Heathrow Airport Limited

Heathrow's North-West Runway

Assessment of Flood Risk

16 June 2014

AMEC Environment & Infrastructure UK Limited

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Non-Technical Summary

By 2015, the Airports Commission are to assess the options for meeting the UK's international connectivity needs, including their economic, social and environmental impact. This assessment will be carried out in accordance with their Appraisal Framework[1], which states in paragraph 1.3 that "*The Commission should base the recommendations in its final report on a detailed consideration of the case for each of the credible options. This should include the development or examination of detailed business cases and environmental assessments for each option, as well as consideration of their operational, commercial and technical viability*."

The extension of Heathrow Airport would require a Flood Risk SFtrategy to mitigate potential impacts of the proposed masterplan. This report provides technical assessment and details underlying Part 5.5 of the Enhancing the Natural Environment Strategy presented in of Volume 1 of Heathrow Airport Limited (HAL) submission to the Airports Commission[2]. It outlines how flood risk has been assessed and explains how the mitigation strategy was developed and refined to achieve betterment to the existing condition.

Modelling of the Flood Risk Strategy confirmed that:

- The concept of diverting water from the River Colne to the west under the M25 is credible. The gradient of the land permits the flow of water downstream, and there is sufficient space to construct a new spur channel;
- Through the use of engineered flow controls it is credible that river flows can be managed to ensure no increase, and in many places a reduction, in flood risk downstream; and
- There is ample space within the enhanced Colne Valley to configure a series of flood storage areas in order to attenuate displaced floodwaters and diverted river flows, ensuring that flood risk is not increased, and in West Drayton, Poyle and Colnbrook reduced.

This report details both the fluvial and groundwater flood risk strategies.

The effectiveness of the Flood Risk Strategy is demonstrated through the results of detailed flood modelling using a refined and enhanced version of the Environment Agency's (EA) integrated hydraulic model (built using ISIS-TUFLOW modelling software) of the Colne Valley.

The mitigation strategy consists of flow diversions, new channels and flood storage areas as well as flow control structures. Upstream of the M4 in West Drayton the flood risk is reduced as a consequence of diverting flow from the River Colne under the M25 to the west in the new River Colne Spur. Downstream of the M4, through Harmondsworth Moor, two proposed storage areas attenuate water upstream of the runway culverts, offering protection to West Drayton and the Airport itself. These attenuation areas also provide protection to the communities in Stanwell Moor by controlling the passage of flood waters to the south.

[1] Airports Commission (2014) Appraisal Framework. April 2014. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/300223/airports-commission-appraisal-framework.pdf

[2] Heathrow (2014) Taking Britain further – Heathrow's plan for connecting the UK to growth

High frequency low magnitude flood events (important for the wetland ecology) will be maintained downstream of the Airport in Staines Moor SSSI. As the River Colne enters the Thames at Staines-upon-Thames no increase in peak flow or water level was observed.

The two new flood storage areas west of the M25 and associated flow control structures will attenuate flood waters protecting Polye and Colnbrook. The strategy achieves a reduction in flood risk in these communities compared against the new flood risk baseline position that has been defined as part of the analysis documented in this report. A new baseline flood risk position has been defined by the refining the Environment Agency's flood model (**Section 5.5.1**) so that the mitigation strategy can be robustly tested.

The extent of flood risk is slightly reduced at the village of Horton as a consequence of the additional upstream storage and flow controls. No increase in peak flow or water level will result as the Colne Brook enters the Thames at Egham.

Overall, the strategy achieves its aim to ensure there is no increase in flood risk to residents or property, and where possible, provide betterment, as a result of the proposed masterplan.

The Flood Risk Strategy fits with the wider Natural Environment Strategy[2] harmonising with many aspects of the Landscape, Biodiversity, Water Quality and Hydroeceology as well as of the Sustainable Drainage Strategies which should be read in conjunction with this report.

Abbreviations

EA	Environment Agency
HAL	Heathrow Airport Limited
mAOD	metres Above Datum
NPPF	National Planning Policy Framework
SAF	Sustainability Appraisal Framework
SFRA	Strategic Flood Risk Asssessment
WFD	Water Framework Directive

Contents

1. Introduction

This report has been prepared by AMEC Environment & Infrastructure on behalf of Heathrow Airport Limited (HAL). To meet the growing need for additional air capacity, HAL has proposed an extension to the existing Heathrow Airport[3]. The proposed development would include:

- A 3,500 m runway to the north-west of the existing Airport;
- Two new terminal buildings;
- Aircraft movement areas and taxiways;
- Various aircraft stands (pier serviced stands and remote stands);
- Car parking; and
- Ancillary uses.

Further details of the development can be found in HAL's submission to the Airports Commission[3]. This report provides the technical assessment and details underlying Part 5.5 of the Enhancing the Natural Environment Strategy presented in Volume 1 of HAL's submission to the Airports Commission[3]. The assessment of potential effects with and without mitigation was undertaken in accordance with the Commission's Sustainability Appraisal Framework (SAF) as described below[4]. **Section 2** of the report describes the legislative and policy context relevant to the assessment. **Section 3** details the current baseline around Heathrow Airport. Potential effects of the proposed development without mitigation are presented in **Section 4**. In **Sections 5 and 6** potential effects with measures of the Fluvial and Groundwater Flood Risk Strategies are assessed, respectively. Conclusions resulting from the assessment are given in **Section 7**.

1.1 Airports Commission Requirements

The Airports Commission's objective for water and flood risk is "*to protect the quality of surface and ground waters, use water resources efficiently and minimise flood risk*". The Airports Commission's Appraisal Framework[4] will assess the potential risk of flooding resulting from airport expansion. The assessment will seek to ensure that an appropriate mitigation strategy accompanies development to ensure the Airport site and the local area is protected from flooding. The mitigation strategy will be evaluated on the basis of how flood waters will be managed within the local environment so that risk to people, property and communities is not increased now or in the future. This report presents the detailed analysis to underpin the proposed Flood Risk Strategy[3]. Engineering design and scheme optimisation will follow in due course.

[3] Heathrow (2014) Taking Britain further – Heathrow-s plan for connecting the UK to growth

[4] Airports Commission (2014) Appraisal Framework. April 2014. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/300223/airports-commission-appraisal-framework.pdf

1.2 Heathrow's Objectives

At the earliest stage of the development of Heathrow's mitigation strategies it was identified that there was an opportunity to provide a 'legacy' for the local area. To ensure that Heathrow met its flood risk and wider water, biodiversity and landscape requirements, specific technical strategies were produced where the overarching focus was to ensure that together they would meet Heathrow's overall objectives for the natural environment.

This report, upon which the Water Strategy has been developed, also sits alongside the Water Quality and Hydro-ecology Assessment[5] which has also been submitted to the Airports Commission. The primary objective is to develop a sustainable and effective strategy that will ensure flood risk is not increased, and protects river flows, water quality and aquatic ecology during and beyond the lifetime of the development that takes into account the potential impacts of climate change.

Our water strategy will achieve our objectives through:

- Realigning watercourses within the enhanced Colne Valley Park to move water sustainably around the airport, and in so doing form part of an enhanced landscape, limiting the amount of culverting required;
- Providing compensatory flood storage to replace the floodplain storage lost through the development. This means flood risk to people and property will not increase and where possible will decrease;
- Ensuring the downstream flow regimes are maintained so there is no adverse impact on water quality, ecology or on other water users;
- Maintaining connectivity of the aquatic habitat through the Colne catchment, utilising the River Colne and its distributaries across the Colne Valley; and
- Avoiding any effects on water quality across all water bodies, both surface water and groundwater, through channel design, best practice construction practices and monitoring during operation.

In doing this the strategy will meet the Airports Commission's requirements, particularly "to protect the quality of surface and ground waters, use water resources efficiently and minimise flood risk". It will also mean the requirements of local, national and European guidance, policies and legislation including the Water Framework Directive (WFD)[6], Foods Directive, UK Floods and Water Management Act and the National Planning Policy Framework (NPPF)[7] are met.

[5] AMEC (2014) Heathrow's North-West Runway – Water Quality and Hydro-ecology Assessment.

[6] European Parliament & Council (2000) Water Framework Directive (Directive 2000/60/EC).

[7] Communities and Local Government (2012) National Planning Policy Framework.

2. Legislative and Policy Context

The Flood Risk Strategy (which formed part of the Enhancing the Natural Environment Strategy) has been developed and tested against the local, national and European policies, legislation, as well as guidance which the Airports Commission will use to assess the proposals. The proposed strategy meets and exceeds these requirements.

Flood risk policies to be considered in any future development include:

- The EU Floods Directive (Directive 2007/60/EC)[8];
- The Flood and Water Management Act 2010[9]; and
- The NPPF[7].

The EU Floods Directive has informed the Flood and Water Management Act and the NPPF. These in turn form the foundation for regional and local government policies such as the London Plan and Local Development Frameworks.

The overarching message is that all development must consider and mitigate flood risk, ensuring risk is not increased as a consequence. The requirement of the NPPF that development should be safe in the event of flooding and must not increase flood risk elsewhere is of key importance. **Table A.1** (**Appendix A**) outlines the principal policies relevant to the development and flood risk.

[8] European Parliament & Council (2007) Directive on the assessment and management of flood risk (Directive 2007/60/EC)

[9] http://www.legislation.gov.uk/ukpga/2010/29/contents

3. Baseline

3.1 The Existing Environment

Heathrow currently sits across the boundary of two river catchments the River Crane and the River Colne. The Airport is bounded in the east by the River Crane, and some ancillary areas along the eastern boundary fall within the EA Flood Zones. The western and southern boundary is formed by the 'Twin Rivers' – the Duke of Northumberland's River and Longford River. Both rivers were "daylighted" (taken out of culvert) and diverted around the existing Airport boundary as part of the Terminal 5 development. The inflow to both of these rivers is controlled so does not pose a flood risk to the Airport. The River Colne flows to the west of the Airport boundary but does not pose a flood risk to the Airport itself. **Figure 1** provides an illustration of the river locations and names.

Although the Airport extends into both the River Colne and River Crane catchments, the proposed area of extension falls only within the River Colne catchment. The River Colne catchment is complex as it contains a number of different channels which branch and interlink along the length of the Colne Valley to the west the Airport. Five main rivers are present within the Colne Valley:

- River Colne;
- River Wraysbury;
- Colne Brook;
- Longford River; and
- Duke of Northumberland's River.

The Duke of Northumberland's River and the Longford River (the current 'Twin Rivers') are important watercourses but they do not have associated floodplains. The River Crane to the east of the Airport is a significant watercourse but it is not affected by the proposal.

The rivers can broadly be divided into two systems, one to the east and one to the west of the M25. **Figure 1** provides an overview of the river systems and EA Flood Zones in the area.

River Channels East of the M25 Motorway

Flowing from north to south, the River Colne and Colne Brook run parallel to each other through the Colne Valley south of Uxbridge. At the village of Thorney the Colne Brook flows west under the M25. The remaining course of the Colne Brook is described in the following section.

The River Colne continues southwards to the east of the M25 and is joined by the Fray's River in West Drayton. Upstream of the M4 the River Colne splits into two channels. The western branch forms the Wraysbury River and the eastern branch remains the River Colne, both continue to flow southwards under the M4 into Harmondsworth Moor.

Immediately to the south of Saxon Lake the River Colne channel divides again, with a western spur being taken off to form the Duke of Northumberland's River. The off-take is governed by an engineered flow control structure. Further south at Longford, a second spur is taken off the River Colne to form the Longford River. The Duke of Northumberland's River and Longford River are historic artificial diversion channels. The purpose of the Duke of Northumberland's River is to convey water around the Airport into the River Crane and then eastwards towards Syon Park and the River Thames at Isleworth. The Longford River on the other hand conveys water around the Airport then southeast to Bushy Park and the River Thames at Hampton Court. Both rivers were diverted around the existing Airport boundary as part of the Terminal 5 development and currently form the 'Twin Rivers'.

After the Longford off-take the River Colne flows southwards in the space between the western Airport boundary and the M25. The River Colne flows under the A3113 and through Stanwell Moor, where it splits again into a series of channels, including the Hithermoor Stream flood relief channel. Beyond Stanwell Moor the River Colne continues through Staines Moor SSSI, until it reaches Staines-upon-Thames where it is rejoined by the Wraysbury River and discharges into the River Thames.

The Wraysbury River flows south through Harmondsworth Moor then along the east side of the M25. Immediately to the south of Bath Road the Wraysbury River turns westwards and passes under the M25. On the western side of the M25 there is an off-take from the Wraysbury River which forms the Poyle Channel. The Poyle Channel takes the majority of flow from the Wraysbury River, through Poyle and towards its confluence with the Colne Brook in the west.

The remaining Wraysbury River continues southwards where the flow is managed by a series of flow control structures operated by the EA. At Staines Moor the Wraysbury River crosses back eastwards under the M25. From here it flows south-east to Staines-upon-Thames where it rejoins the River Colne and discharges into the River Thames.

River Channels West of the M25 Motorway

Once the Colne Brook has passed under the M25 it flows around the north western edge of Junction 15/ 4b of the M25/ M4, it passes under the M4 emerging in the vicinity of the Old Slade Lane sewage works. From here it continues to flow south-westwards around a series of lakes. The Colne Brook enters the village of Colnbrook south of the A4. The Colne Brook is formed of a number of different channels through Colnbrook, which are understood to be legacy channels associated with historic industrial activity in the area.

South of Colnbrook the Colne Brook has its confluence with the Poyle Channel. The combined channel of the Colne Brook then flows south to the east of the village of Wraysbury, discharging into the River Thames at Egham.

Additionally, the Horton Brook, which is not part of the Colne catchment, flows north-east to south-west from the M4 along the western boundary of Colnbrook village. It flows around the base of the Queen Mother Reservoir then flows south east through a series of gravel pit lakes.

Hydrogeology

Heathrow Airport and the surrounding area are underlain by a shallow aquifer known as the Taplow Gravels or Terrace Gravels. The gravels lie on London Clay, which in turn lies over a major Chalk aquifer. The Terrace Gravels are very permeable and are typically 3 to 6 m thick (the thickness varies across the site due to past gravel extraction). The groundwater levels in the Gravels are usually shallow and within 2 m of the ground surface. The London Clay is more than 50 m thick and prevents groundwater interaction between the gravel and chalk aquifers. Further hydrogeological details can be found in **Appendix B** of the Water Quality and Hydro-ecology Assessment[5].

3.2 Existing Flood Risk

Table 3.1 summarises the sources of present flood risk in the area in and around the proposed Airport expansion boundary (from Grand Union Canal in the north, to the River Thames in the south).

Table 3.1 Flood Risk Summary

Source of Flooding	Source Potentially Present	Notes
Fluvial	Yes	There are numerous fluvial watercourses in and around the development area. These each have an associated floodplain. The proposed Airport expansion intersects with areas of existing floodplain. This source of risk is discussed further in **Section 3.3**.
Groundwater	Yes	A potential risk exists in low lying areas around the Airport, given that the surrounding area is underlain by saturated gravel deposits, with groundwater levels close to the surface. This risk of rising groundwater levels leading to groundwater flooding is discussed further in **Section 3.4**
Surface Water	Yes	There is risk of surface water flooding. The EA surface water flood risk map shows there are pockets of high risk across the wider area. Surface water run-on will not pose a risk to the development site as it will be elevated. Surface water run-off from the Airport had the potential to increase risks elsewhere but this risk it mitigated by the Sustainable Drainage Strategy[10]
Sewer	No	There is no known risk of sewer flooding. This will be reassessed at a later stage in a detailed flood risk assessment.
Tidal	No	There is no tidal flood risk.
Artificial	Yes	There are a number of large water storage reservoirs to the south west. These raised reservoirs pose a residual flood risk in the event of a failure in the impounding embankment. Risk from these reservoirs to the new development will be assessed as part of a detailed flood risk assessment at a later stage. The high level review undertaken identifies these features as largely being to the south and therefore down slope of the Airport, as such the areas at most risk of failure are to the south of the reservoirs, not to the north like Heathrow Airport as this is upslope.

[10] AMEC (2014) Sustainable Drainage Assessment

3.3 Fluvial Flood Risk

3.3.1 Assessment Methodology

The baseline assessment of fluvial flood risk has been undertaken using the EA's Flood Zone Mapping information – provided to AMEC in January 2013. Two Flood Zones were provided:

- Flood Zone 2 represents land assessed as having between a 1% (1 in 100) and 0.1% (1 in 1,000) probability of river flooding in any given year; and
- Flood Zone 3 represents land assessed as having a 1% (1 in 100) or greater probability of river flooding in any given year.

Figure 1 shows the predicted flood extent associated with the main rivers in the area. The baseline assessment is focussed on the north-west runway masterplan area. The flood risk to the east of the Airport (from the River Crane – as discussed **in Section 3.1**) has not been assessed as it will remain unchanged in the event of the north-west runway being constructed.

3.3.2 Historic Fluvial Flood Risk

The River Colne catchment, in the vicinity of the Airport, has a long history of flooding. The most notable event took place in 2003, with other recorded flooding events occurring in 1987, 1993, 2000 and 2001. **Table 3.2** provides further details. There was also flooding in early 2014.

Table 3.2 Flood History

Flood Event	Details
1987	Flooding along the Colne Brook through Thorney, and along the River Colne through West Drayton and Harmondsworth Moor.
1993	Flooding along the Wraysbury River through Harmondsworth Moor, and along the River Colne through Stanwell Moor.
2000	Flooding along the Colne Brook through Colnbrook and Poyle, and along the River Colne through Stanwell Moor and West Drayton.
2001	Flooding along the Colne Brook through Colnbrook and Poyle, and along the River Colne through Longford.
2003	Flooding along the Colne Brook through Thorney, Colnbrook and Poyle, and along the Horton Brook through Colnbrook. Also along the River Colne through West Drayton, Harmondsworth Moor, Longford and Stanwell Moor.
2014	Flooding along the Colne Brook, County Ditch and Cottesbrook Ditch through Colnbrook and Poyle. Also along the Wraysbury River and River Colne through West Drayton and Harmondsworth Moor.

3.3.3 Present Day Fluvial Flood Risk

Five key settlements are identified as being at risk of flooding during a flood event which has a 1% chance (1 in 100 years) of occurring annually:

- Colnbrook;
- Poyle;
- Stanwell Moor;
- Longford; and
- West Drayton.

Colnbrook is at risk of flooding from both, the Colne Brook and Horton Brook, as well as smaller ditches (Cottesbrook Ditch and County Ditch). Poyle is shown to be at risk of flooding from the Poyle Channel and Colne Brook. Longford and Stanwell Moor are at risk of flooding from the River Colne. West Drayton is at risk of flooding from the River Colne, Wraysbury River and Fray's River.

The Airport itself is not shown to be at risk of flooding. However there are areas of floodplain located within the boundary of the north-west runway masterplan, these areas form the focus of the mitigation strategy.

3.3.4 Future Fluvial Flood Risk

The EA Flood Zones are based on present day climate conditions. In the future flood risk is predicted to increase due to climate change. In line with the Airports Commission SAF[4], flood risk needs to be assessed for a 1% (1 in 100 years) annual exceedance probability event (including an allowance for climate change).

To determine how flood risk may increase in the future the EA's Flood Zone 2 has been used as a proxy, since the higher return period event (1 in 1000 year or 0.1% AEP) can be used to indicate where increases in flood extent may be expected in the future as a consequence of climate change.

Using Flood Zone 2 as a proxy, notable increases in flood risk are observed in the following areas, which is independent of any airport development:

- Colnbrook and Poyle: between the A4 and Park Street and in the vicinity of the Horton Brook to the west;
- West Drayton: along the River Colne, Wraysbury River and Fray's River; and
- Stanwell Moor: along the River Colne and associated ditches.

3.3.5 Existing Fluvial Flood Defence Schemes

The EA has implemented a series of existing flood alleviation schemes within the wider River Colne catchment, which benefit local communities. These include:

- The Lower Colne Improvements Scheme (1999 – 2003), which includes the flood diversion channel at Stanwell Moor;
- The Tanhouse Farm Scheme (1996),along the Colne Brook through Colnbrook; and
- The Colnbrook Flood Alleviation Scheme (2005), which involved removing the fish pass at the Mill Street weir in Colnbrook, as well as works along the County Ditch/ Cottesbrook Ditch to the north of Colnbrook and Poyle.

3.4 Groundwater Flood Risk

Existing Strategic Flood Risk Assessments (SFRAs) were conducted by Slough Borough Council[11] and the London Borough of Hounslow[12]. The aims of the assessments were to:

- Collate known sources of flooding;
- Delineate areas of flooding;
- Recommend appropriate land use in areas of flood risk, and
- Recommend flood mitigation solutions that may be integrated into designs to minimise flood risk.

The London Borough of Hounslow had no incidents of groundwater flooding on record and stated that the risk of groundwater flooding was relatively low. The SFRA for Slough noted areas which are known to be at risk; including parts of Colnbrook, directly west of Heathrow. Groundwater flooding in Colnbrook has been attributed to a reduced cross sectional area of the aquifer through which groundwater could flow, leading to an increase in local hydraulic gradient (and hence water levels) as water is funnelled between impermeable sub-surface features. Examples of such features noted by Slough Borough Council include:

- The in-filling of sites excavated for sand and gravel (usually sealed and used for landfill);
- The construction of Queen Mother and Wraysbury reservoirs; and
- The development of Thames Water’s Iver South Sludge Treatment Works.

The thickness of the Terrace Gravels is variable across Heathrow and in the Colne Valley, a consequence of both natural variation and as a result of past gravel extraction. The Gravels are also heterogeneous, with layers of silt and clay interbedded with the gravels. Overall the shallow and unconfined Gravels have a high permeability. As a

[11] Slough Borough Council (2007) Strategic Flood Risk Assessment.

[12] London Borough of Hounslow (2007) Strategic Flood Risk Assessment.

consequence, they can readily accept recharge from rainfall and groundwater can flow easily though the aquifer. The contours of the water levels in the Gravels are displayed in **Figure 2**, where each contour represents the elevation (in mAOD) of the water table. The groundwater levels in the Gravels have a shallow gradient, with a general flow direction from north-east to south-west.

However, local variations in the groundwater do occur, as seen in **Figure 3**. Local groundwater conditions have been assessed in the past. For example, a study conducted by Cremer & Warner[13] investigated the groundwater conditions in the former Perry Oaks site, where the Terminal 5 building is located. An impermeable 'clay curtain' was installed originally to isolate the Perry Oaks site (of a sewage treatment works and fuel farm) from the gravel aquifer. The groundwater contours in **Figure 3** display discontinuity across the 'clay curtain', confirming the isolation of groundwater within the site and the aquifer outside of the site. For example, in the north-west of the area enclosed by the 'clay curtain' the groundwater elevations are approximately 20.0 mAOD, whereas the external area to the north is approximately 50 cm higher (20.5 mAOD).

As the 'clay curtain' was retained during construction of Terminal 5[14] it is therefore likely that the general flow directions remain similar today. From **Figure 3** it is noted that in the residential area of Longford, north of the former Perry Oaks site, there is an area of elevated groundwater which is not observed in regional contours.

The general groundwater flow direction within the gravels is towards the south/ south-west across Heathrow; however, such observations confirm that the flow direction in the gravel aquifer can be locally variable.

[13] Cremer & Warner (1993) Summary of ground conditions in the vicinity of Perry Oaks, Heathrow

[14] Dames & Moore (1994) Phase I desk study and scoping exercise – Environmental assessment of Perry Oaks fuel depot, Heathrow Airport

4. Effects before Mitigation

4.1 Fluvial Flood Risk Effects

The impact of the proposed expansion on flood risk in the wider area (from Grand Union Canal in the north, to the River Thames in the south) and flood risk to the proposed assets is considered.

The proposed masterplan intersects a number of watercourses including: River Colne, Wraysbury River, Colne Brook, Longford River, and Duke of Northumberland's River. In total 12.6 km of watercourse lie within the boundary of the proposal and will be lost without mitigation. **Table 4.1** shows the length of each watercourse lost.

Within the boundary of the north-west runway masterplan an estimated 155,000 m^3 (155 mega litres) of floodplain storage in the 1% annual exceedance probability event (including an allowance for climate change event) will be lost. In addition to the loss of direct floodplain storage, there will be a loss of floodplain flow routes which connect areas of storage north of the runway to areas south of the runway. The effect of losing these flow routes means that there is a further reduction in the available floodplain storage as the disconnected storage areas cannot be utilised in a flood event. Therefore without mitigation the floodplain storage volumes in the Colne Valley would be reduced and flood risk to local communities and the Airport would increase.

Table 4.1 Length of Watercourse Lost (km)

Watercourse	Length Lost (km)
Duke of Northumberland's River	3.6
Longford River	2.4
River Colne	3.4
Wraysbury River	1.8
Bigley Ditch	0.3
Colne Brook	1.1
TOTAL	12.6

In addition to lost floodplain storage, the flow regime in the rivers of the Colne Valley will also be substantially altered, to the extent that the water supply to lower reaches of some of the rivers will be cut off. Substantial changes to the water environment of this kind will have impacts on aquatic and riparian habitats, water quality, and downstream users such as agricultural abstractors. These effects are described in full detail in the Water Quality and Hydro-ecology Assessment[5].

Without mitigation measures the proposed masterplan will fail to meet European, national and local legislative requirements, polices and guidance. The effects of the masterplan have not been simulated using the hydraulic model (described in **Section 5.5**) as a qualitative assessment is sufficient to demonstrate the need for a robust, comprehensive and integrated Fluvial Flood Risk Strategy.

4.2 Groundwater Flood Risk Effects

The proposed masterplan has the potential to effect groundwater flood risk during construction and operation.

4.2.1 During Construction

Dewatering

To enable the construction of basement features localised dewatering of the gravel aquifer, achieved by groundwater abstraction, may be necessary. Due to the physical properties of the gravels, dewatering a local site has the potential to impact a large area of the surrounding aquifer. There is also the possibility that the uncontrolled disposal of the abstracted groundwater to the ground surface may cause localised flooding if not suitably managed.

Temporary Works

Areas of land will need to be prepared to enable construction of foundations. This is likely to involve removal of gravel deposits and made-ground, and the insertion of supporting structures (e.g. coffer dams). Material may then be used to infill the ground, for example during construction of tunnels, which may alter the aquifer's hydraulic properties. Reducing the lateral permeability of the sub-surface, may restrict groundwater movement, leading to local rises in the water table and changes to groundwater flow direction and hence increase the risk of localised groundwater flooding.

4.2.2 During Operation

Impermeable Barriers

The construction of impermeable foundations or concrete clay lined water bodies will act as barriers to groundwater flow. These impermeable barriers will reduce the area in which the groundwater is able to flow, which may cause groundwater levels to rise as water builds up, or a 'funnelling' effect of water between impermeable barriers.

This may be especially important for the Terminal 6 Satellite as it is approximately 1km in length and orientated east-west (**Figure 4**). Depending on its design, the building's basement structure may prevent the general movement of groundwater flowing south-west and may cause impounding of groundwater along the northern perimeter of the structure. The presence of historic landfills may restrict groundwater movement even further, resulting in rising groundwater levels to the west and increasing the risk of localised groundwater flooding.

4.3 Impacts on Other Sources of Risk

Impacts of the proposed expansion on surface water flood risk are detailed in the Sustainable Drainage Assessment[10].

The development should not impact on any other sources of flood risk, but this will be confirmed at a later date as part of a detailed flood risk assessment.

5. Fluvial Flood Risk Strategy

5.1 Mitigation Strategy Methodology

This chapter restates the strategy presented within the masterplan submission. This has been undertaken in order for this report to be read as a 'stand alone' document. Throughout the description of the strategy additional detail has been provided to assist the Airports Commission and their consultees in better understanding the mitigation strategy. However, there is no deviation from the strategy which was set out and costed for in the masterplan submission documents.

The Flood Risk Strategy has been developed in synergy with the wider Enhancing the Natural Environment Strategy[3], so as to maximise benefits and achieve the greatest levels of enhancement. The method for developing the strategy has been:

- Evolve the masterplan to avoid impacts where possible (**Section 5.2**);
- Develop an interlinked series of measures to achieve a hydraulically sound Flood Risk Strategy (**Section 5.3**);
- Justify the key components of the strategy, detailing why other options were not taken forward (**Section 5.4**);
- Credibility testing of the strategy against the baseline condition, using the refined ISIS-TUFLOW model of the Colne Valley (**Section 5.5**); and
- Assessment of effects of the mitigation strategy (e.g. impacts after mitigation) in **Section 5.6.**

The strategy aims to ensure the new Airport development is not at risk of flooding and ensure that people and properties upstream of the M4 in West Drayton and downstream of the Airport in local communities including Stanwell Moor and Colnbrook are not placed at an increased risk of flooding.

5.2 Evolution of the Masterplan

Since HAL's initial submission of the north-west runway masterplan to the Airports Commission in July 2013 the masterplan has been developed further to optimise the environmental impacts. The evolution of the north-west runway masterplan has, reduced and avoided adverse impacts on flood risk as much as is practically possible.

The following changes/ additions to the masterplan have reduced the impact of flood risk in the vicinity:

- The new runway has been moved southwards and its spatial extent reduced preserving more of the natural river channel and floodplain within Harmondsworth Moor;
- The new runway has been elevated at its western end by 2 m to allow the watercourses to pass under the Airport in the shortest possible culverts and without the need for pumping;

- The overall reduction in the spatial extent of the north-west runway masterplan preserves more of the existing floodplain, reducing the volume of compensatory floodplain storage required; and
- Space has been made for a river corridor between the western boundary of the Airport and the M25. This minimises the length of culvert required under the Airport.

5.3 Fluvial Flood Risk Strategy

The complex nature of the river channel configuration and floodplain environment within the Colne Valley necessitates a mitigation strategy that is comprehensive and interlinked. A series of standalone interventions at individual points of flooding will not achieve a credible and effective solution. Therefore a system-wide approach has been taken, considering the flow routes along the valley, to develop a strategy that includes river channel diversions and the creation of new rivers. Furthermore, the strategy creates new areas of floodplain storage, utilising areas of green open space to the west of the Airport boundary. This approach has been taken in preference to using hard engineering solutions. The strategy does not simply convey more water through the floodplain, it retains the water within the landscape to ensure that flood risks are reduced wherever possible, and that there is no increase in flood risk at any point.

The following sections describe the Flood Risk Strategy in more detail. The measures which will be introduced to the east of the M25 are described first, followed by the description of the measures that will be implemented to the west of the M25. **Figure 5** shows the proposed Flood Risk Strategy graphically.

5.3.1 To the East of the M25 Motorway

North of village of Thorney a new length of watercourse will be constructed to divert flow from the River Colne to the Colne Brook (the route of this new river is detailed in the next **Section 4.3.2**). The River Colne will continue to flow southwards along its current course. The off-take to the new river (hereafter called the River Colne Spur) will reduce the volume of water flowing down the River Colne/ Wraysbury River towards the Airport. Reducing the flow (assumed by $6m^3/s$ at the peak of a 1% AEP including an allowance for climate change event) in the River Colne. This reduces the current flood risk situation in the community of West Drayton. The strategy will maintain the overall mass balance of the flood flows and preserve ecological important low flow regimes. The strategy for ensuring that low flows regimes for ecological purposes will be maintained are presented in the Water Quality and Hydro-ecology Assessment[5].

As the River Colne flows past West Drayton it will continue to split to form the Wraysbury River and the two watercourses will retain their current channels as they pass under the M4.

In the south of Harmondsworth Moor (in the vicinity of where the re-aligned A4 road will cross) the two rivers will be combined into a single ‘feeder channel’ which will flow into a twin bore culvert passing southwards under the north-west runway. The culvert bores will be designed so as to allow access for maintenance and there will be low level shelf for animals to migrate along. Optimisation of the culverts for fish passage and low flow conveyance are detailed in the Water Quality and Hydro-ecology Assessment[5].

As the Wraysbury River and the River Colne enter the 'feeder channel' a combination of weirs and sluices, with associated fish passes, will manage the discharge into this combined channel. Flow control at this point is important as it restricts the flow passing through the culverts and ultimately the peak flows being conveyed southwards to Stanwell Moor and Poyle. The flow controls are the trigger mechanism for activating the flood storage areas in Harmondsworth Moor. The provision of new floodplain storage within Harmondsworth Moor effectively manages the risk of flooding to the Airport and it compensates for the lost floodplain storage that was present between Harmondsworth Moor and Stanwell Moor. The storage areas in Harmondsworth Moor (totalling an area approximately 135,000m^2) effectively allow water to spread out within the landscape rather than backing up into West Drayton. The first storage area is an area between the Wraysbury River and River Colne and the second storage area is south of Saxon Lake.

As the River Colne flows southwards through Harmondsworth Moor (before entering the culvert feeder channel) there is an off-take to provide flows for what becomes the Duke of Northumberland's River. The off-take will remain and enter a separate smaller culvert which will run parallel to the main culvert under the north-west runway.

Downstream of the north-west runway, the culverts will outfall into two new channels. The larger of the two channels will form the combined River Colne and Wraysbury River; and the smaller of the two will form the combined Duke of Northumberland's River and Longford River. At present these two watercourses form the Twin Rivers and flow round the Airport in separate channels. The strategy is to retain them in a single channel until further along their course. This channel will run southwards along the boundary before passing into the Airport and flowing through the 'Airport City' area in the south west corner of the masterplan. The channel will then head eastwards and join the current Twin River channels just east of the Terminal 5 and 6 access road. At this point the flow will be divided to maintain present day downstream low flow regimes.

The combined Colne and Wraysbury rivers channel, which will flow southwards between the M25 and the edge of the Airport, will then split to form the current constituent river reaches: an off-take channel will be diverted westwards under the M25 motorway (utilising the existing Wraysbury River crossing) where it will split to form the Wraysbury River and the Poyle Channel. The main channel will then continue to flow southwards and reconnect with the current River Colne upstream of Stanwell Moor. As noted above, the current flow regimes in the River Colne and Wraysbury River will be maintained through a combination of existing and new flow control structures. The only difference will be a reduced flow into the Poyle Channel (the flow will be reduced by the same proportion as the flow off-take down the new River Colne Spur). The flow regime downstream of the Poyle Channel in the Colne Brook will be maintained, as water that would have been flowing down it will then be joined by the new River Colne Spur which joins the Colne Brook at its confluence with the Poyle Channel.

The low flow regime in the Wraysbury River, Colne Brook, River Colne, Duke of Northumberland's River and Longford River will be unchanged and there will be no increase in flood risk.

5.3.2 To the West of the M25 Motorway

The River Colne Spur diversion channel will flow from the River Colne at Thorney southwards through Thorney Golf Course where it will have a confluence with the Colne Brook. Thorney was chosen as the optimum place to off-take water from the River Colne to the Colne Brook as the Golf Course provided adequate open space to construct a new watercourse. The length of the Colne Brook channel from the new confluence to the M25 will be enlarged to increase the capacity of the channel. An increased channel capacity is needed to ensure that water levels do not increase from present estimates and thus ensure that people and property in Thorney are not put at increased flood risk.

The strategy will utilise the existing M25 crossing. Downstream of the M25 the channel will then divide; one part of the diversion will become the existing Colne Brook with current day low flow regimes maintained and the other part of the diversion will form the River Colne Spur (in the form of a new ecologically enhanced channel flowing through the landscape). Both watercourses will pass under the M4 motorway - the existing Colne Brook will utilise the existing crossing and a new crossing (in the form of multiple parallel culverts) will be introduced to the west, under the M4, to allow the River Colne Spur to continue southwards.

The area upstream of the M4 and to the west of the M25 will form the first flood storage area in this western portion of the strategy. The area will be completely landscaped to provide ecological enhancement and up to 194,000m^3 of flood storage capacity. This storage area will be configured to become active when the water level in the River Colne Spur reaches a trigger level. This will allow the attenuation and storage of the peak of the hydrograph, 'flattening' the hydrograph. This will act to contain the peak flood which would have previously travelled down the Poyle Channel but which is now travelling down the River Colne Spur. The stored water will then be released on the receding limb of the hydrograph so as to not increase flood risk downstream.

South of the M4 motorway the existing Colne Brook will follow its current course for a short distance before being diverted into a new ecologically enhanced channel around the western end of the north-west runway. This channel will then connect with the existing Colne Brook south of the A4, immediately upstream of Colnbrook village. From here it will continue unchanged, southwards towards its confluence with the Poyle Channel. On the south side of the M4 motorway the new River Colne Spur will flow south-westwards towards the Horton Brook where it will pass under the A4.

In the area between the M4 motorway and the A4 the second area of new floodplain storage is provided. This storage area will be configured to act as a natural floodplain along the Colne Brook. The ground and bank spill levels will be lowered to the same level to allow water to naturally spill and spread across the new floodplain, an embankment will be in place just upstream of the A4 to confine the flooding to this designated area. This storage area should provide approximately 127,000m^3 of storage and provides compensation for storage lost under the proposed runway and ensures that peak flows downstream of the A4 road are not increased in the 1% AEP event (including an allowance for climate change). The release of water from the storage area will be controlled and will only occur on the receding limb of the flood hydrograph. This will act to ensure flood risk is not increased downstream by maintaining a lower peak for a longer duration.

The final element of the Flood Risk Strategy is to link the River Colne Spur back to the Colne Brook and thus complete the diversion and maintain the overall mass balance in the system. South of the A4 the River Colne Spur will flow parallel to the Horton Brook to the west of the village of Colnbrook. To avoid any interaction of flows with the Horton Brook, a short reach of the Horton Brook will be realigned into a new ecologically enhanced channel slightly to the west of its current alignment. The realignment of Horton Brook makes space for the River Colne Spur to pass through the Crown Meadows parkland (which exists between Brands Hill and Colnbrook) without any interaction with the Horton Brook flows. The River Colne Spur will utilize the existing Horton Brook channel along this reach, the existing channel will be enlarged to contain the flow. In addition defence works may be needed along the small drain which discharges into the existing Horton Brook channel. This is to ensure no adverse impacts on flood risk along its length as a consequence of it now draining into the new spur channel which will have a different flow regime to the existing Horton Brook.

Once through Crown Meadows, the River Colne Spur will then flow southeast under the Horton Road around Popes Close and continue down to rejoin the Colne Brook at Poyle and in so doing complete the Fluvial Flood Risk Strategy. The area between Horton Road and Colne Brook is being re-landscaped and will include a series of wetland areas. These areas have to potential to be landscaped so they offer additional flood storage in extreme events. They will not be designed as purpose built flood storage areas, rather wetland areas which have the capacity to accommodate flooding should an extreme event occur.

Outside of the flood storage areas, all new channels will be designed to contain the 1% AEP peak flow, including an allowance for climate change, to ensure that flood risk is not increased. The channels will be two/ three stage channels, and be designed to maintain an appropriate low flow regime and provide ecological habitat.

5.4 Rationale for the Key Elements of the Strategy

Sustainability has been a key factor in developing the strategy. The strategy provides a solution that also improves local landscape and recreational provision, and is of high value for biodiversity maximising ecosystem services through the development of a multifunctional landscape.

The strategy has three key elements:

- Channel diversion moving water from the River Colne across to Colne Brook;
- Some culverting under the runway; and
- A series of flood storage areas.

These elements were selected as the optimum way of achieving the aim of the mitigation strategy. The following sections provide information as to why these elements were selected over alternative options.

5.4.1 Why are Diversions Required?

The strategy includes the diversion of water from the River Colne (upstream of its split into the Wraysbury River) across to the Colne Brook and around the west of the new Airport boundary in the enhanced Colne Valley. Possible alternatives to diversions were considered. These sought to maintain the rivers as separate channels, culverting them along their current alignment under the Airport.

To maintain the current flow regime (e.g. without diversion) downstream of the Airport in the River Colne and Wraysbury River, very large culverts would be required under the runway. Conveying the river flows in culverts would not address the floodplain storage issue as without attenuation flood risk will be increased downstream.

Two attenuation options were available, underground, or upstream. Underground flood storage solutions were ruled out at the start of the process on the grounds of sustainability, credibility, feasibility and the potential residual risks to the operational Airport. The provision of sufficient upstream storage, without increasing water levels in West Drayton, would likely require the complete removal of all high ground in Harmondsworth Moor. This was dismissed as an option on the grounds of landscape impact and ecological impact and the lack of potential to reduce current levels of flood risk in West Drayton.

Culverting the rivers along their current alignment was dismissed as an option on the grounds of sustainability, adverse impacts on the water environment and a lack of potential to provide the required ecological mitigation needed within the enhanced Colne Valley. The biodiversity strategy requires the re-provision of ecologically valuable watercourses. Only a new diversion can achieve this level of habitat creation.

River diversions have been preferred over in situ culverting because this solution provides additional benefits for hydroecology, flood risk, sustainability, and fish passage.

5.4.2 Why is Minimal Culverting Required?

Alternative options to avoid any culverting of the River Colne, Wraysbury River, Longford River and Duke of Northumberland's River were investigated but none were found to be credible.

Moving the rivers so they flowed around the new Airport boundary was considered, but was discredited as an idea for two reasons:

1. It is not physically possible to bring the water round the northern boundary due to the constraints associated with the realignment of the M25. Specific constraints were associated with the complex arrangement of both rising and falling slip roads and the main carriageway clearance requirements; and

2. Channel gradients would have been too shallow to maintain downstream flow regimes, especially along the Longford River and Duke of Northumberland's River. Pumping would be required, which is unsustainable.

Alternative diversions north of the M4 and some further to the north of the proposed Thorney off-take were initially reviewed, the objective being to avoid the need for culverting. But in all cases, the only way of avoiding culverts was to divert all of the River Colne, Fray's River and Wraysbury River, to the west around West Drayton. The adverse ecological and landscape impacts of these options were considered to outweigh the impacts of minimal culverting.

5.4.3 Why are Flood Storage Areas Required?

It is necessary to re-provide the volume of floodplain storage lost as a consequence of the proposed runway. The strategy has chosen to utilise flood storage areas for this purpose.

Alternatives were discussed including underground storage and raised flood defences.

- Underground storage: smaller scale ‘Tokyo style[15]’ underground flood chambers were discussed, but ruled out due to the high maintenance cost, low environmental benefit and lack of sustainability (flood water would have to be pumped back out); and

- Raised flood defences: Raised flood defences along the banks of the rivers would allow for additional flood storage within the channel. This is not a sustainable option as ongoing maintenance and inspection would be required. Aesthetically it would result in the disconnection of the surrounding population and landscape from the rivers.

Flood storage areas are designed to be landscape features with a multifunctional use, therefore dovetailing with the landscape section of the wider Enhancing the Natural Environment chapter[3].

5.5 Testing of Fluvial Flood Risk Strategy

Section 5.3 describes the strategy and **Section 5.4** provides the rationale for why the key components of the strategy have been incorporated. This section presents describes how the strategy has been tested and the results of that testing.

To test the strategy AMEC has undertaken detailed hydraulic modelling for the purpose of testing options. The Lower Colne hydraulic model was obtained from the EA and refined for this assessment. The primary refinement was to adapt large areas of the floodplain model so that all floodplains had the functionality to fully represent 2-Dimensional (2D) flow. This adaptation represents a large scale enhancement of the model provided by the EA as 2D representation is widely accepted as being a superior approach. Refining the existing model allowed to demonstrate the robustness and credibility of the strategy. The refined model was used to define a new base case (1% AEP event including an allowance for climate change). Refinement was required as it was not possible to compare results of scenario modelling with the current EA baseline model.

Section 5.5.1 describes how the baseline model was refined. **Section 5.5.2** describes how the strategy was represented in the model. **Section 5.6** describes the result of the testing.

5.5.1 Environment Agency Lower Colne Model refinements

The EA model of the Lower Colne includes the River Colne, Colne Brook, Wraysbury River, Duke of Northumberland’s River, Longford River and Horton Brook. This model was used to produce the EA Flood Zones. The Lower Colne model is a 1D-2D ISIS-TUFLOW model. However a significant section of the EA model south of the M4 is 1D only. Flood outlines and depths from 1D only models have recognised limitations, a 2D representation of the floodplain, provides more accurate flood extents. For this investigation the area south of the M4 is critical, as this is where the Airport expansion is proposed. Therefore it was decided to refine the EA model to create a fully 1D-2D model for the Lower Colne.

[15] The Metropolitan Area Outer Underground Discharge Channel is located in the Greater Tokyo Area of Japan. The system channels flood waters from the rivers within Toyko through a series of tunnels to a huge underground storage tank where the water remains before being pumped out to the Edogogawa River downstream. http://www.ktr.mlit.go.jp/edogawa/gaikaku/

The main refinements made to the Lower Colne model were:

- The original model extent was reduced to focus on the area of interest;
- The 1D representation of the floodplain, including small ditches, was removed, and replaced with a 2D representation based on LiDAR digital terrain data; and
- The fish pass on the Colne Brook at Mill Street, Colnbrook village was removed[16].

No other changes were made to the original model; it was assumed the original EA approved model was fit for purpose.

The new fully 1D-2D model was run for the 1% AEP event (including an allowance for climate change).

Differences were observed between the EA Flood Zones (which were derived from the original EA model) and the new model results. Some differences are attributed to the different return periods being used (Flood Zone 3 is equivalent to the present day 1% AEP event, Flood Zone 2 is equivalent to the present day 0.1% AEP event). Other differences are as a consequence of representing the banks of the Poyle Channel, Horton Brook and River Colne in the 2D model using LIDAR terrain data. In places the LIDAR shows the banks lower than originally modelled in the 1D model. Consequently, water now spills into the 2D domain and floods locations which were previously 'dry'. Resulting in flood extents larger than those indicated by the EA flood Zones. The differences observed between the modelled extents and the EA Flood Zones will be discussed with the EA at a later date, and investigated further as part of a detailed Flood Risk Assessment.

The results of this new 1D-2D modelling have been used to inform the development of the mitigation strategy. The new 1% AEP (plus climate change) results were also used to measure the credibility of the proposed mitigation strategy.

5.5.2 Representation of the Fluvial Mitigation Strategy in the Model and Assumptions

Please note that all the modelling is preliminary at this stage and is subject to some alteration during the design process. This reflects the fact that there will be ongoing adaptation to optimise the strategy in consultation with stakeholders.

The 1D-2D model was reconfigured to represent the Flood Risk Strategy. The individual aspects of the strategy have not been through detailed engineering design at this early stage but basic hydraulic principles were used combined with modelling iterations to estimate the dimensions and details associated with various parts of the strategy including: size of new channels and culverts; flow stage relationships; flow split percentages; floodplain spill levels; and flood storage area dimensions. These details and dimensions are not final, but an estimate at the current time of how the scheme may be configured, the details are therefore subject to change as the strategy

[16] Environment Agency (March 2010) Working with Natural Processes to Manage Flood and Coastal Erosion Risk

develops and enters the detailed design stage. **Table 5.1 to Table 5.4** below provide details of how the various parts of the strategy have been represented in the model to date. The following four sections focus on:

- Flow control structures;
- Flood storage areas;
- River channels; and
- Structures (e.g. new culverts).

The modelling has confirmed (**Section 5.6**) that the mitigation strategy is credible and achieved the objectives that were established at the outset of the project. Please note details of the various components of the scheme such as the channels, flood storage areas and flow control structures have not been through an engineering design or optimisation process. The testing only considered the 1% AEP event (including an allowance for climate change). Aspects of the model such as the details pertaining to the flow control structures will need to be optimised for low flow regimes as well as for high flows in due course.

Flow Controls

A key element of the strategy is the combining of flows from different watercourses and subsequent splitting of flows back into their various original channels, further down the valley. To represent flow splits simple ISIS flow-head control units were used. For each flow–head control unit a series of flow and water level data series are input to define the control. The flow control unit works by controlling the amount of flow downstream for a given water level upstream. The flow–water level relationships used in the model have been derived by plotting the water level against flow for a given cross section and design event (1% AEP plus climate change). The linear relationship between them was then used to provide the input into to ISIS flow-head control units. **Table 5.1** details the flow control units added to the model.

In subsequent stages of the design process, the current flow control units will be replaced in the model with designed structures such as sluices and weirs. At this stage, flow control units are considered appropriate for demonstrating the credibility of the strategy.

Table 5.1 Details of Flow Control Units

Mitigation Scheme Feature	Details
Flow control off-take from River Colne to the Duke of Northumberland's River	Flow-water level relationship as original model limited to 3m^3/s
River Colne flow control into runway culvert feeder channel	Flow-water level relationship for channel section limited to 9.5m^3/s
Wraysbury River flow control into runway culvert feeder channel	Flow-water level relationship for channel section limited to 9.5m^3/s
River Colne, Wraysbury River and Poyle Channel flow split upstream M25. Two flow control structures 1. River Colne, 2. Poyle Channel.	Flow-water level relationship for upstream combined channel section calculated. Flow was proportioned accordingly for the River Colne and Poyle Channel. 50% River Colne 7.5% Poyle Channel The remainder of flow directed down the Wraysbury River.
Flow control structure at Longford River off-take from new Duke of Northumberland's combined flow channel	Flow-water level relationship for channel section limited to 0.9m^3/s
Off-take to River Colne Spur	35% of River Colne flow at Thorney abstracted and input into the River Colne Spur channel. Equates to a peak of 6m3/s for the 1% AEP with climate change event. Maintains the shape of River Colne hydrograph down the River Colne Spur.
River Colne Spur & Colne Brook flow split downstream of M25. Two flow control structure.	Flow-water level relationship for upstream combined channel section calculated. Flow was proportioned accordingly for the River Colne Spur and Colne Brook. 48% River Colne Spur 52% Colne Brook
River Colne Spur flow control to force water into M25-M4 flood storage area	Flow-water level relationship for channel section limited to 6.24m^3/s
Colne Brook flow control from flood storage area	Flow-water level relationship for channel section limited to 7.2m^3/s

Flood Storage Areas

Four new flood storage areas are proposed as part of the strategy. These are included in the 2D TUFLOW model by modifying the ground levels across a certain area. Once the water levels in the 1D ISIS nodes (connected to the storage area) reach the bank spill level water will leave the 1D ISIS model and be attenuated in the flood storage area. There are two types of storage area used in the strategy:

1. **Storage areas which act like natural floodplain**: In these instances the ground and bank spills levels are lowered to the same level to allow water to naturally spill and spread across the new floodplain. These are generally impounded by an embankment or high ground at the downstream to confine the flooding to a designated area. These start to store water on the rising limb of the hydrograph. They can be configured to offer flood storage in lower return period events as well. They should naturally drain as the flood recedes. This type of storage area is used in the two locations in Harmondsworth Moor and in the storage area just north of the A4 on the west side of the M25; and

2. **Storage areas which are only activated in high flow events**: These have a bank spill level higher than the invert of the flood storage area. They are generally impounded around their entire length with a section of the embankment set to a lower level where water is designed to enter the storage area. They are designed to removed the peak of the hydrograph, 'flattening' the hydrograph. An outfall structure is required to drain this type of storage area after the flood event. The 'drawdown' has not been modelled, but in due course this will be represented – discharge from the storage area will occur at a defined point on the receding limb on the hydrograph. This type of flood storage area is deployed north of the M4.

Table 5.2 provides an overview of the flood storage areas included in the model.

Table 5.2 Details of Flood Storage Areas

Mitigation Scheme Feature	Dimensions
Harmondsworth Moor flood storage area 1 (between River Colne and Wraysbury River)	Area: 37000m^2 Invert: 23m Bank spill level:23m
Harmondsworth Moor flood storage area 2 (South of Saxon Lake)	Area: 64000m^2 Invert: 23.5m Bank spill level:23.5m
M25-M4 flood storage area	Area: 243000m^2 Invert: 22.3m Bank spill level:23.1m Bank spill 500m left bank of River Colne Spur.
Colne Brook flood storage area	Area: 127000m^2 Invert: 21m Bank spill level:21m

River Channels

A series of new river channels are included in the strategy. For the purposes of modelling the channels, simplified rectangular and trapezoidal channels were assumed. The two or three stage ecologically enhanced channels which will ultimately be constructed were not represented in this initial phase of the credibility testing. The Manning's equation was used in places to ensure that channel width and depth was adequate to convey the necessary flow. Channel inverts were informed by the existing channels in the area, and gradients were assumed to be constant. **Table 5.3** outlines the details of the new channels.

Table 5.3 Details of New River Channels

Mitigation Scheme Feature	Dimensions
Runway 1 Feeder Channel	Width: 50m Depth: 2m Shape: Rectangular
Combined River Colne and Wraysbury River channel around Airport boundary	Width: 50m Depth: 2m Shape: Rectangular
River Colne channel around Airport boundary	Width: 20m Depth: 2m Shape: Trapezoid
Runway 2 feeder channel	Width: 12m Depth: 2m Shape: Rectangular
Combined Duke of Northumberland's River and Longford River channel around Airport boundary	Width: 12m Depth: 2m Shape: Rectangular
River Colne Spur channel upstream M25	Width: 15m Depth: 2m Shape: Trapezoid
River Colne Spur channel downstream M25	Width: 10m Depth: 2m Shape: Trapezoid
River Colne Spur channel immediately upstream of M4 down to Colne Brook confluence	Width: 15m Depth: 2m Shape: Trapezoid

New in Structures

The dimensions of the new structures proposed as part of the strategy have been informed by modelling iterations. Notably the runway culverts dimensions were determined following a series of model runs. Detailed hydraulic engineering design or feasibility has not been undertaken at this stage. Lengths of structures were determined in GIS using OS mapping and are approximate. **Table 5.4** outlines the details of the new structures included in the model.

Table 5.4 Details of New Structures

Mitigation Scheme Feature	Dimensions
Runway culvert 1 (River Colne and Wraysbury River)	Width: 50m[17] Height: 2.5m Length: 800m Invert:21m Shape: Rectangular
Runway culvert 2 (Duke of Northumberland's River and Longford River)	Width: 12m Height: 2m Length: 800m Invert:21.8m Shape: Rectangular
River Colne Spur culvert under M4	Diameter: 4 culverts 2m diameter Length: 60m Invert:20.1m Shape: Circular
River Colne Spur under A4, Colnbrook Road, Horton Road.	Free spanning bridges (2m deep)

5.6 Effects of Mitigation

The mitigation model was run for the 1% AEP event (including allowance for climate change). The results were compared to the model results from the new fully 1D-2D model (described in **Section 5.5.2**). **Figures 6 to 10** provide an overview of how the mitigation strategy performs compared to the baseline.

North- of Airport

Upstream of the M4 in West Drayton the flood risk extent is reduced for the mitigation run (**Figure 6**). This is a consequence of removing water from the River Colne to feed the River Colne Spur channel. Downstream of the M4 the two proposed storage areas are operating as intended and attenuating water upstream of the runway culverts.

South of the Airport

Downstream of the Airport in Stanwell Moor a very slight reduction in flood extent is observed (**Figure 7**). The flow controls in place within the model aim to maintain the flood flow regime downstream in the River Colne. Due to the slight change in event hydrograph as a consequence of the new runway culverts and associated flow controls the peak flow through this section of the River Colne has been reduced slightly, and in some small locations this

[17] The masterplan submitted to the Airports Commission details two 25 m wide culverts in place of one 50 m wide culvert. This is not likely to cause any notable change in the results. During the design phase the culvert dimensions will be optimised for the purpose of conveying low flows and the required high flows.

has resulted in a reduction in flood extent. Further downstream as the River Colne enters the Thames no increase in peak flow or water level was observed.

North-west of the Airport

The two new flood storage areas west of the M25 are operating and storing flood water as planned. These areas are shown on (**Figure 8)** as new areas of flooding in the modelled mitigation flood extent. There is also a slight increase in flood extent around the Old Slade lake system. This is as a consequence of water impounding behind the embankment associated with the downstream flood storage area. The increase in flood extent is within an area where more flooding is expected as part of the mitigation strategy and does not affect people or property.

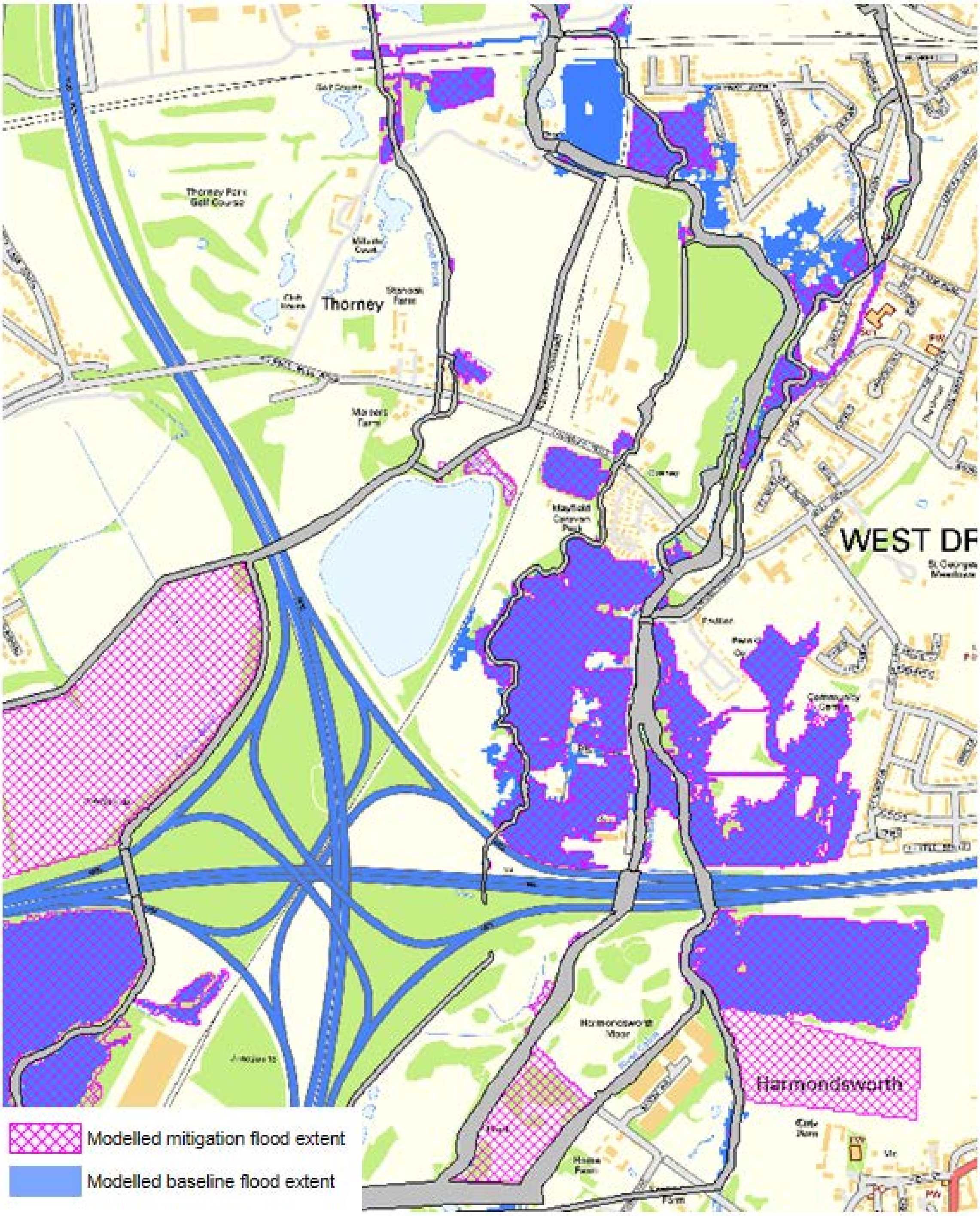
West of the Airport

Through the villages of Colnbrook and Poyle a reduction in flood extent is observed (**Figure 9**). Through southern Poyle, the flood extent resulting from water spilling from the Poyle channel in the new modelled scenario is removed. This is as a result of the reduction in flow along the Poyle Channel due to the off-take of flow into the River Colne Spur at Thorney. The reduction in flow causes a reduction in peak water level, removing the risk of water exceeding the bank heights. The flood extent has also been reduced in northern Colnbrook and Poyle along the County Ditch. This is due to the disconnection of the floodplain flow route which existed from the Old Slade lakes across the A4 into the County Ditch. It is also the result of a reduction in flow along the Colne Brook due to the imposed flow control at the outfall of the flood storage area.

South-west of the Airport

Through the village of Horton the flood risk extent is reduced slightly as a consequence of the additional upstream storage and flow controls in place to manage the peak flows downstream (**Figure 10**). Further downstream as the Colne Brook enters the Thames no increase in peak flow or water level was observed.

Figure 6 **Change in Flood Extent Upstream of the North-west Runway (1% AEP event including an allowance for climate change)**



Contains Ordnance Survey data © Crown copyright and database right 2014

Figure 7 Change in Flood Extent through Stanwell Moor (1% AEP event including an allowance for climate change)

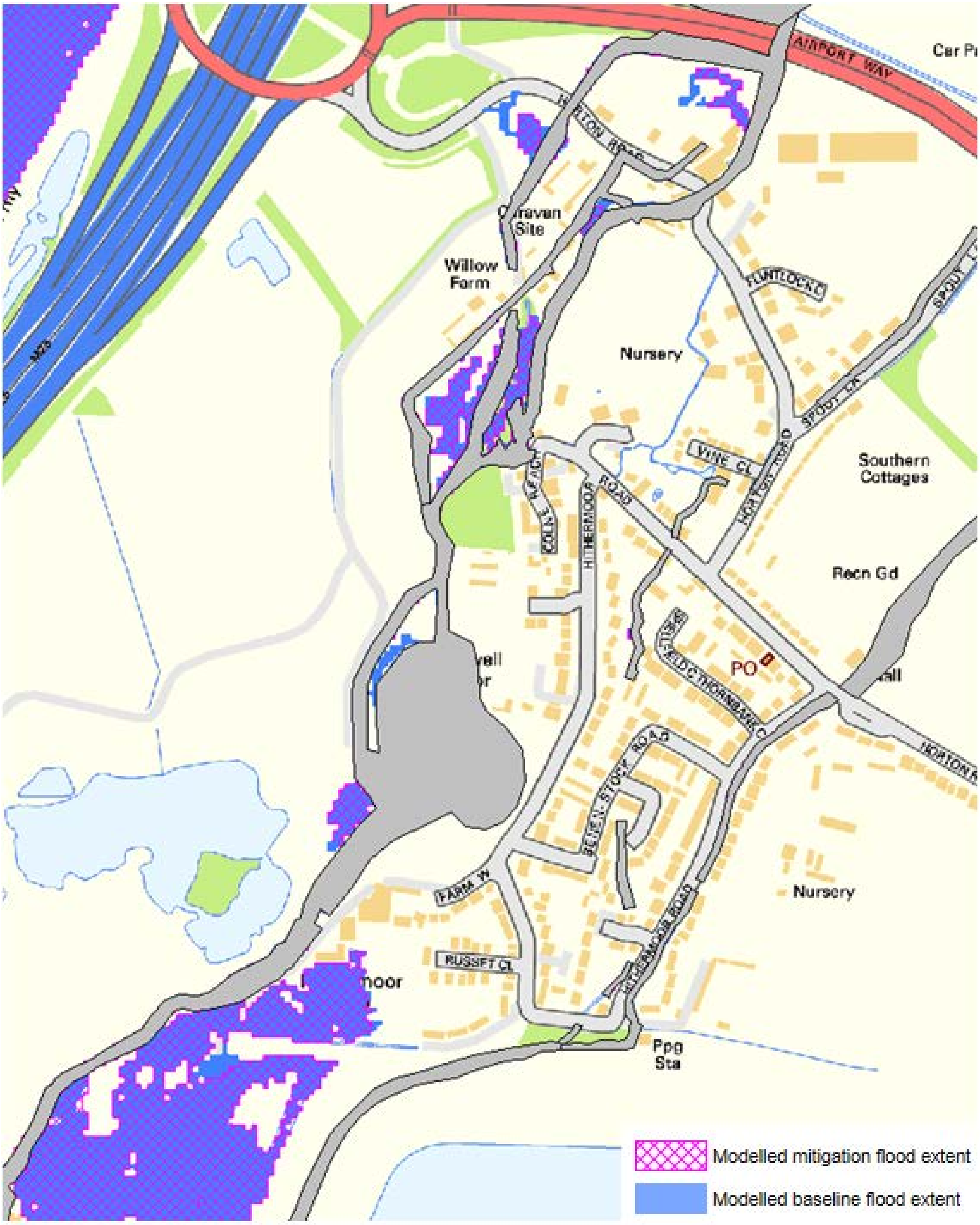


Figure 8 **Change in Flood Extent West of M25 (1% AEP event including an allowance for climate change)**

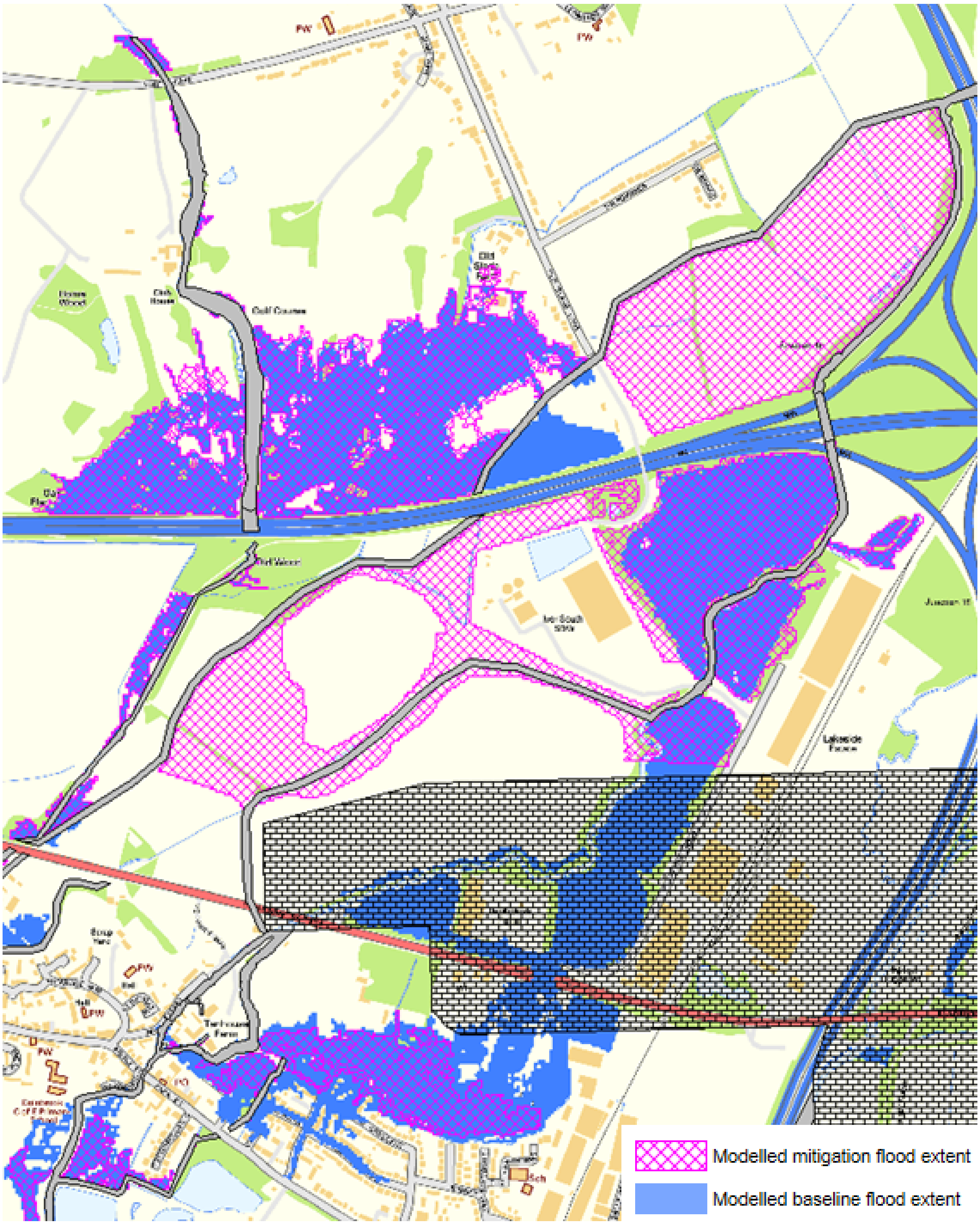


Figure 9 **Change in Flood Extent in Colnbrook and Poyle (1% AEP event including an allowance for climate change)**

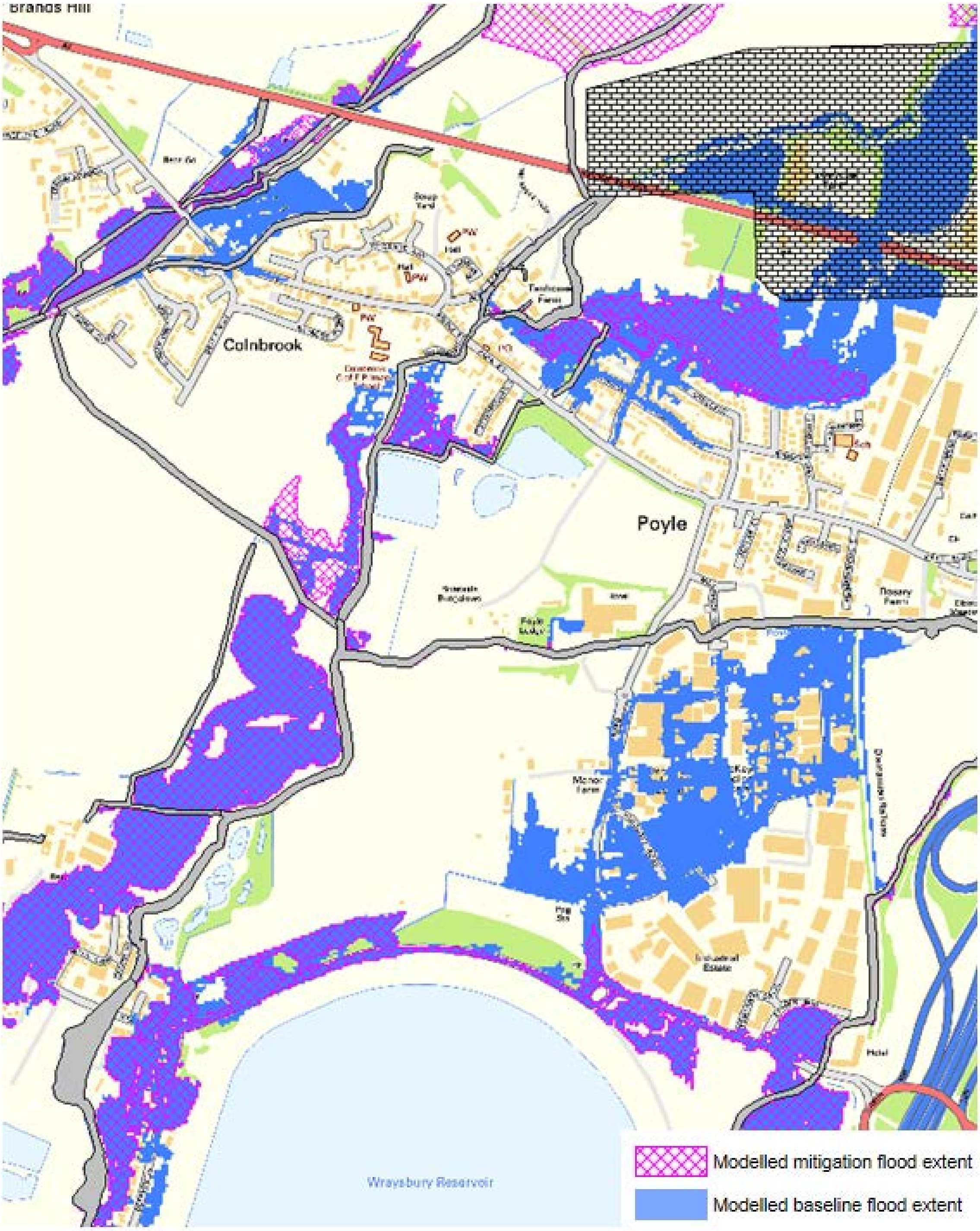
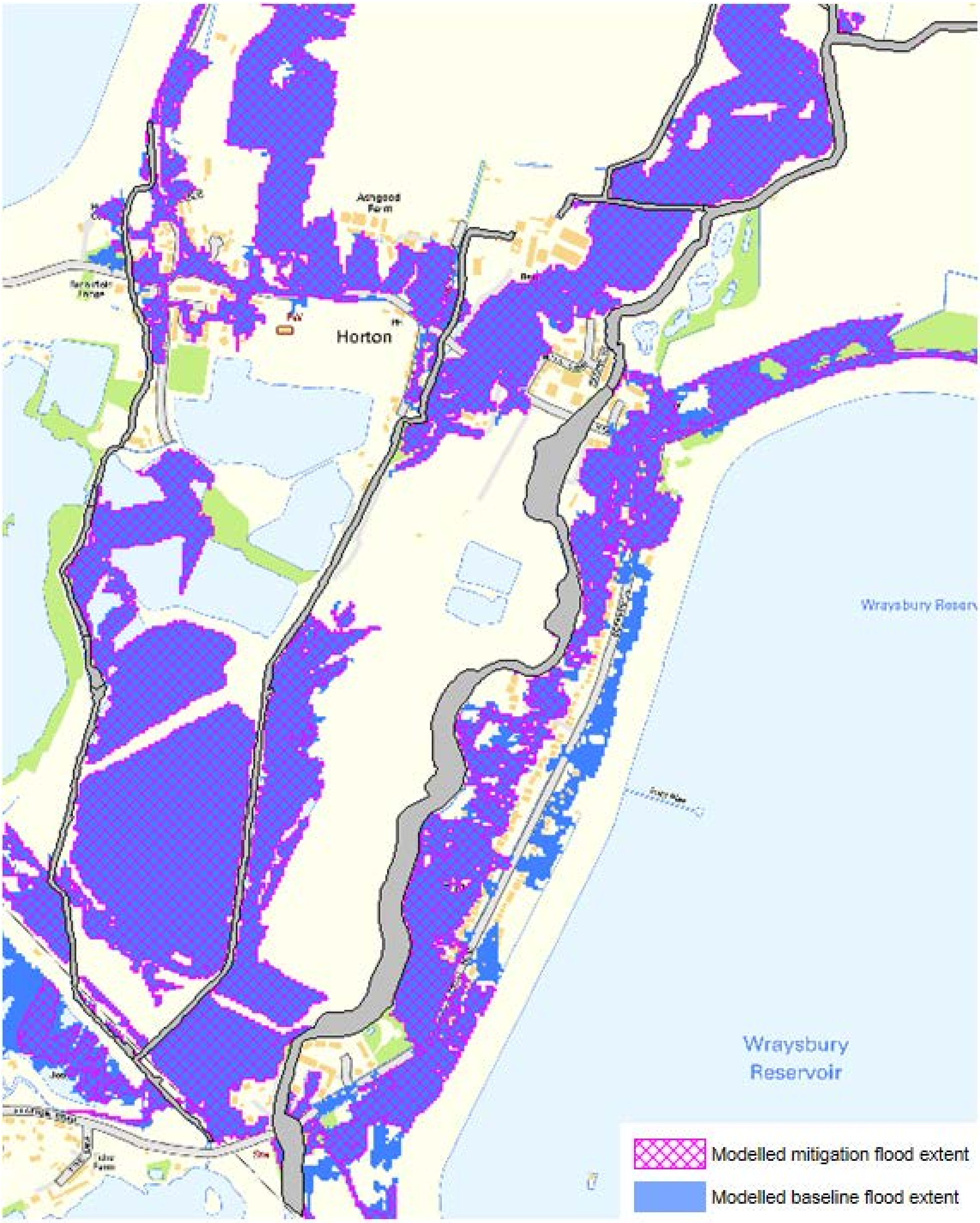


Figure 10 Change in Flood Extent in Horton (1% AEP event including an allowance for climate change)



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The hydraulic model testing detailed in this section demonstrates that the strategy achieves the objectives set out in **Section 1.2**. It has been demonstrated that there is sufficient channel gradient to allow the flow of water round and under the airport so that upstream reaches can be reconnected with downstream reaches with no overall loss in the water balance of the Colne Valley. The modelling also demonstrates that:

- Through the use of adequate flow controls it is possible for flood flows to be controlled to ensure no increase, and in many places a reduction, in flood risk downstream; and
- There is adequate space in the surrounding area to configure a series of flood storage areas to store and attenuate the necessary flood waters to ensure flood risk is not increased.

5.7 Mitigation Strategy during Construction

The mitigation scheme ensures no increase in flood risk to people and property as a consequence of the masterplan. To maintain this during construction the strategy will need to be implemented in stages and will need to be mindful that at no point during construction can flow downstream along any of the watercourses be impeded. It is recommended that the following principles are adhered to:

1. All new sections of river and culvert should be constructed separate from the existing river channels, to allow the rivers to continue to operate as normal during construction;
2. If possible, construction works should commence with the elements of the strategy which fall west of the M25, as the off-take of flow should help in the construction of the strategy to the east;
3. All associated structures, flood storage areas and flow control measures should be in place before the new sections of channel are connected to the main river network; and
4. To the east of the M25 (associated with the run-way construction) temporary diversions are likely to be required to facilitate construction of the Airport and the proposed elements of the mitigation strategy.

A detailed construction plan will be required. The plan should outline the order construction activities should be undertaken to ensure flood risk is not increased to the surrounding areas during construction.

A flood can occur at any point during construction. To minimise this risk, as much of the construction as possible should occur in summer, especially the ‘switching’ of water into the new channels.

6. Groundwater Flood Risk Strategy

The proposed development has potential impacts on the risk of groundwater flooding during construction and operation.

6.1 During Construction

Dewatering will be required to enable construction of foundations. To reduce the volume of water produced from dewatering the strategy is to deploy temporary engineering structures, such as coffer dams. Coffer dams use sheet piling to prevent interaction between the construction site and the surrounding area. The sheet piling is placed around the site to prevent water draining (and material moving) into the construction area where the ground is excavated and water is pumped out. The volume of material removed, water abstracted and the radius of impact will therefore be limited to the dimensions of the coffer dam.

To minimise the potential increase in groundwater flood risk, the existing thickness and permeability of the gravel aquifer will be maintained, promoting movement of groundwater through the site. Excavated material will be used for infilling, such as after the construction of a tunnel, thereby minimising unnecessary waste disposal and maintaining the physical properties of the ground.

It is possible that during excavation contaminated material may be discovered. If such an event occurred, careful consideration will be taken to select a suitable material as infill, to minimise changes to groundwater levels and flow direction.

6.2 During Operation

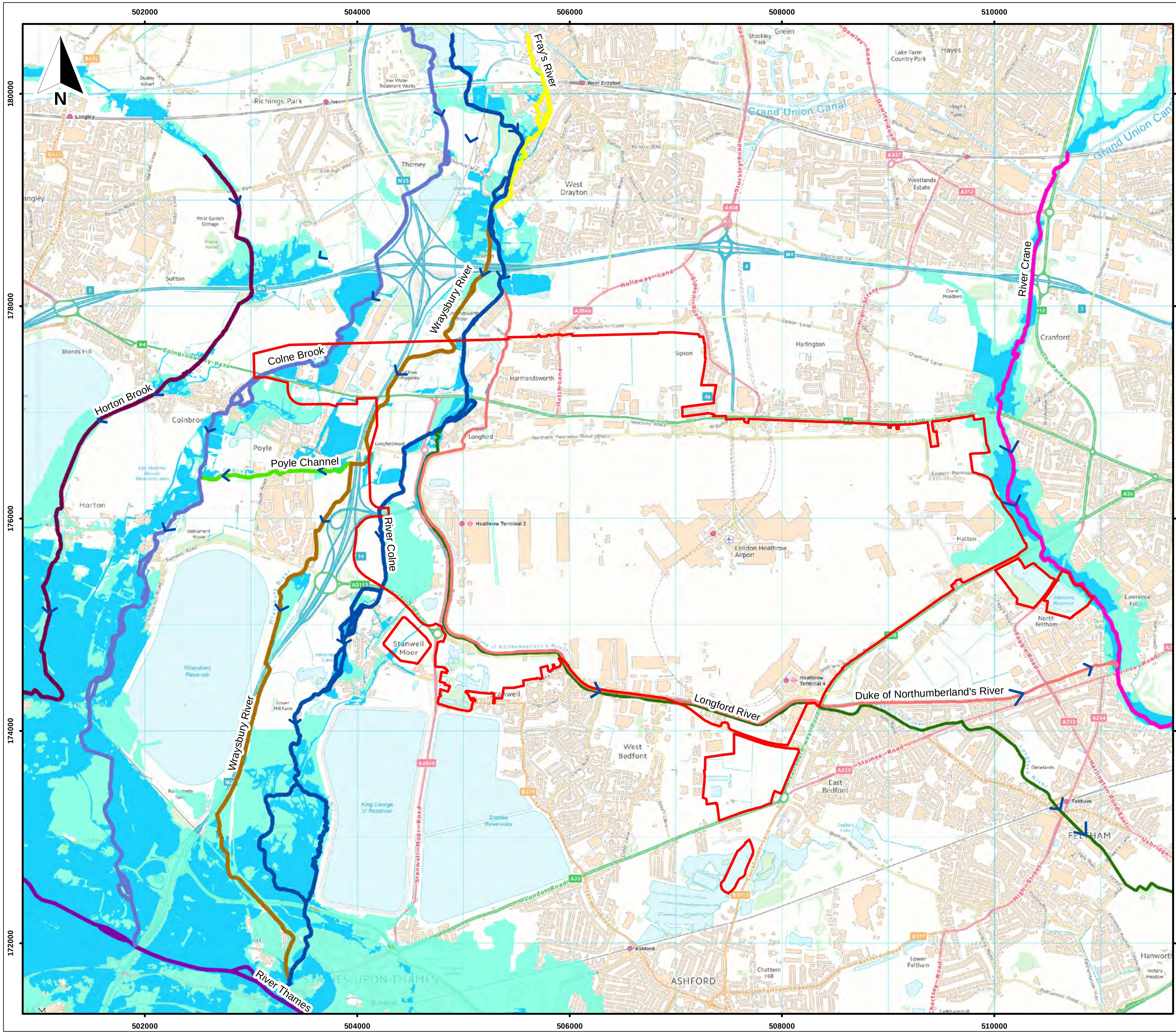
To mitigate against the rise in groundwater levels associated with impermeable barriers, such as foundations or basements, a material of high permeability will be used to promote the flow of groundwater around the barrier. Drains containing gravel, e.g. 'French drains,' surrounding foundations and basements will promote groundwater flow around the structure, reducing the risk of rising groundwater levels. Similar designs can be used along impermeable stretches of rivers, for example where rivers are culverted or have clay bases, to prevent localised groundwater mounding. Further investigations will determine the extent to which this mitigation measure will need to be implemented.

The strategy for ensuring that the natural discharge pathways, from the gravel aquifer to those existing river channels that are to be lost, is to infill these channels with permeable material. This will permit groundwater to continue flow to a natural discharge point further downstream.

7. Conclusions

This report has provided technical evidence to support Part 5.5 of the Enhancing the Natural Environment Strategy of Volume 1 of the HAL's submission to the Airports Commission[3]. It has focussed on how the strategy will manage the water environment with respect to flood risk. Specifically aiming to ensure there is no increase in flood risk to people and property as a result of the proposed Airport expansion.

The Flood Risk Strategy has evolved over time, with consideration of alternative options to provide an enhanced solution that addresses other aspects of the natural environment (WFD & hydroecology, biodiversity and landscape). Hydraulic modelling of the strategy has shown it to be credible and effective, ensuring flood risk to people and property is not increased and offering betterment to the existing condition in settlements like West Drayton, Colnbrook and Poyle.



Key:

Site boundary

Key Rivers

- Colne Brook
- Duke of Northumberland's River
- Fray's River
- Horton Brook
- Longford River
- Poyle Channel
- River Colne
- River Crane
- River Thames
- Wraysbury River

Flood Zones

Flood Zone 2

Flood Zone 2 represents land assessed as having between a 1% (1 in 100) and 0.1% (1 in 1,000) probability of river flooding in any given year.

Flood Zone 3

Flood Zone 3 represents land assessed as having a 1% (1 in 100) or greater probability of river flooding in any given year.

0 500 1,000 1,500 Metres

Scale: 1:35,000 @ A3

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Flood Risk Report
Figure 1

Key Rivers and Associated Environment Agency Flood Zones

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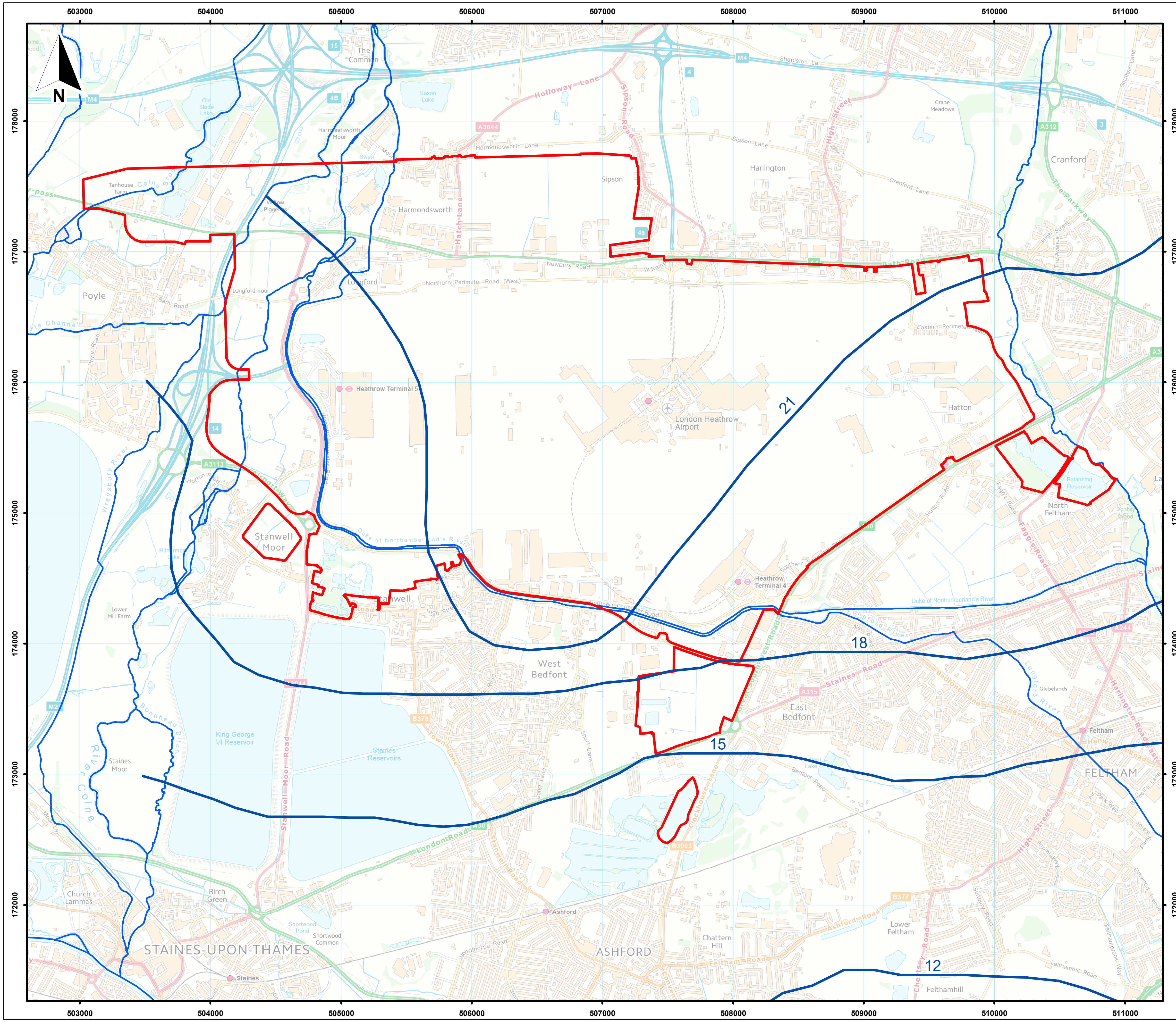

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Key:

- Airport Boundary
- Rivers
- Regional Groundwater Level Contours - mAOD (Clark & Sims, 1998)

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Figure 2
General groundwater contours under Heathrow

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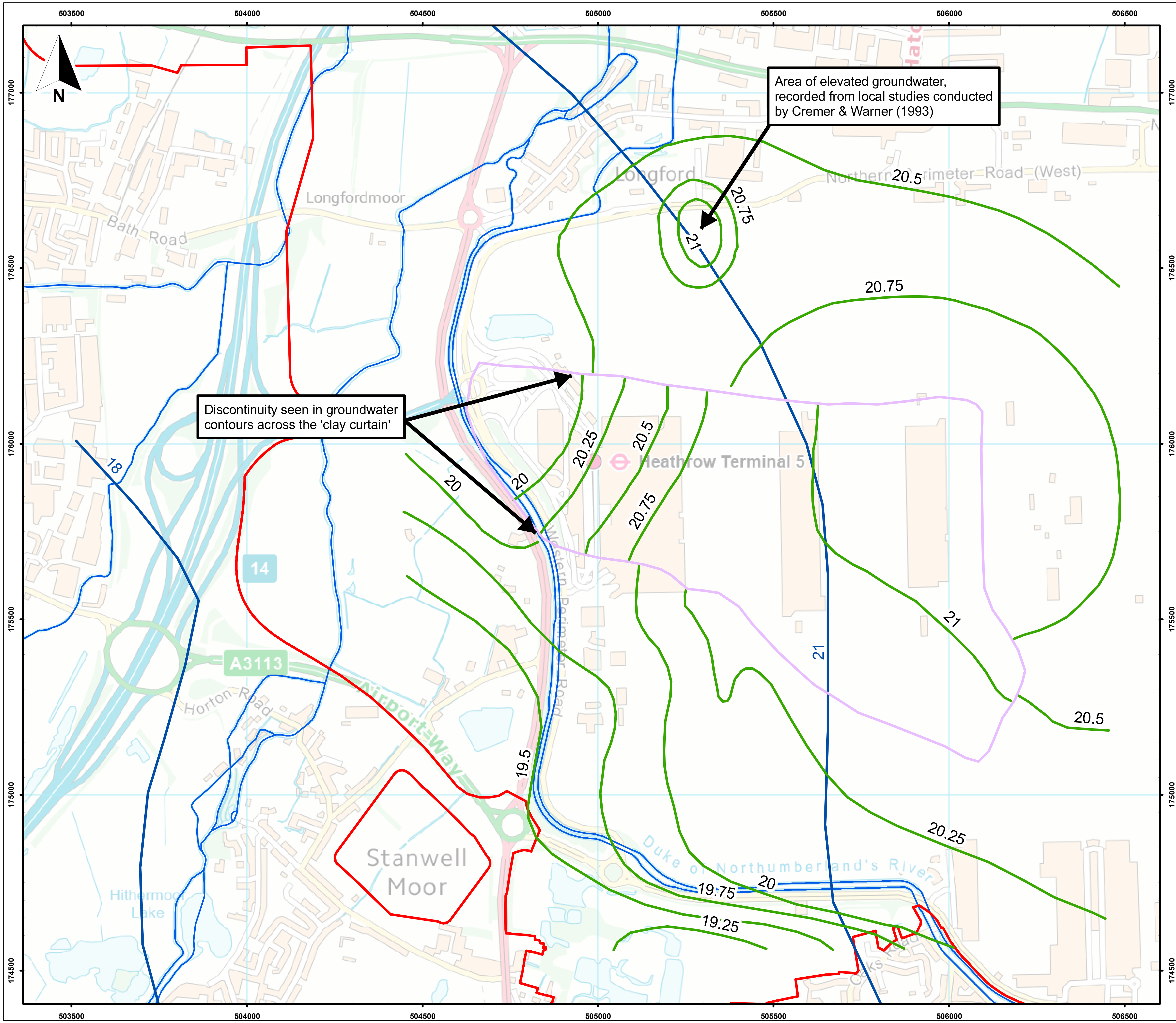

Key:

- Airport Boundary
- Rivers
- Clay Curtain Boundary
- Local Groundwater Level Contours - mAOD (Cremer & Warner, 1993)
- Regional Groundwater Level Contours - mAOD (Clark & Sims, 1998)

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Figure 3
Local groundwater contours

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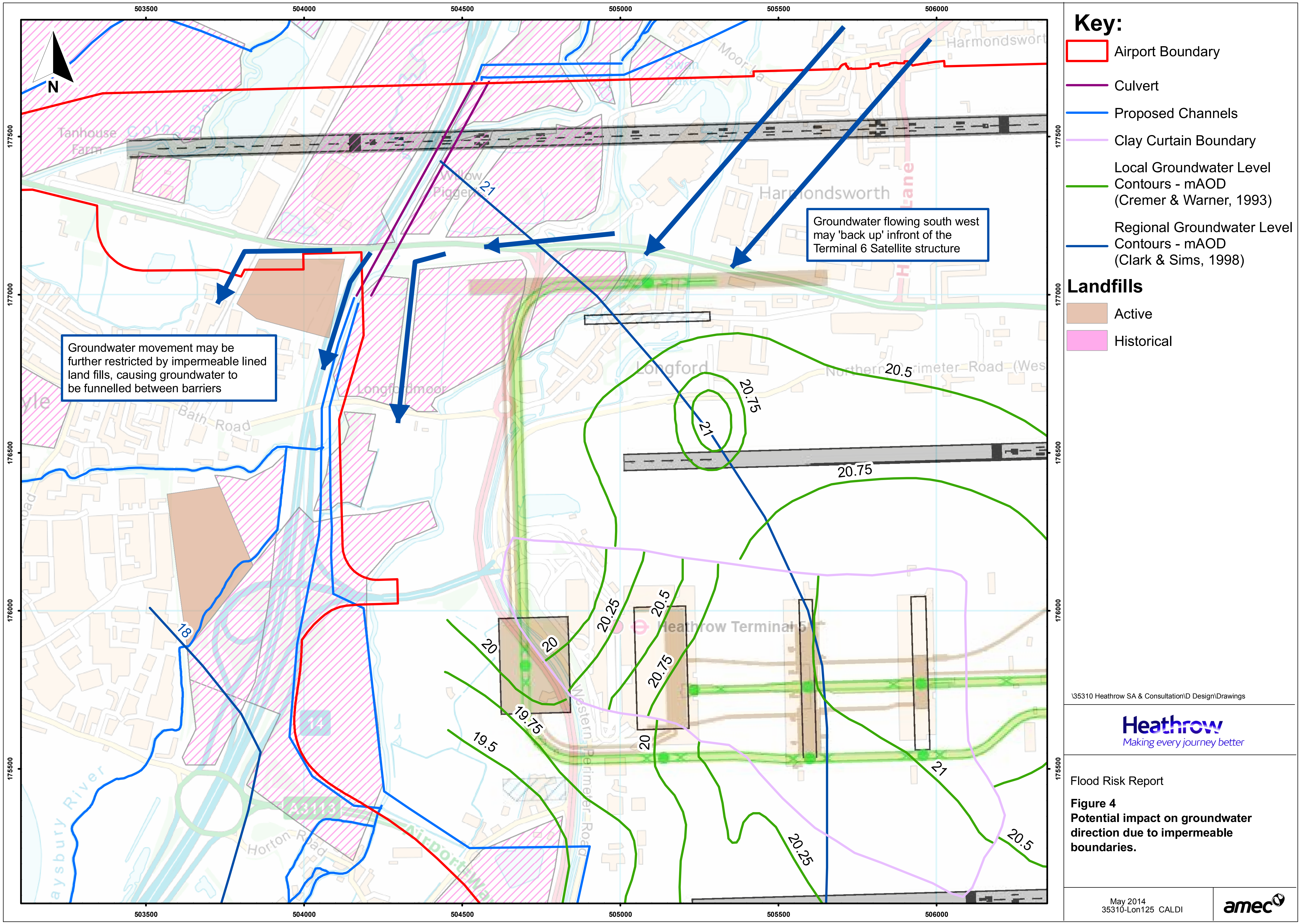
Key:
Airport Boundary
Culvert
Proposed Channels
Clay Curtain Boundary
Local Groundwater Level Contours - mAOD (Cremer & Warner, 1993)
Regional Groundwater Level Contours - mAOD (Clark & Sims, 1998)
Landfills
Active
Historical
Groundwater flowing south west may 'back up' infront of the Terminal 6 Satellite structure
Groundwater movement may be further restricted by impermeable lined land fills, causing groundwater to be funnelled between barriers
Harmondsworth
Longford
Heathrow Terminal 5
Tanhouse Farm
Bath Road
Horton Road
Northern Perimeter Road (West
Western Perimeter Road
N
503500
504000
504500
505000
505500
506000
177500
177000
176500
176000
175500
21
20.5
20.75
20.25
20
19.75
19.5
18
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Figure 4
Potential impact on groundwater direction due to impermeable boundaries.
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35310-Lon125 CALDI
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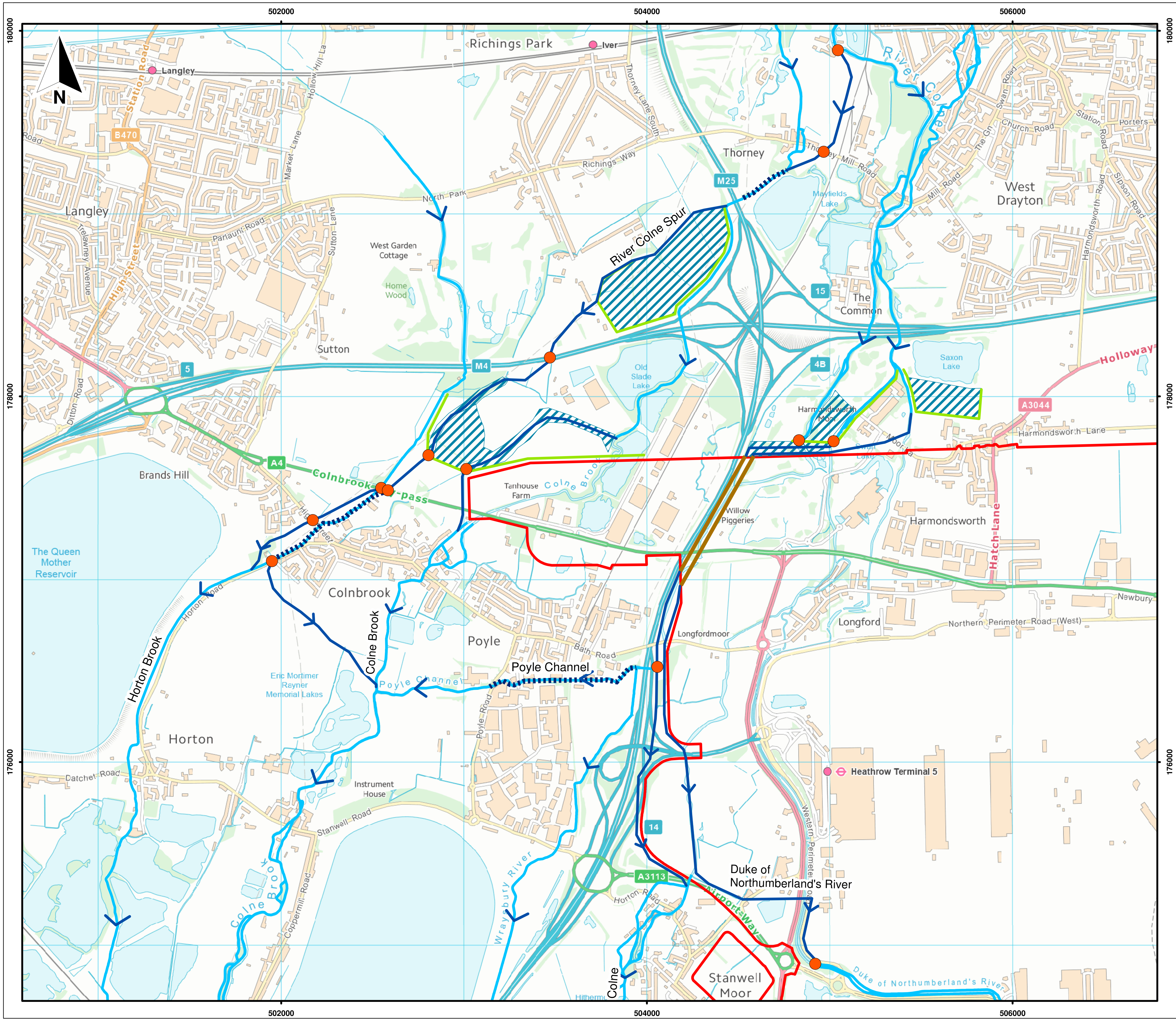

Key:

- Site boundary
- Existing rivers
- New channels
- Channel modification
- Flood bunds
- Culverts
- Structures
- Flood storage areas

0 500 1,000 Metres

Scale: 1:20,000 @ A3

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Flood Risk Report
Figure 5

Flood Risk Mitigation Strategy

June 2014
35310-Lon58c RAMPJ

Appendix A
Legislative and Policy Review

Table A.1 Principal Policies and Planning Tests relating to Flood Risk

Policy Document	Relevant Policy
International / National Policies	
1) The Floods Directive	Appropriate measures must be implemented to ensure flood risk is mitigated and not increased.
2) National Planning Policy Framework	Ensure the development is safe and does not increase flood risk elsewhere, ensuring: • No interruption of floodplain conveyance • No increase in runoff, • No reduction in floodplain storage. NPPF defines three zones of flood risk: - Flood Zone 1 is the area that has less than a 0.1 per cent (1 in 1000) chance of a flood occurring each year. - Flood Zone 2 is the area that could be flooded from a river by a flood with up to a 0.1 per cent (1 in 1000) chance of occurring each year. - Flood Zone 3 is the area that could be flooded from a river by a flood that has a 1 per cent (1 in 100) or greater chance of happening each year. Safeguard land from development that is required for current and future flood management.
3) Floods and Water Management Act	Flood risk and water on site must be sustainable managed.
4) Land Drainage Act	Ensure development is set back 8 metres from a river, and river restoration opportunities as part of the development have been explored.
Regional Policies	
1) London Plan	Flood risk management Minimise/ mitigate against flood risk to site; ensure development does not increase flood risk elsewhere. Ensure compliance with NPPF Prove the development has been designed to be flood resilient or resistant ensuring that: - The development will remain safe and operational under flood conditions; - A strategy of either safe evacuation and/ or safely remaining in the building is followed under flood conditions; - Key services including electricity, water etc will continue to be provided under flood conditions; - Buildings are designed for quick recovery following a flood. Sustainable drainage Utilise SuDS, manage run-off close to source and aim for Greenfield Run-off rates. Restoration of the Blue Ribbon Network Contribute to the restoration and enhancement to the Blue Ribbon Network by: - Taking opportunities to open culverts and naturalise river channels; - Prevent development and structures into the water space; - Resisting the impounding of rivers; - Protect the open character of the Blue Ribbon Network. London's canals and other rivers and waterspaces. Development is respectful of the local character and contributes to the accessibility and active water related uses of the water bodies.

Table A.1 (continued) Principal policies and planning tests relating to flood risk

Policy Document	Relevant Policy
Local Policies	
1) Hillingdon Core Strategy draft policies 2012	EM1 Climate Change Adaptation and Mitigation Development must have considered impact on flood risk management, foul and surface water drainage and water consumption. Implementation of Living Walls & Roofs, and SuDS EM3: Blue Ribbon Network Positive enhancement through improvement in access to and the quality of river corridors. EM6: Flood Risk Management New development to be directed away from away from flood zones 2 and 3. Where not possible flood risk should be suitably mitigated. The use of sustainable urban drainage systems (SuDS) is encouraged.
2) Hillingdon Unitary Development Plan 1998 (Saved Policies)	OE7 implement flood protection measures as part of the proposed development to a satisfactory standard. OE8 proposed development includes appropriate surface water attenuation measures to a satisfactory standard.
3) Southern Hillingdon Area Action Plan	Ensure an 8m buffer zone from edge of watercourses

In addition to the key policies, which any proposed development will have to adhere to, future development will also need to be mindful of the other key guidance documents in existence with reference to flood risk. These include:

- Thames Catchment Flood Management Plan[18];
- Thames River Basin Management Plan[19];
- River Thames Flood risk management scheme[20]; and
- Various local strategic flood risk assessments.

These are general strategy documents, which consider the local area, and have policies and action plans to guide flood risk management. In general, they aim to ensure that:

- Areas are safeguarded for future flood risk management use;
- Greenfield runoff rates are achieved; and
- Overall flood risk is reduced.

[18] Environment Agency (2009) Thames: Catchment Flood Management Plan.

[19] Environment Agency (2009) Water for life and livelihoods – River Basin Management Plan – Thames River Basin District.

[20] Environment Agency (2012) River Thames flood risk management scheme – Policy Paper.

In addition, the following best practice documents relating to the detailed design of features within a development apply:

- CIRIA Culvert Design and Operation Guide (C689)[21];
- CIRIA: The SuDS Manual (C697)[22]; and
- Various local and regional land drainage byelaws.

[21] Construction Industry Research and Information Association (2010) Culvert design and operation guide (C689).

[22] Construction Industry Research and Information Association (2007) SuDS Manual (C697).