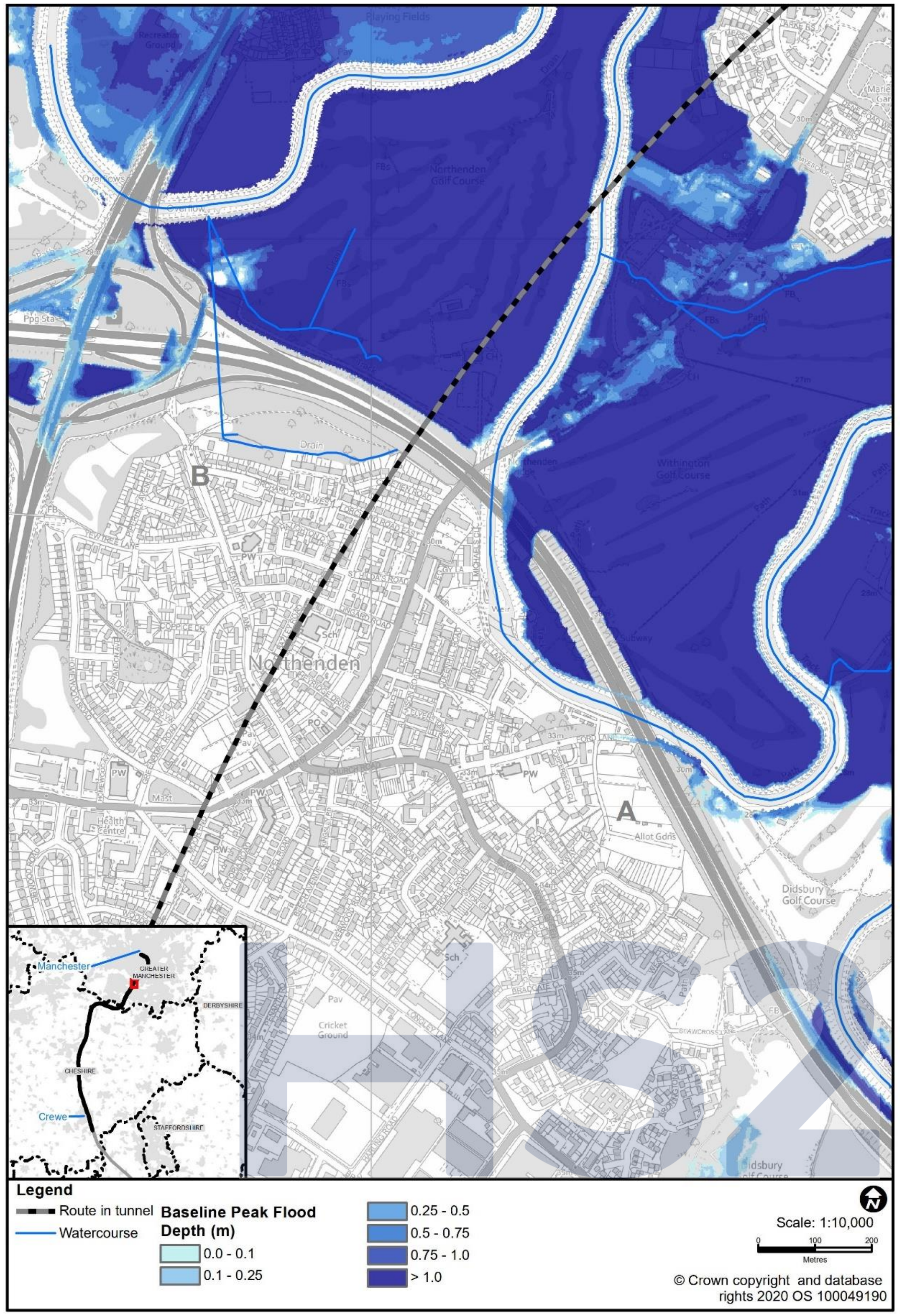
Deep flooding of Northenden golf course takes place (A) and there is risk of flooding of properties along the floodplain at locations B, C and D.

Figure 9: Peak flood depth downstream of The Hollies vent shaft (5% AEP)



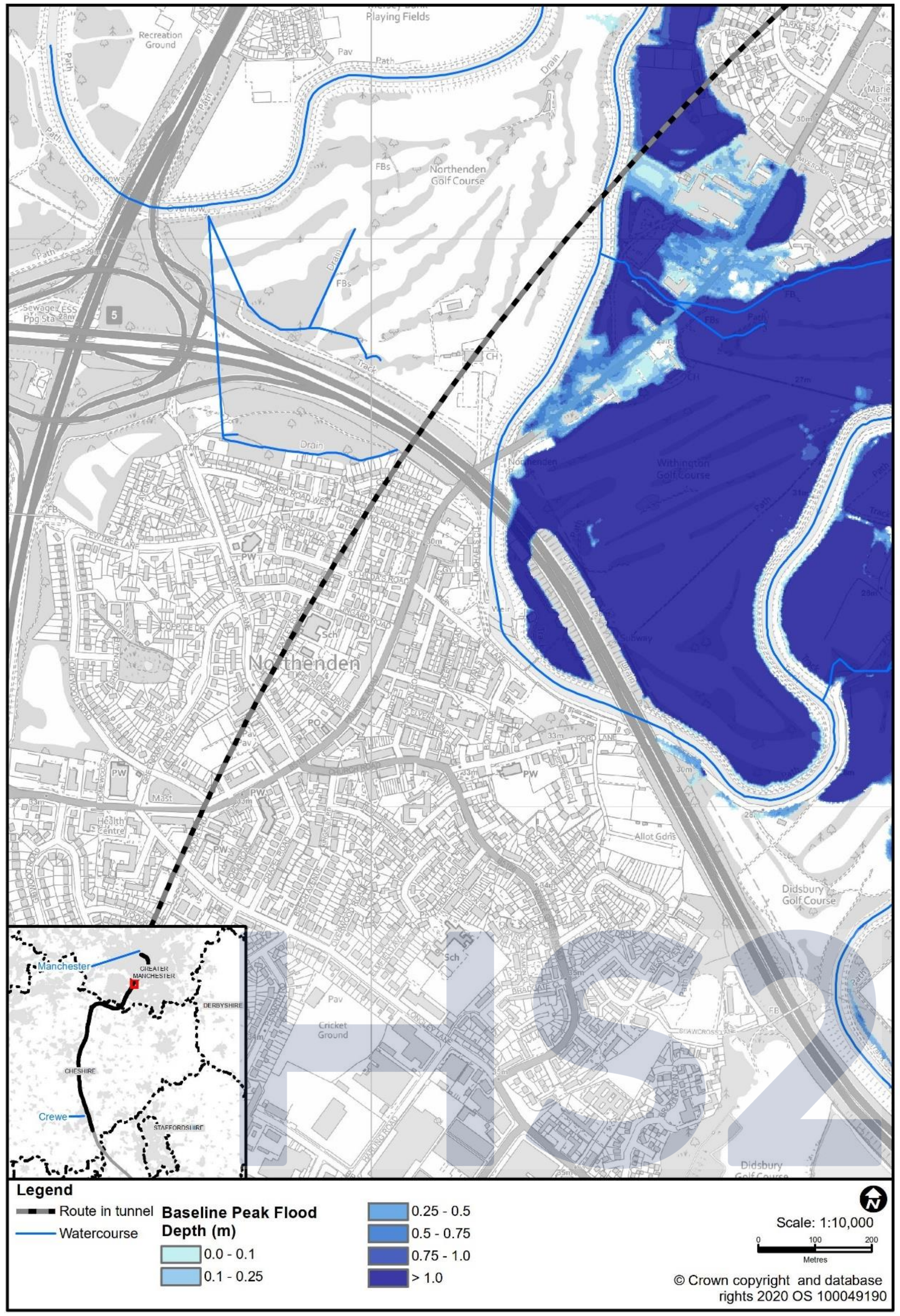
There is no flooding of Northenden golf course or property downstream of Palatine Road.

Figure 10: Peak flood depth in Northenden area (1% AEP + CC)



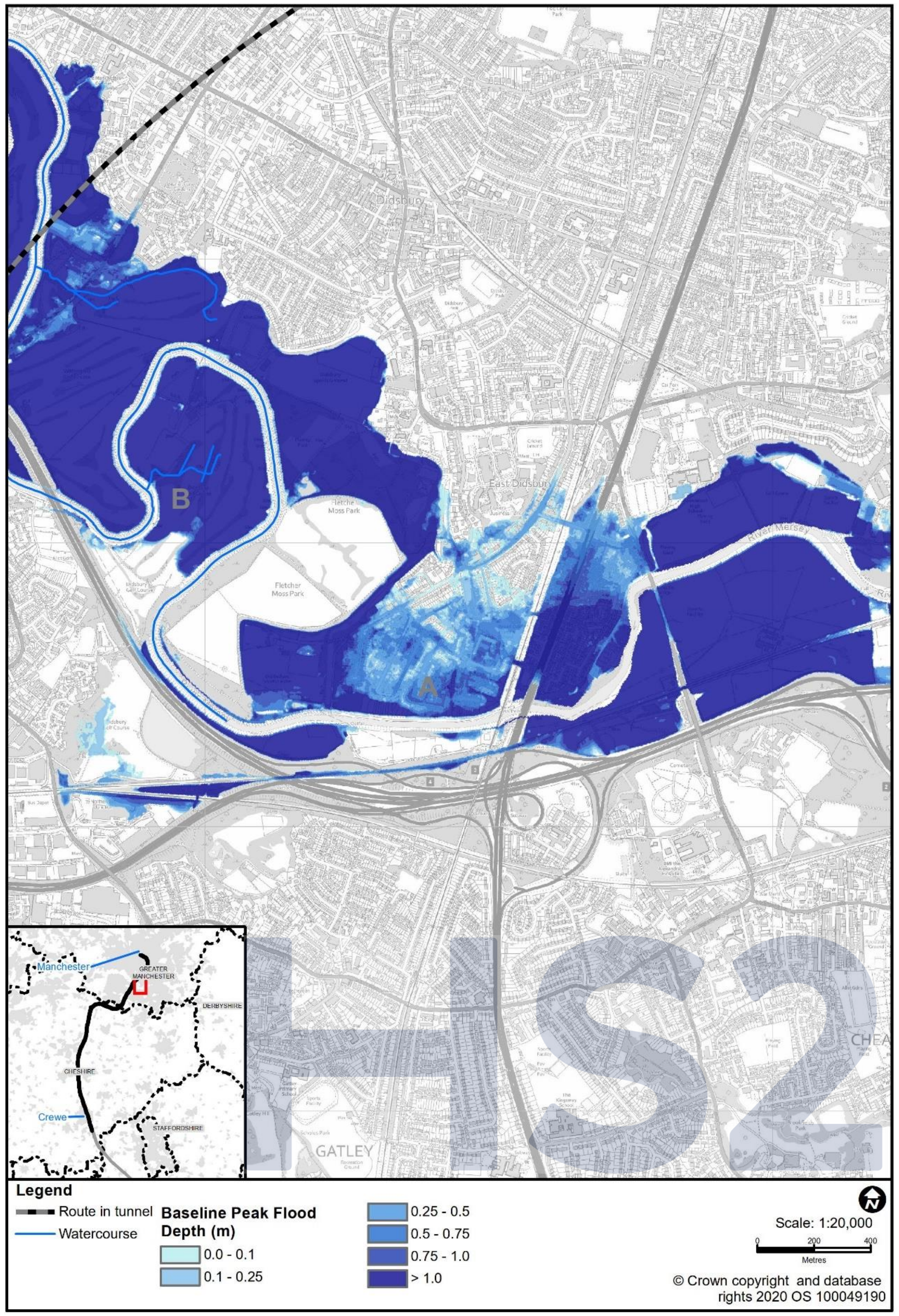
Flooding of static caravans and temporary accommodation along Ford Lane A, no flooding to properties at location B.

Figure 11: Peak flood depth in Northenden area (5% AEP)



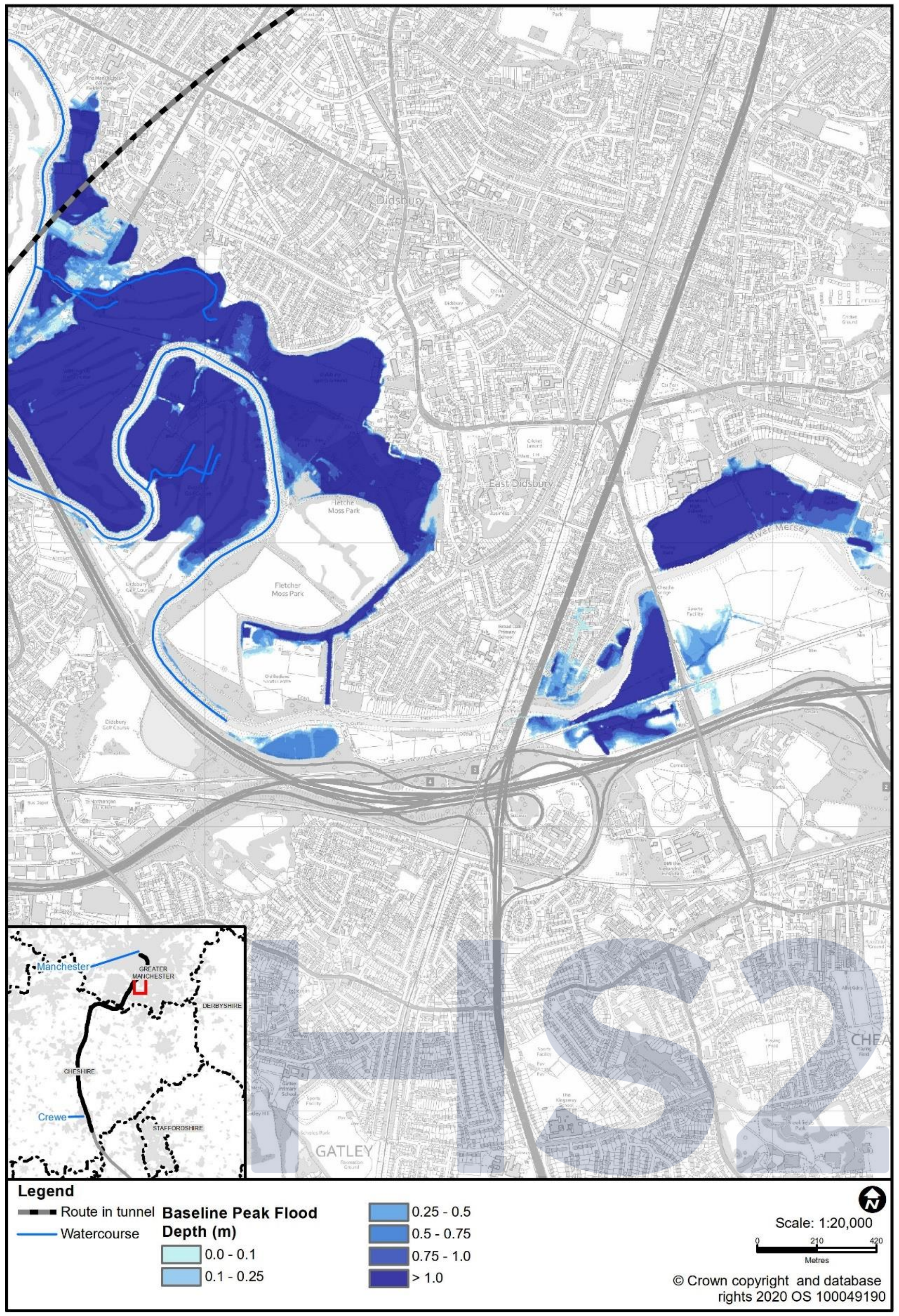
No flooding in the area of Northenden.

Figure 12: Peak flood depth in Didsbury and upstream (1% AEP + CC)



Large areas of open space are flooded to a depth of above 1m, with areas of flooding surrounding receptors (A) upstream of the Didsbury flood storage basin (B).

Figure 13: Peak flood depth in Didsbury and upstream (5% AEP)



Limited flooding in open spaces, apart from within the Didsbury flood storage basin.

5.2 AP2 revised scheme

5.2.1 The AP2 revised scheme model has been run for the 5.0% AEP, 1.0% AEP, 1.0% AEP + CC, and 0.1% AEP design flood events. The 1.0% AEP + CC simulation is based on a 53% increase in peak river flows.

5.2.2 The modelled flood extents with the AP2 revised scheme for the 5.0% AEP event are presented in the SES2 and AP2 ES Volume 5, Water resources and flood risk Map Book: Map Series WR-06 - Modelled Baseline and Post Development Flood Extent 1 in 20 (5%) Annual Probability of River Flooding, maps WR-06-323 and WR-06-324. The modelled flood extents with the AP2 revised scheme for the 1.0% AEP + CC event are presented in the SES2 and AP2 ES Volume 5, Water resources and flood risk Map Book: Map Series WR-05 - Modelled Baseline and Post Development Flood Extent 1 in 100 (1%CC) including Climate Change Annual Probability of River Flooding, maps WR-05-323 and WR-05-324.

5.2.3 The impact of the AP2 revised scheme vent shaft relocation (AP2-007-003) and its associated raised compound on peak flood levels is presented as an overview within the 2D extents for the 5.0% AEP and the 1.0% AEP + CC events in Annex A (Figure A1 and Figure A2 respectively).

Permanent impacts

1.0% AEP plus climate change event

5.2.4 Detailed information for the 1.0% AEP + CC event is provided in the areas where there is an impact on properties in Figure 14 and Figure 15. These figures include the baseline peak flood depths as well as the impacts resulting from the AP2 revised scheme operational site. Table 2 provides flood risk information for those properties potentially affected as a result of the AP2 revised scheme. Table 2 includes peak water levels and peak depths above threshold for the baseline and the AP2 revised scheme. The difference in peak water levels at these properties provides an indication of the impact as a result of the scheme.

Figure 14: Baseline peak flood depth in the area of The Hollies vent shaft (1.0% AEP +CC event)

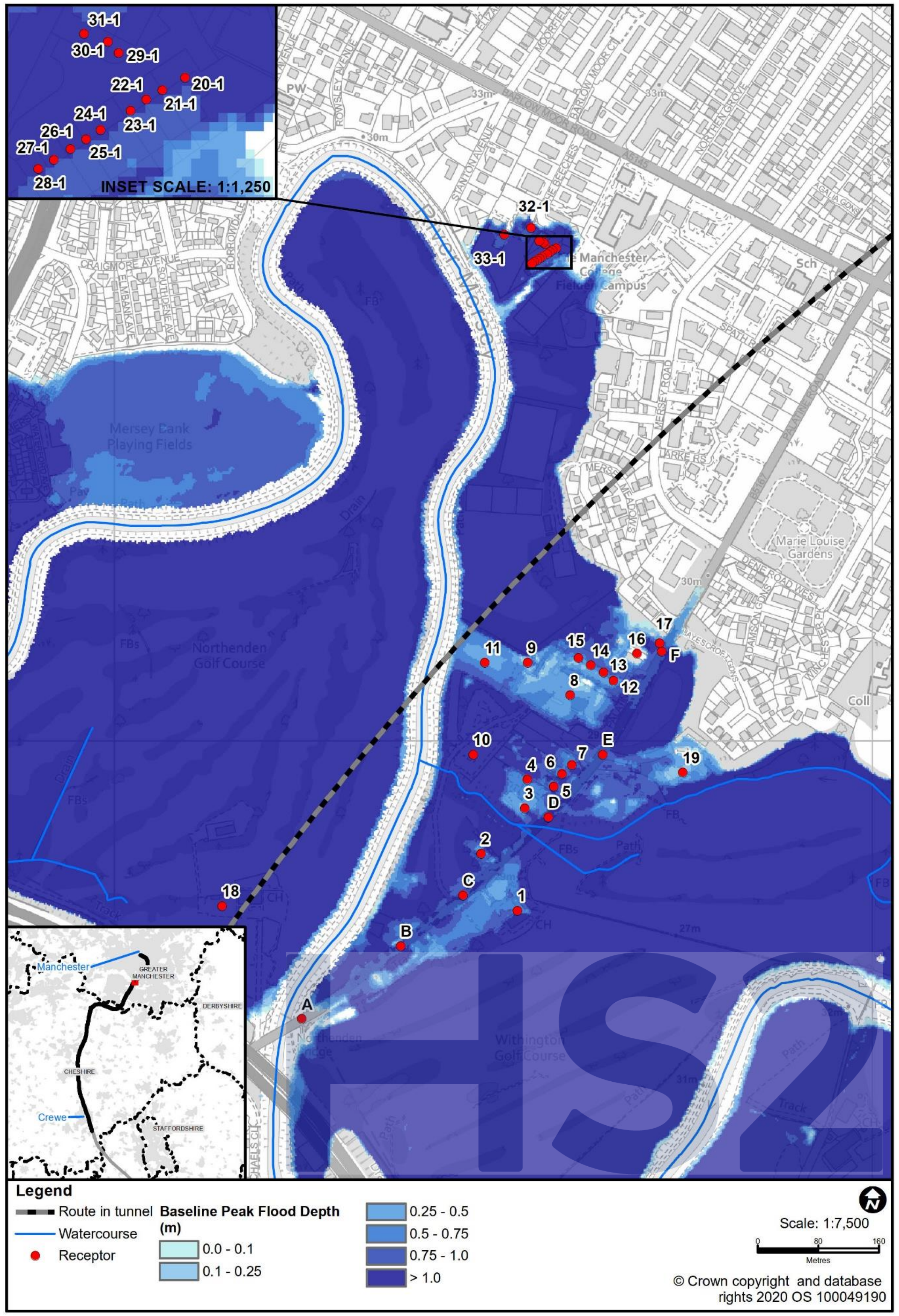


Figure 15: Change in peak flood level in the area of The Hollies vent shaft (1.0% AEP + CC event)

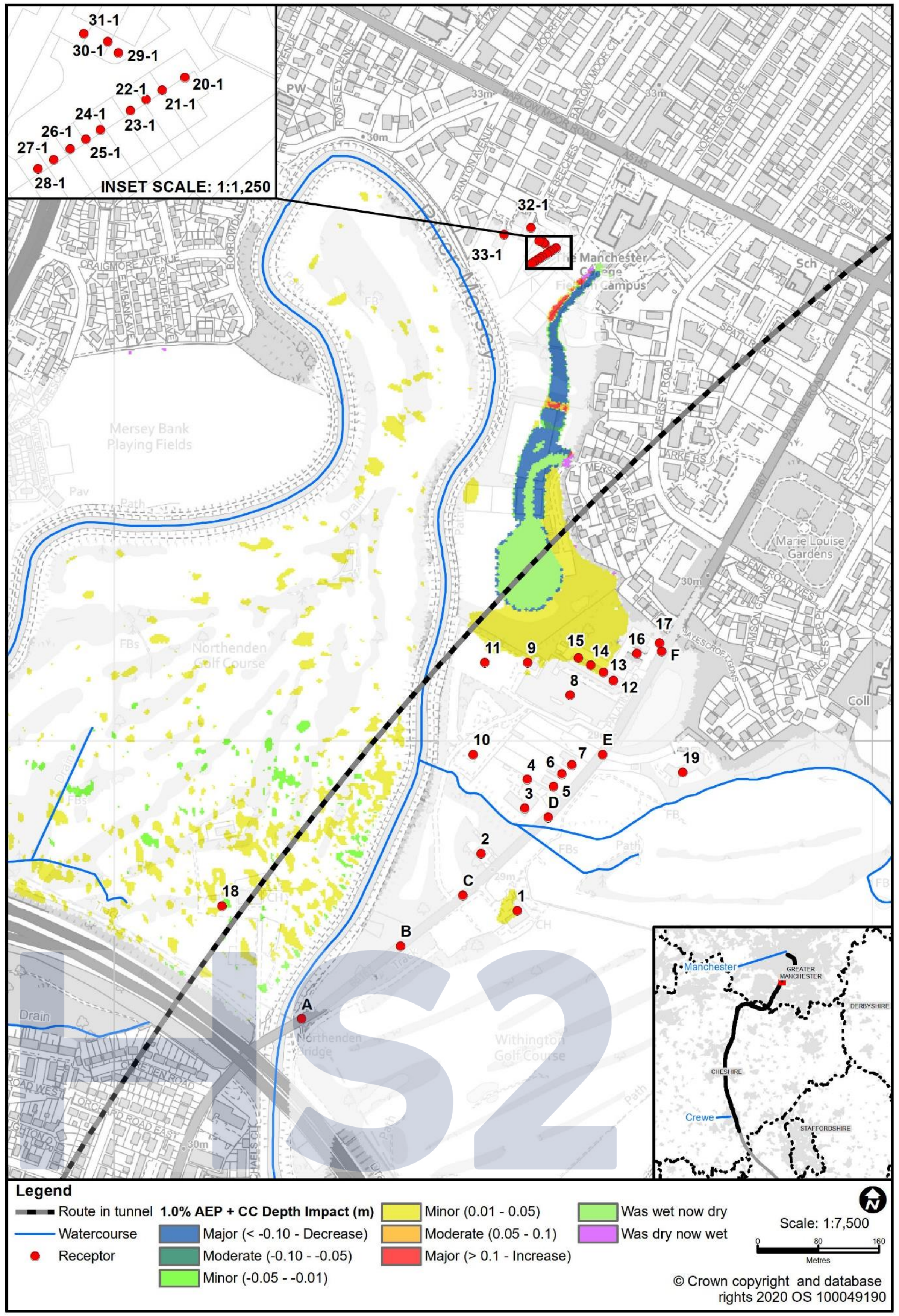


Table 2: Change in peak flood level in the area of The Hollies vent shaft for the 1.0% AEP + CC event (see Figure 15)

Receptor details				Peak flood levels m AOD (depth above ground level (m)) 1.0% AEP + CC event		Peak water level
ID[17]	Receptor type	Ground level (m AOD)	Assumed threshold level (m AOD)	Baseline water level	AP2 revised scheme scenario	Difference (m)
A	Road	30.754	30.754	Dry	Dry	N/A
B	Road	29.086	29.120	30.101 (1.015)	30.102 (1.016)	0.001
C	Road	29.073	29.141	30.095 (1.022)	30.097 (1.024)	0.002
D	Road	29.120	29.188	30.242 (1.122)	30.241 (1.121)	0.000
E	Road	29.194	29.279	30.138 (0.943)	30.138 (0.943)	0.000
F	Road	29.347	29.346	30.135 (0.788)	30.135 (0.788)	0.000
1	Commercial	29.490	29.896	30.245 (0.755)	30.262 (0.788)	0.017
2	Residential	29.548	29.493	30.061 (0.513)	30.063 (0.514)	0.002
3	Residential – multiple occupancy	29.707	29.740	30.144 (0.437)	30.144 (0.437)	0.000
4	Secondary electrical sub-station	29.456	29.561	30.057 (0.601)	30.057 (0.602)	0.000
5	Residential	29.475	29.597	30.217 (0.742)	30.216 (0.741)	0.000
6	Residential	29.277	29.573	30.201 (0.924)	30.201 (0.924)	0.000
7	Residential	29.407	29.429	30.162 (0.756)	30.162 (0.755)	0.000
8	Commercial property	29.550	29.425	30.035 (0.485)	30.036 (0.486)	0.001
9	Commercial property	29.526	29.296	29.749 (0.223)	29.754 (0.228)	0.005
10	Car park	26.528	26.666	30.012 (3.483)	30.013 (3.485)	0.001
11	Car park	29.399	29.355	29.852 (0.453)	29.854 (0.454)	0.001
12	Residential – multiple occupancy	29.524	29.563	29.886 (0.362)	29.890 (0.367)	0.005
13	Residential – multiple occupancy	29.413	29.535	29.778 (0.366)	29.787 (0.375)	0.009
14	Residential – multiple occupancy	29.239	29.527	29.728 (0.489)	29.743 (0.504)	0.014
15	Residential – multiple occupancy	29.227	29.560	29.706 (0.479)	29.722 (0.495)	0.016
16	Residential – multiple occupancy	30.989	31.290	Dry	Dry	N/A
17	Secondary electrical sub-station	29.462	29.733	30.132 (0.670)	30.132 (0.670)	0.000
18	Commercial property	25.898	26.029	29.688 (3.789)	29.678 (3.780)	-0.010
19	Residential – multiple occupancy	30.036	30.047	30.252 (0.217)	30.252 (0.216)	-0.001
20	Residential	28.564	28.628	29.674 (1.109)	29.677 (1.112)	0.003
21	Residential	28.453	28.646	29.674 (1.221)	29.678 (1.225)	0.004
22	Residential	28.510	28.695	29.675 (1.164)	29.679 (1.169)	0.004
23	Residential	28.510	28.689	29.675 (1.165)	29.679 (1.169)	0.004
24	Residential	28.509	28.680	29.673 (1.165)	29.678 (1.169)	0.004
25	Residential	28.409	28.666	29.672 (1.263)	29.676 (1.267)	0.004
26	Residential	28.422	28.727	29.671 (1.249)	29.674 (1.252)	0.003
27	Residential	28.580	28.709	29.670 (1.089)	29.671 (1.091)	0.002
28	Residential	28.656	28.704	29.669 (1.013)	29.670 (1.014)	0.001
29	Residential	28.358	28.576	29.671 (1.314)	29.674 (1.316)	0.003

[17] Reference numbers, denote receptors potentially impacts by the AP2 revised scheme, and the locations are shown on the associated Figure 15.

Receptor details				Peak flood levels m AOD (depth above ground level (m)) 1.0% AEP + CC event		Peak water level
ID[17]	Receptor type	Ground level (m AOD)	Assumed threshold level (m AOD)	Baseline water level	AP2 revised scheme scenario	Difference (m)
30	Residential	28.369	28.592	29.671 (1.302)	29.673 (1.304)	0.003
31	Residential	28.382	28.593	29.670 (1.288)	29.673 (1.291)	0.003
32	Residential– multiple occupancy (5 ground floor flats)	28.473	28.730	29.668 (1.195)	29.668 (1.195)	0.001
33	Residential– multiple occupancy (6 ground floor flats)	28.602	28.758	29.670 (1.068)	29.670 (1.069)	0.001

5.2.5 Figure 14 and Figure 15 and Table 2 indicate that for the 1.0% AEP + CC event the AP2 revised scheme will have minor impacts on peak flood levels. There will be a minor impact at two residential properties on Palatine Road (up to a 0.016m increase in peak flood level on western 2 blocks of Riverside Court) and a minor impact at the Withington golf course club house commercial property (0.017m increase in peak flood level).

5.2.6 The AP2 revised scheme relocated vent shaft (AP2-007-003) and its associated raised compound have a localised effect on the flow routes around the shaft and the mechanism of flooding in The Hollies vent shaft area, between the Didsbury flood storage basin and the River Mersey.

5.0% AEP event

5.2.7 Detailed information for the 5.0% AEP event is provided in Figure A1. This figure presents the depth difference impacts resulting from the AP2 revised scheme operational site. Increases in peak flood levels of greater than 100mm are observed immediately surrounding the shaft site. The receptors in these areas are existing woodland, areas designated for grassland or woodland mitigation planting as part of the AP2 revised scheme and an existing tennis court.

Temporary and permanent impacts 1.0% AEP event

5.2.8 The flood defences along the River Mersey are designed to protect against flooding from the river to approximately the 1.0% AEP event. Therefore, the detailed information for the 1.0% AEP event was also reviewed, to understand if there are any changes to flood extents and flood depths due to the AP2 revised scheme, when flood defences are overtopping. This assessment includes the raised land associated with the operational site and the additional raised ground to form the construction dry working area, as this provides the most conservative estimate of the impact during the 1.0% AEP event.

5.2.9 The impact on properties during the 1.0% AEP are set out in Figure 16 to Figure 17. These figures include the baseline peak flood depths as well as the impacts resulting from the AP2 revised scheme. Table 3 provides flood risk information for those properties potentially affected as a result of the AP2 revised scheme. The table includes peak water levels and peak depths above threshold for the baseline and the AP2 revised scheme. The difference in peak water levels at these properties provides an indication of the impact as a result of the scheme.

Figure 16: Baseline peak flood depth in The Hollies vent shaft area (1.0% AEP event)

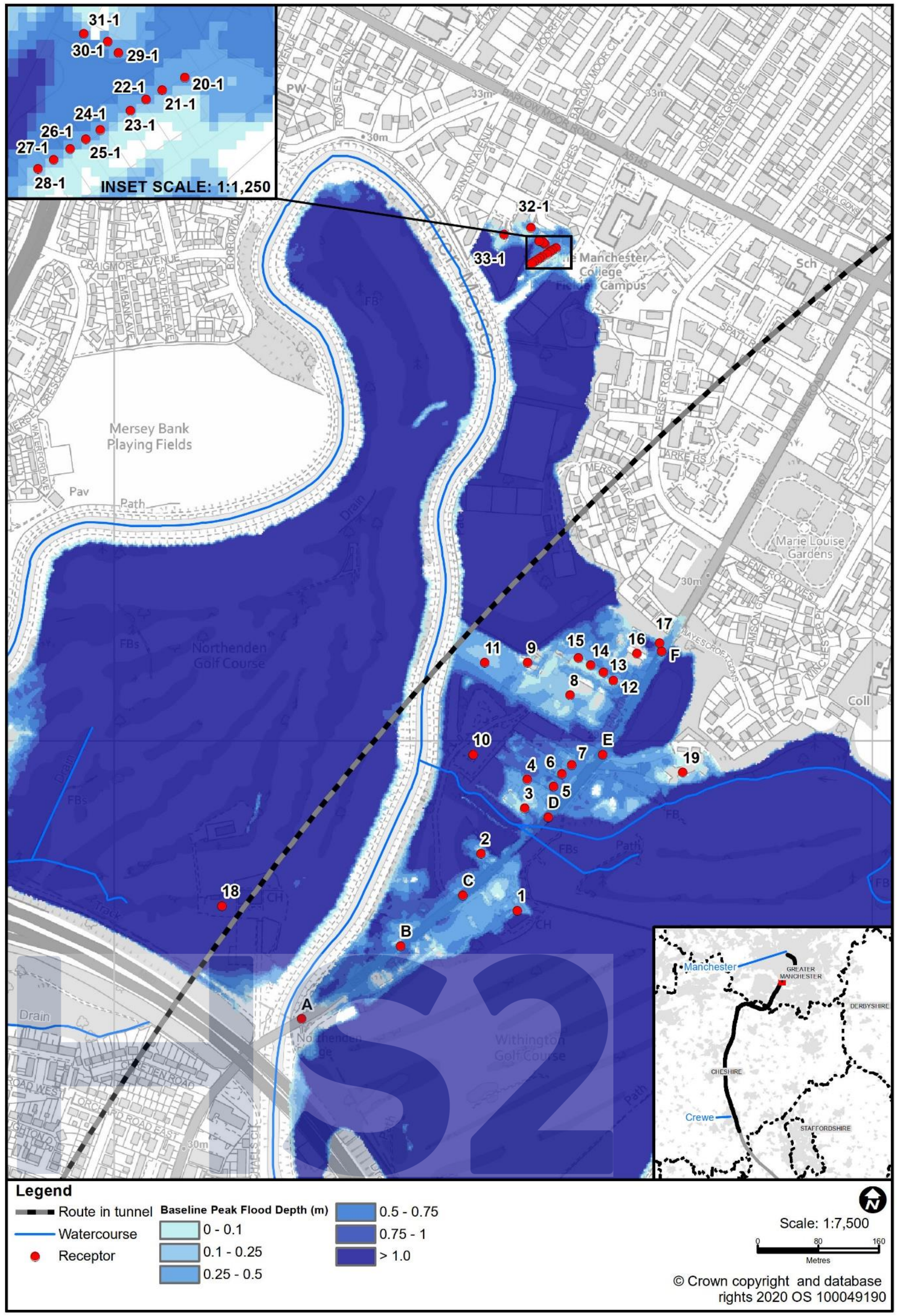


Figure 17: Change in peak flood level in The Hollies vent shaft area (1.0% AEP event)

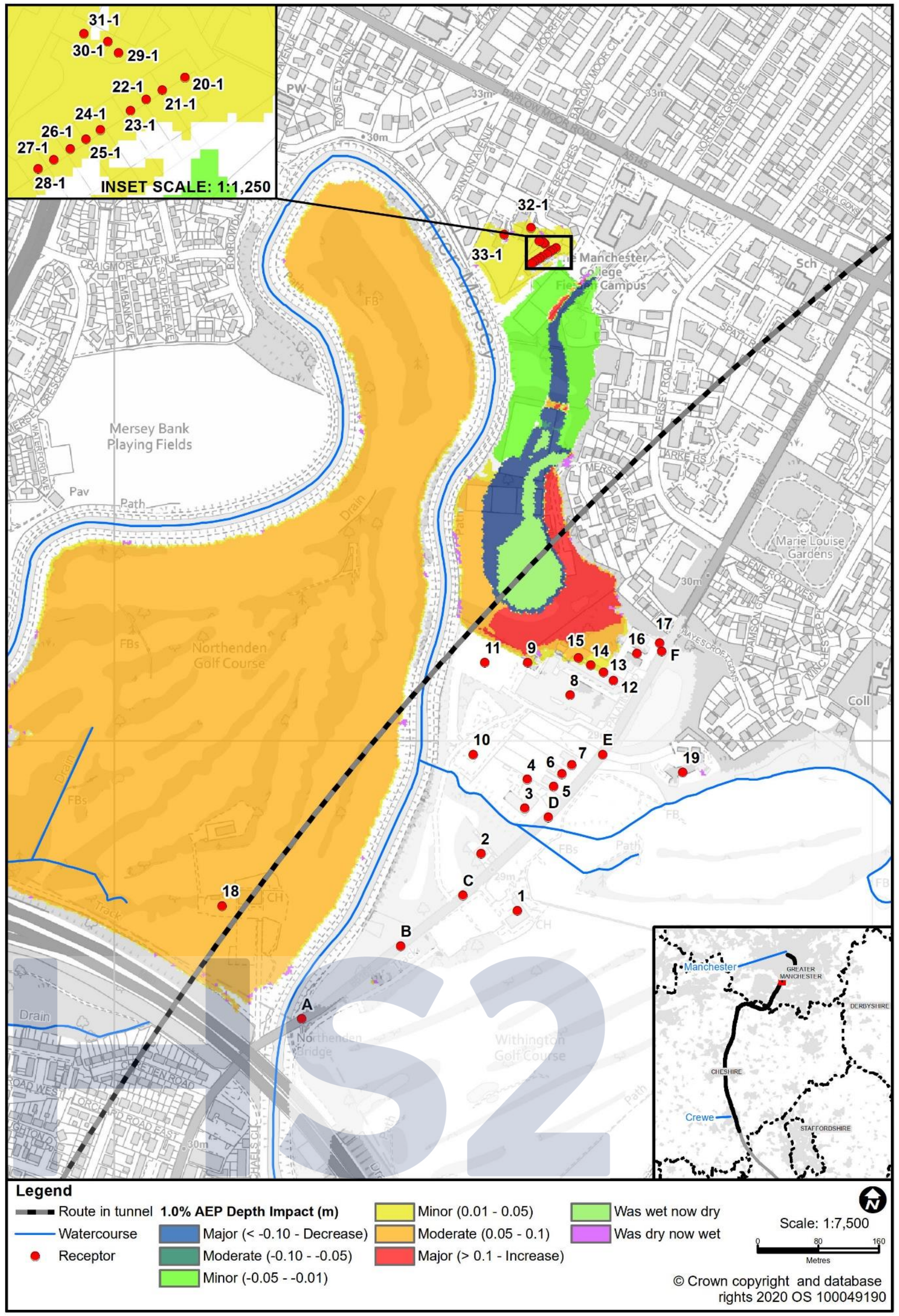


Table 3: Change in peak flood level in The Hollies vent shaft area for the 1.0% AEP event (see Figure 17)

Receptor details				Peak flood levels m AOD (depth above ground level (m)) 1.0% AEP event		Peak water level
ID[18]	Receptor type	Ground level (m AOD)	Assumed threshold level (m AOD)	Baseline water level	AP2 revised scheme scenario	Difference (m)
A	Road	30.754	30.754	Dry	Dry	N/A
B	Road	29.086	29.086	29.744 (0.658)	29.749 (0.663)	0.005
C	Road	29.073	29.073	29.760 (0.686)	29.764 (0.690)	0.004
D	Road	29.120	29.120	29.910 (0.790)	29.913 (0.793)	0.003
E	Road	29.194	29.194	29.799 (0.605)	29.803 (0.609)	0.004
F	Road	29.347	29.347	29.799 (0.452)	29.803 (0.456)	0.004
1	Commercial	29.490	29.790	29.916 (0.427)	29.923 (0.434)	0.007
2	Residential	29.548	29.848	29.749 (0.201)	29.753 (0.205)	0.004
3	Residential – multiple occupancy	29.707	30.007	29.888 (0.181)	29.890 (0.184)	0.003
4	Secondary electrical sub-station	29.456	29.756	29.758 (0.303)	29.762 (0.306)	0.003
5	Residential	29.475	29.775	29.875 (0.400)	29.878 (0.403)	0.003
6	Residential	29.277	29.577	29.859 (0.582)	29.862 (0.585)	0.003
7	Residential	29.407	29.707	29.823 (0.416)	29.826 (0.419)	0.003
8	Commercial property	29.550	29.850	29.756 (0.206)	29.759 (0.209)	0.003
9	Commercial property	28.996	29.296	Dry	Dry	N/A
10	Car park	26.528	26.528	29.734 (3.205)	29.737 (3.209)	0.003
11	Car park	29.399	29.399	29.665 (0.266)	29.667 (0.268)	0.002
12	Residential – multiple occupancy	29.508	29.808	29.592 (0.084)	29.595 (0.085)	0.003
13	Residential – multiple occupancy	29.390	29.690	29.496 (0.107)	29.505 (0.110)	0.008
14	Residential – multiple occupancy	29.239	29.539	29.427 (0.188)	29.443 (0.204)	0.016
15	Residential – multiple occupancy	29.226	29.526	29.337 (0.111)	29.388 (0.161)	0.051
16	Residential – multiple occupancy	30.990	31.290	Dry	Dry	N/A
17	Secondary electrical sub-station	29.462	29.762	29.798 (0.336)	29.802 (0.340)	0.004
18	Commercial property	25.898	26.198	27.873 (1.975)	27.938 (2.040)	0.065
19	Residential – multiple occupancy	29.747	30.047	Dry	Dry	N/A
20	Residential	28.564	28.864	28.815 (0.250)	28.839 (0.274)	0.024
21	Residential	28.453	28.753	28.815 (0.362)	28.839 (0.386)	0.024
22	Residential	28.510	28.810	28.815 (0.304)	28.839 (0.329)	0.024
23	Residential	28.510	28.810	28.815 (0.305)	28.839 (0.329)	0.024
24	Residential	28.509	28.809	28.815 (0.306)	28.839 (0.330)	0.024
25	Residential	28.409	28.709	28.815 (0.406)	28.839 (0.430)	0.024
26	Residential	28.422	28.722	28.815 (0.392)	28.839 (0.416)	0.024
27	Residential	28.580	28.880	28.815 (0.234)	28.839 (0.259)	0.024
28	Residential	28.656	28.956	28.815 (0.159)	28.839 (0.183)	0.024
29	Residential	28.358	28.658	28.815 (0.457)	28.839 (0.481)	0.024

[18] Reference numbers, denote receptors potentially impacts by the AP2 revised scheme, and the locations are shown on the associated Figure 17.

Receptor details				Peak flood levels m AOD (depth above ground level (m)) 1.0% AEP event		Peak water level
ID[18]	Receptor type	Ground level (m AOD)	Assumed threshold level (m AOD)	Baseline water level	AP2 revised scheme scenario	Difference (m)
30	Residential	28.369	28.669	28.815 (0.445)	28.839 (0.470)	0.024
31	Residential	28.382	28.682	28.815 (0.433)	28.839 (0.457)	0.024
32	Residential– multiple occupancy (5 ground floor flats)	28.473	28.773	28.815 (0.342)	28.839 (0.366)	0.024
33	Residential– multiple occupancy (6 ground floor flats)	28.602	28.902	28.815 (0.213)	28.839 (0.237)	0.024

5.2.10 The results shown in Figure 16, Figure 17 and Table 3 indicate that for the 1.0% AEP event, the AP2 revised scheme will have impacts on peak flood levels. The results suggest that the AP2 revised scheme will lead to earlier overtopping of flood defences to Northenden Golf Course and the earlier circumvention of the Beeches Mews flood wall than would occur in the baseline. This leads to a minor impact (0.024m increase in peak water level) at 14 properties at Beeches Mews and a moderate impact (0.065m increase in peak water level) at the Northenden golf course club house. There is also a localised effect just upstream of the revised scheme shaft with minor impacts on one residential property at Palatine Road (up to 0.016m increases in peak water level at second block of Riverside Court) and a moderate impact at one residential property on Palatine Road (with an increase in peak water level of 0.051m at most western block of Riverside Court). These are the same two properties which are identified as permanently impacted by the scheme in the 1.0% AEP + CC event.

Potential permanent downstream impacts

5.2.11 A review of the changes in peak flood flows downstream of the relocated vent shaft site (see Figure 18) suggests that the loss of floodplain storage due to the presence of the AP2 revised scheme leads to a 0.1% increase in peak flood flow (0.5m^3/s increase compared to a baseline flow of 568.1m^3/s) downstream Princess Road bridge during the 1 in 100 year + CC event, indicating that the construction of the relocated vent shaft pushes a greater volume of water downstream. The total volume of flood flow passed downstream is 42,400m^3. This has potential to lead to new significant effects compared to the hybrid Bill scheme as the proposed replacement floodplain storage (RFS) on Withington Golf Course in the original scheme mitigated the loss of flood storage volume. As shown in Figure 19, the permanent operational site also leads to an 0.1% increase in peak flood flows (0.3m^3/s increase in peak flood flow compared to a baseline flow of 286.5m^3/s) downstream of Princess Road during the 1 in 100 year event. The total volume of flood flow passed downstream is 38,900m^3. No increase in peak flood flows is observed in the 1 in 20 year event (see Figure 19).

5.2.12 During construction, the additional loss of floodplain storage, due to the additional presence of the raised construction compound, leads to an 0.2% increase in peak flood flows (0.5m^3/s increase in peak flood flow). The modelled peak flood flow downstream of Princess Road Bridge with the AP2 revised scheme permanent operational and temporary construction site in place is presented in Figure 20. The total volume of flood flow passed downstream is 55,600m^3.

5.2.13 The AP2 revised scheme model 2D extent ends just downstream of Princess Road bridge and therefore not sufficiently downstream to identify any potential downstream impacts. The 2D extent of the 2018 Environment Agency regional model extends downstream of Princess Road to the Manchester Ship Canal. This model has a coarser resolution and is not designed to predict flood impacts on individual properties or parcels of land. It is therefore not considered to be sufficiently robust, to predict the impacts of such as small increase in peak flows, with a reasonable degree of accuracy.

5.2.14 During the passage of the hybrid Bill, the AP2 revised model will be extended to cover the area immediately downstream of Princess Road to allow potential flood compensation areas to be identified.

Figure 18: Peak river flow downstream of Princess Road bridge (at small weir approx. 620m downstream of bridge) during the 1 in 100 year +CC event with the AP2 revised scheme operational site

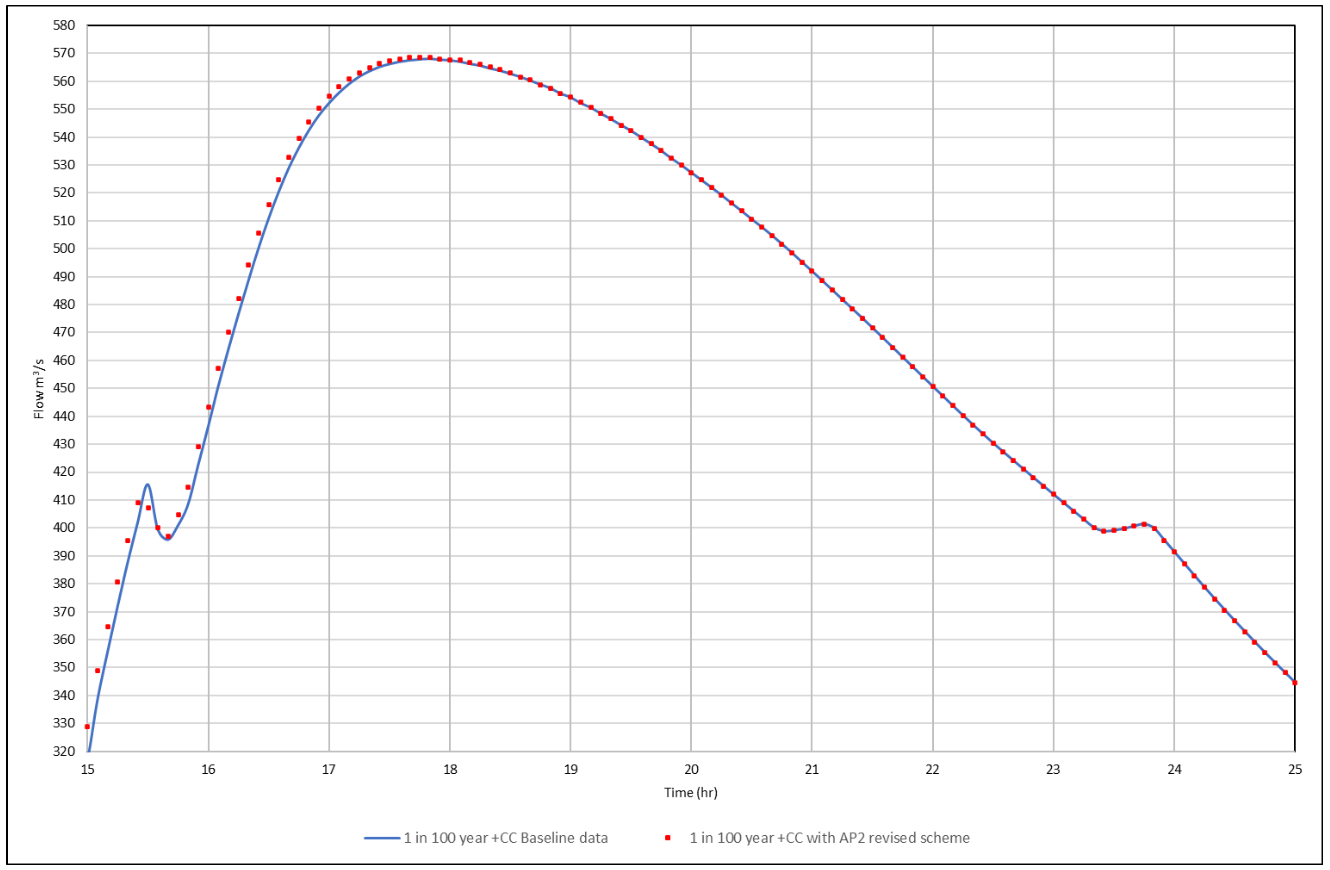


Figure 19: Peak flood flow downstream of Princess Road bridge (at small weir approx. 620m downstream of bridge) during the 1 in 100 year event and the 1 in 20 year event with the AP2 revised scheme operational site

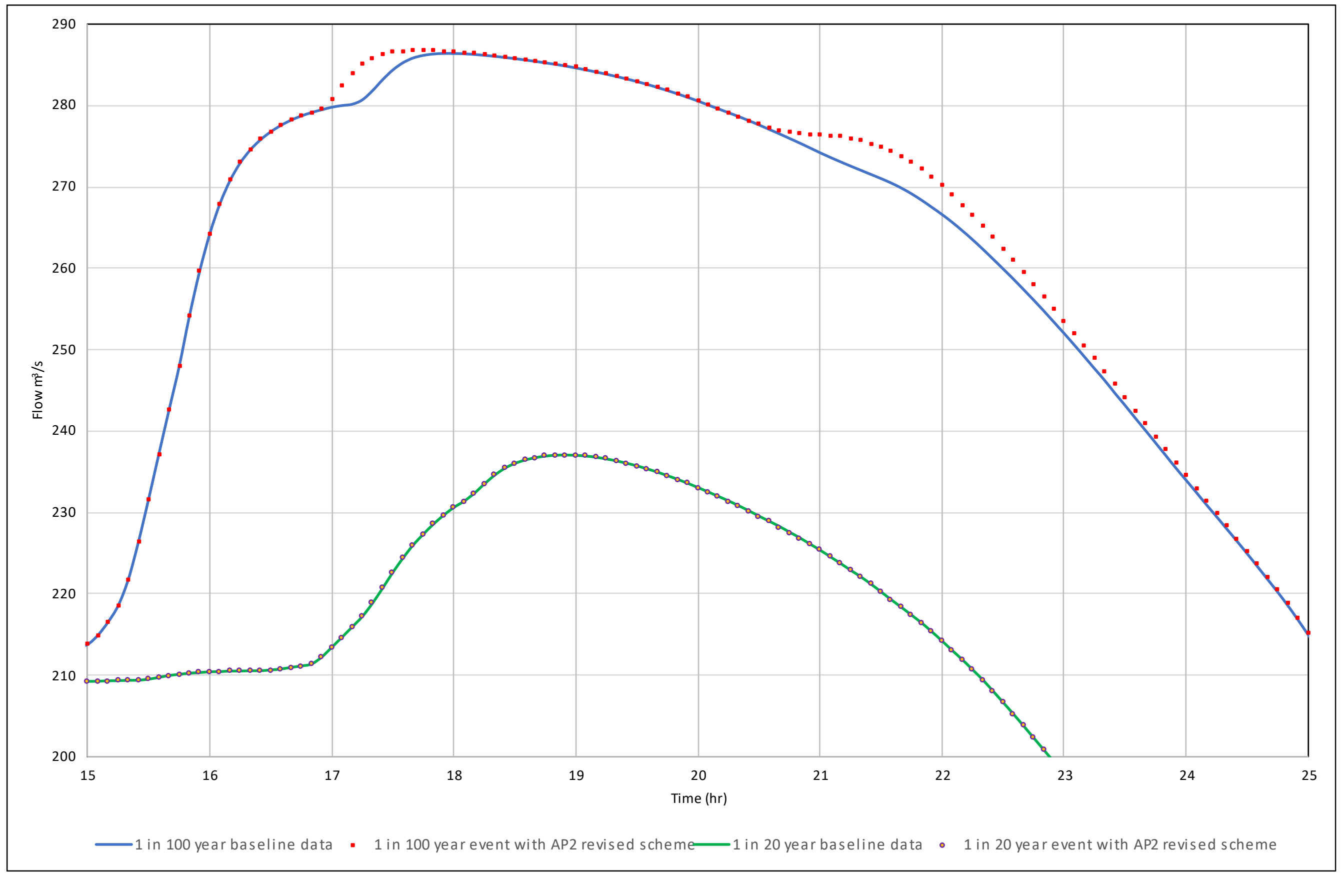
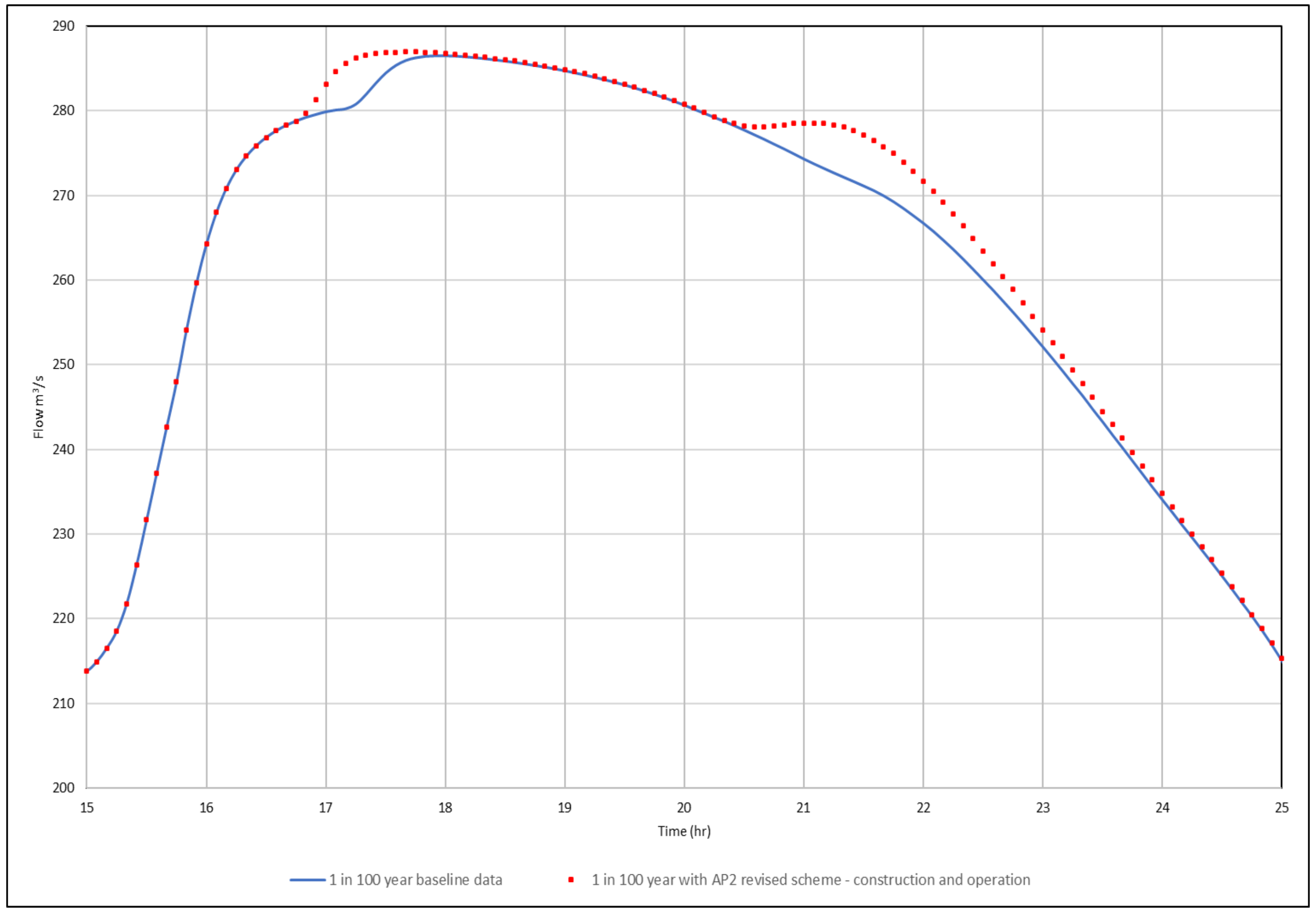


Figure 20: Peak flood flow downstream of Princess Road bridge (at small weir approx. 620m downstream of bridge) during the 1 in 100 year event with the AP2 revised scheme construction and operational site



6 Model proving

6.1 Run performance

6.1.1 The time step parameters used are one second for the 1D AP2 revised scheme model element and two seconds for the 2D AP2 revised scheme model element. Final cumulative mass balance error is within +/-2.0% for all model runs undertaken.

6.2 Validation

6.2.1 Following the original scheme model build, an independent review of the model was carried out following the HS2 technical standards. The findings of this review were discussed and subsequently, improvements were made to the original scheme model prior to calibration. The key elements that have been addressed are:

- left and right banks of Northenden weir were added to simulate flows bypassing the weir through the side bank slopes;
- the crest length of the Northenden weir has been adjusted to take account of the weir skew angle compared to the river flow direction; a value of 37m has been included;
- inclusion of an existing flood wall along Ford Lane;
- inclusion of a full barrier to flow to represent the M60 bridge abutment on the western bank of the River Mersey;
- removal of model instabilities for both low and high flows, by changing the Northenden crump weir to a general spill unit;
- inclusion of a 25 degrees skew angle on the Palatine Road bridge; and
- all bridges in the 1D FMP model have been set to switch to orifice flow conditions when surcharged; this is to enhance the accuracy of the model when simulating head losses at surcharging bridges.

6.3 Sensitivity analysis

6.3.1 Analysis was undertaken to assess the sensitivity of the 1.0% AEP + CC AP2 revised scheme baseline model outputs to the following scenarios:

- use of Upper end CC allowance of an 85% increase in peak river flow;
- increase in Manning's n roughness (channel, structures and floodplain) by 20%; and
- decrease in Manning's n roughness (channel, structures and floodplain) by 20%.

6.3.2 No sensitivity tests have been undertaken for the downstream boundary condition as the downstream boundary is 19.6km away from the AP2 revised scheme vent shaft relocation (AP2-007-003). This is considered sufficiently far downstream to ensure there is no effect at the AP2 revised scheme vent shaft.

6.3.3 The results indicate that the AP2 revised scheme model is sensitive to the manning's n parameter as well as the change in flows from a 53% to an 85% increase in peak river flow.

6.4 Blockage analysis

6.4.1 Blockage analysis has not been undertaken as there are no major constrictions on the River Mersey in the vicinity to the AP2 revised scheme relocated vent shaft and associated compound.

6.5 Run parameters

6.5.1 Run parameters from the Environment Agency 2012 model have been retained in the AP2 revised scheme model, with the following improvements/exceptions:

- MaxItr (the maximum number of iterations performed at each step) has been increased from 13 to 19 to enhance the likelihood of convergence during the iterative step process; and
- Theta has been increased from the value of 0.7 (default) to 1.0 to enhance computational efficiency via switching to a fully implicit numerical scheme.

6.5.2 All model runs have been performed using default run parameters in TUFLOW as recommended in the software literature.

7 Limitations

7.1.1 New topographic surveys were not undertaken and the AP2 revised scheme model was built using available information supplied in the 2012[5] and 2018[3] Environment Agency models.

7.1.2 One event, Storm Christoph, has been utilised in the calibration of this AP2 revised scheme model. However, further calibration and verification events will be undertaken as part of further design development.

8 Conclusions and recommendations

8.1.1 A 1D-2D AP2 revised scheme modelling approach has been selected to allow for effective modelling of the complex flood mechanisms in the Didsbury area. This modelling makes use of the original scheme model which is reported in the main ES (Volume 5, Appendix: WR-006-00009). The original scheme model was reviewed externally by a third party consultant in 2021. Following the updates to the original scheme model as a result of the third party review, the original scheme model was calibrated against the Storm Christoph event of January 2021. The calibration points used were the water level gauges at Northenden Weir, Stenner Lane and Withington Golf Course.

8.1.2 The AP2 revised scheme model results indicate that for the 1.0% AEP + CC event, the AP2 revised scheme will have minor impacts on peak flood levels. There will be a minor impact at two residential properties on Palatine Road (up to 0.016m increase in peak flood level) and a minor impact at the Withington golf course club house commercial property (a 0.017m increase in peak flood level). In addition, the loss of floodplain storage leads to a modelled increase in peak flood flow downstream of Princess Road. This has the potential to lead to minor increases in peak flood level downstream in areas already at risk of flooding. Further work is recommended to extend the model downstream to allow assessment of potential mitigation options to remove the increase in peak flood flows and volume downstream of Princess Road bridge.

8.1.3 The AP2 revised scheme model results indicate that for the 1.0% AEP event, the AP2 revised scheme will lead to earlier overtopping of flood defences at Northenden Golf Course and Beeches Mews, than currently occurs. This leads to a minor impact (0.024m increase in peak water level) at 14 residential properties at Beeches Mews and a moderate impact (0.065m increase in peak water level) at the Northenden Golf Course. There is also a localised effect just upstream of the AP2 revised scheme vent shaft relocation (AP2-007-003) with a minor impact on peak flood levels at one residential property on Palatine Road (0.016m increases in peak water level) and a moderate impact on peak flood levels at a second residential receptor on Palatine Road (with an increase in peak water level of 0.051m). These two residential properties on Palatine Road are the same receptors impacted in the 1 in 100 year + CC event.

8.1.4 The AP2 revised scheme model results indicate that the current proposed design achieves the freeboard requirements for the shaft.

Annex A: Flood level impact maps

The water level difference has been mapped for the 5.0% AEP and 1.0% AEP + CC events as described in Section 5, see Figure A1 and Figure A2.

Figure A1: The Hollies vent shaft impact map for 5.0% AEP (1 in 20 year) with AP2 revised scheme

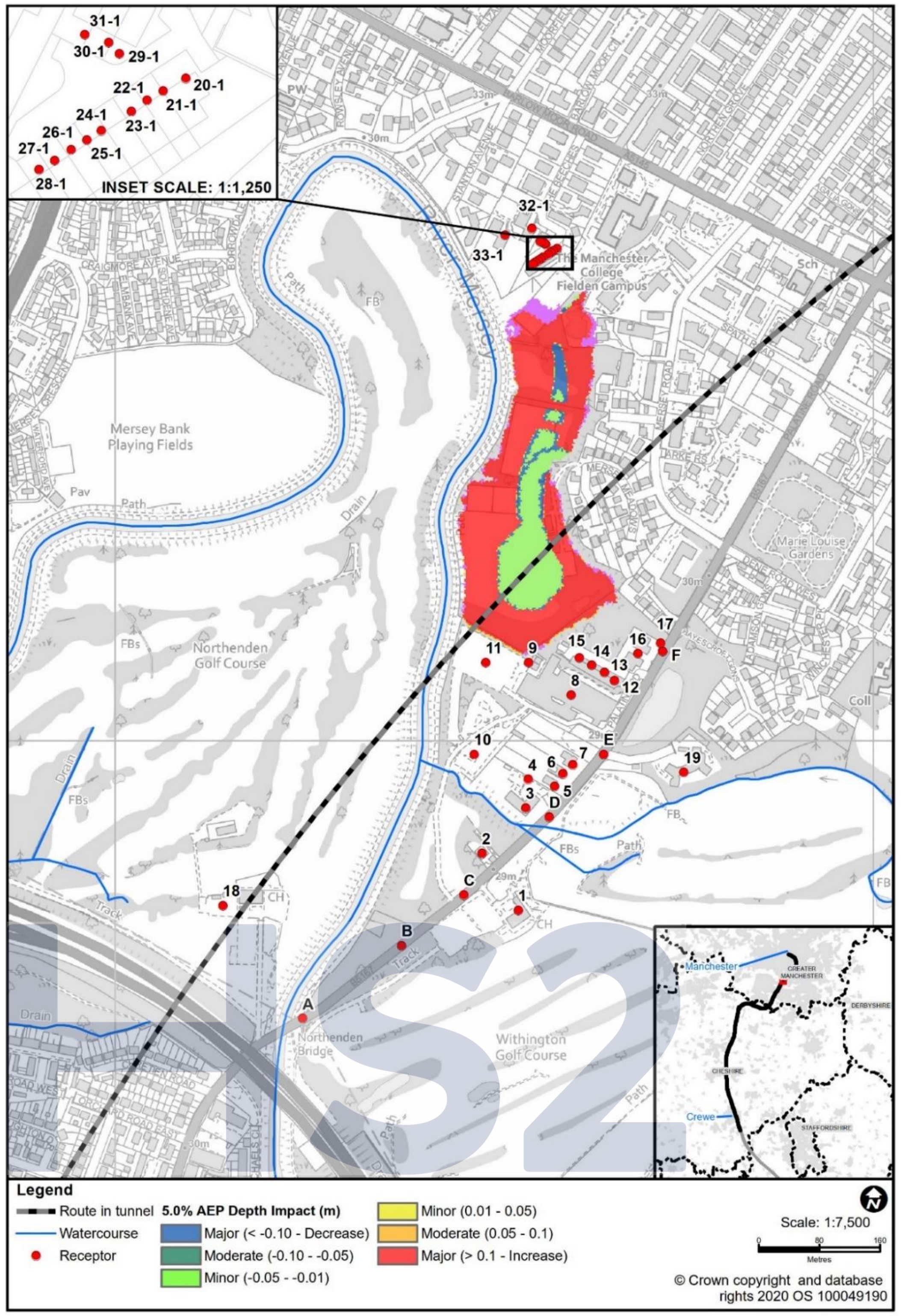


Figure A2: The Hollies vent shaft impact map for 1.0% AEP + CC (1 in 100 year plus CC) with AP2 revised scheme