E154

High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

CA4: Whitmore Heath to Madeley

Water resources assessment (WR-002-004)

July 2017

ES 3.5.2.4.14

High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

CA4: Whitmore Heath to Madeley

Water resources assessment (WR-002-004)

July 2017

Department for Transport

High Speed Two (HS2) Limited has been tasked by the Department for Transport (DfT) with managing the delivery of a new national high speed rail network. It is a non-departmental public body wholly owned by the DfT.

High Speed Two (HS2) Limited,
Two Snowhill
Snow Hill Queensway
Birmingham B4 6GA

Telephone: 08081 434 434

General email enquiries: HS2enquiries@hs2.org.uk

Website: www.gov.uk/hs2

A report prepared for High Speed Two (HS2) Limited:

ARUP ERM

High Speed Two (HS2) Limited has actively considered the needs of blind and partially sighted people in accessing this document. The text will be made available in full on the HS2 website. The text may be freely downloaded and translated by individuals or organisations for conversion into other accessible formats. If you have other needs in this regard, please contact High Speed Two (HS2) Limited.

recycle

Printed in Great Britain on paper containing at least 75% recycled fibre.

Contents

List of figures

List of tables

1 Introduction

1.1 Structure of the water resources and flood risk appendices

1.1.1 The water resources and flood risk appendices comprise both route-wide and community area specific documents. The route-wide appendices comprise:

- a Water Framework Directive (WFD) compliance assessment (Volume 5: Appendix WR-001-000); and
- a water resources operation and maintenance plan (Volume 5; Appendix WR-005-000).

1.1.2 For the Whitmore Heath to Madeley (CA4) area, the area specific appendices comprise:

- a water resources assessment (this Appendix); and
- a flood risk assessment (Volume 5: Appendix WR-003-004).

1.1.3 Hydraulic modelling reports, which describe the approach to assessing key flood risk issues identified within the community area, are included in Background Information and Data (BID[1]).

1.1.4 Maps (WR-01 and WR-02) referred to throughout this water resources assessment are contained in the Volume 5, Water resources and flood risk Map Book.

1.2 Scope, assumptions and limitations

1.2.1 The scope, assumptions and limitations for the water resources and flood risk assessment are set out in Volume 1 (Section 8), the Scope and Methodology Report (SMR)[2] and the SMR Addendum[3].

1.2.2 The Whitmore Heath to Madeley area covers a section of the Proposed Scheme that is approximately 9.1km long. The spatial scope of the assessment was based upon the identification of surface water and groundwater features within 1km of the centre line of the route of the Proposed Scheme. For the purposes of this assessment this spatial scope is defined as the study area.

1.2.3 The assessment considers the construction and operational features of the Proposed Scheme within the study area. These are shown on Volume 2: Map Series CT-05 and Map Series CT-06. The Proposed Scheme will be constructed on a series of cuttings, embankments and at grade sections. There are two viaducts, the Meece Brook viaduct and the River Lea viaduct, and two tunnels, one at Whitmore Heath and one south-west of Madeley.

1.2.4 This assessment covers the potential impacts of the Proposed Scheme on existing surface water and groundwater resources, including consideration of:

[1] HS2 Ltd (2017), *High Speed Two (HS2) Phase 2a (West Midlands – Crewe), Background Information and Data, Hydraulic Modelling Reports, BID WR-004*, www.gov.uk/hs2
[2] Volume 5: Appendix CT-001-001, Scope and Methodology Report
[3] Volume 5: Appendix CT-001-002, Scope and Methodology Report Addendum

- surface waters[4];
- aquifers;
- abstractions (licensed and unlicensed) and consented discharges; and
- springs and other groundwater - surface water interactions with implications for water resources and/or groundwater dependent terrestrial ecosystems.

1.2.5 The route-wide WFD compliance assessment (Volume 5: Appendix WR-001-000) provides a comprehensive review of the potential impacts of the Proposed Scheme on designated WFD surface water and groundwater bodies. The WFD compliance assessment, which involved extensive walkover surveys, informed both the value attributed to relevant receptors, such as watercourses, and the assessment of impacts and effects used in this assessment.

1.2.6 The water resources assessment considers the pollution risks associated with routine discharges of runoff from new sections of highway proposed within the study area, during the operational phase of the Proposed Scheme. This assessment uses the Highways Agency Water Risk Assessment Tool (HAWRAT) as presented in Design Manual for Roads and Bridges[5]. An assessment is required if the Annual Average Daily Traffic flow value (AADT) exceeds 10,000 vehicles, and the heavy goods component of the AADT exceeds 500. A screening exercise identified one highway modification in the Whitmore Heath to Madeley area which required an assessment of highway pollution.

1.2.7 Pollution risks associated with trains using the Proposed Scheme during its operational phase are considered on a route-wide basis within Volume 3, Route-wide effects, Section 16, Water resources and flood risk.

1.3 Study area description and key features

1.3.1 The area is predominantly rural in character, except for the small urban areas of Whitmore (to the east of the southern extent of the route), Whitmore Heath (located above the Whitmore Heath tunnel), Baldwin's Gate (located to the south-west of the route) and Madeley (located to the north east of the route).

1.3.2 The main environmental features of relevance to water resources include:

- Meece Brook, River Lea and their associated tributary watercourses;
- the Sherwood Sandstone Group Principal aquifer;
- the permeable superficial deposits and Warwickshire Group bedrock Secondary A aquifers;
- the Mercia Mudstone Group Secondary B aquifer;

[4] Ponds are not included in the water resources assessment, these are assessed as ecological receptors in Volume 2, Whitmore Heath to Madeley area report, Section 8, Ecology and biodiversity

[5] Design Manual for Roads and Bridges, *Road Drainage and the Water Environment*, Volume 11 Environmental Assessment, Section 3 Environmental Assessment Techniques, Part 10, HD45/09

- 6 springs or potential spring features within, or directly adjacent to, the area required for construction;
- one licensed public groundwater abstraction from the Sherwood Sandstone Group Principal aquifer;
- two licensed private groundwater abstractions from the Warwickshire Group Secondary A aquifer;
- three unlicensed groundwater abstractions (one from the Sherwood Sandstone Group Principal aquifer, one from superficial deposits Secondary A aquifer and one from an unknown aquifer); and
- two unlicensed private surface water abstractions, one from the River Lea and one from one of its tributaries.

2 Stakeholder engagement

2.1.1 Discussions have been held with the following stakeholders to inform the water resources assessment:

- the Environment Agency;
- Stafford Borough Council (SBC) and Newcastle-Under-Lyme Borough Council (NBC), with regard private unlicensed water abstractions;
- Severn Trent Water Ltd, with regard to public groundwater abstractions and the water resources management plan within this and the adjacent areas; and
- the owners of private licensed and unlicensed abstractions (where survey access has been available).

3 Baseline data

3.1 Surface water

3.1.1 The surface water features crossed by the Proposed Scheme within this study area, including their location, current overall WFD status and future overall status objectives, are tabulated in the Volume 2, Whitmore Heath to Madeley area report, Section 15. The receptor values attributed to each individual watercourse, based on the methodologies set out in the SMR[6], as applied in the WFD Compliance Assessment (Volume 5, Appendix WR-001-000) are also provided.

3.1.2 Table 1 summarises surface water abstractions in the study area. Their locations are shown on Map WR-01-106b and WR-01-107a. There are no licensed surface water abstractions within the study area. Records of private unlicensed water abstractions which comprise those for quantities less than 20m^3 per day, have been obtained from the local authorities. This data indicates that there are two private unlicensed surface water abstractions within the study area. As there is no obligation to register private water supplies, unregistered supplies may also be present. Private water supplies are assessed as high value receptors unless details obtained from the owner indicate otherwise.

Table 1: Surface water abstractions

Map identifier (ID) and (map grid square)[7]	Distance and direction from route	Abstraction source	Maximum daily abstraction (m^3)	Purpose
Private unlicensed supplies				
4/SA/1 (D5)	20m north of the route (inside the land required for construction of the Proposed Scheme)	Tributary of River Lea	20	Not known
4/SA/2 (G6)	40m north of the route (inside the land required for construction of the Proposed Scheme)	River Lea	20	Not known

3.1.3 There are five consented discharges to surface water within the study area, as shown in Table 2. These have been assessed as low value receptors.

[6] Volume 5: Appendix CT-001-001, Scope and Methodology Report
[7] Unique ID numbers for unlicensed surface water abstractions are shown on Map WR-01-106b and Map WR-01-107a from south to north.

Table 2: Consented discharges to surface water

Permit identifier (and map grid square)	Distance and direction from route	Discharge type	Receiving water body
T/02/35804/R (F6)[8]	500m south-west of the route (350m west of the land required for construction of the Proposed Scheme)	Sewage discharges - final/treated effluent - water company	Tributary of Meece Brook
T/02/35804/R (F6)[8]		Sewage discharges - final/treated effluent - water company	Tributary of Meece Brook
T/02/00440/S (F4)[8]	550m north-east of the route (90m north-east of the land required for construction of the Proposed Scheme)	Sewage discharges - final/treated effluent - not water company	Meece Brook
16810091 (H4)[9]	950m north-east of the route (400m north-east of the land required for construction of the Proposed Scheme)	Sewage discharges - storm overflow/storm tank - water company	River Lea
16810091 (H4)[9]	900m north-east of the route (440m north-east of the land required for construction of the Proposed Scheme)	Sewage discharges - final/treated effluent - water company	River Lea

3.2 Groundwater

3.2.1 A summary of the geological units present in the Whitmore Heath to Madeley area is presented in the Land quality section in ES Volume 2, Whitmore Heath to Madeley area report, Section 10. The hydrogeological characteristics of the geological units are summarised in the Water resources and flood risk section in the Volume 2, Whitmore Heath to Madeley area report, Section 15 and further detail is provided below.

3.2.2 Map WR-02-204 (Volume 5: Water resources assessment and flood risk Map Book) shows the superficial and bedrock geology within the study area.

3.2.3 All Alluvium, River Terrace Deposits and Glaciofluvial Deposits in the study area are classified as Secondary A aquifers by the Environment Agency.

3.2.4 There are three bedrock aquifers in the study area. The Sherwood Sandstone Group is classified as a Principal aquifer, the Warwickshire Group is classified as Secondary A aquifers and the Mercia Mudstone Group is classified as a Secondary B aquifer.

3.2.5 There are no Environment Agency observation boreholes which monitor groundwater level within the study area. There are however two Environment Agency observation boreholes which monitor groundwater level in the Sherwood Sandstone Group,

[8] Map WR-01-106b
[9] Map WR-01-107a. Discharges in the study area are listed from south to north.

located approximately 3.2km and 3.7km south-west of the route at Clowes Wood and Woore respectively. There are also two groundwater level observation boreholes in the Stone and Swynnerton area (CA3) within 2.5km of the study area which also monitor the Sherwood Sandstone Group at Shelton under Harley and Upper Hatton Wood. Figure 1 shows the location of these monitoring boreholes and Figure 2 shows available groundwater level monitoring data plotted over time. In addition, information supplied by Severn Trent Water Ltd provides rest water level at the PWS near Whitmore.

Figure 1: Location of Environment Agency groundwater level monitoring boreholes (Sherwood Sandstone Group)

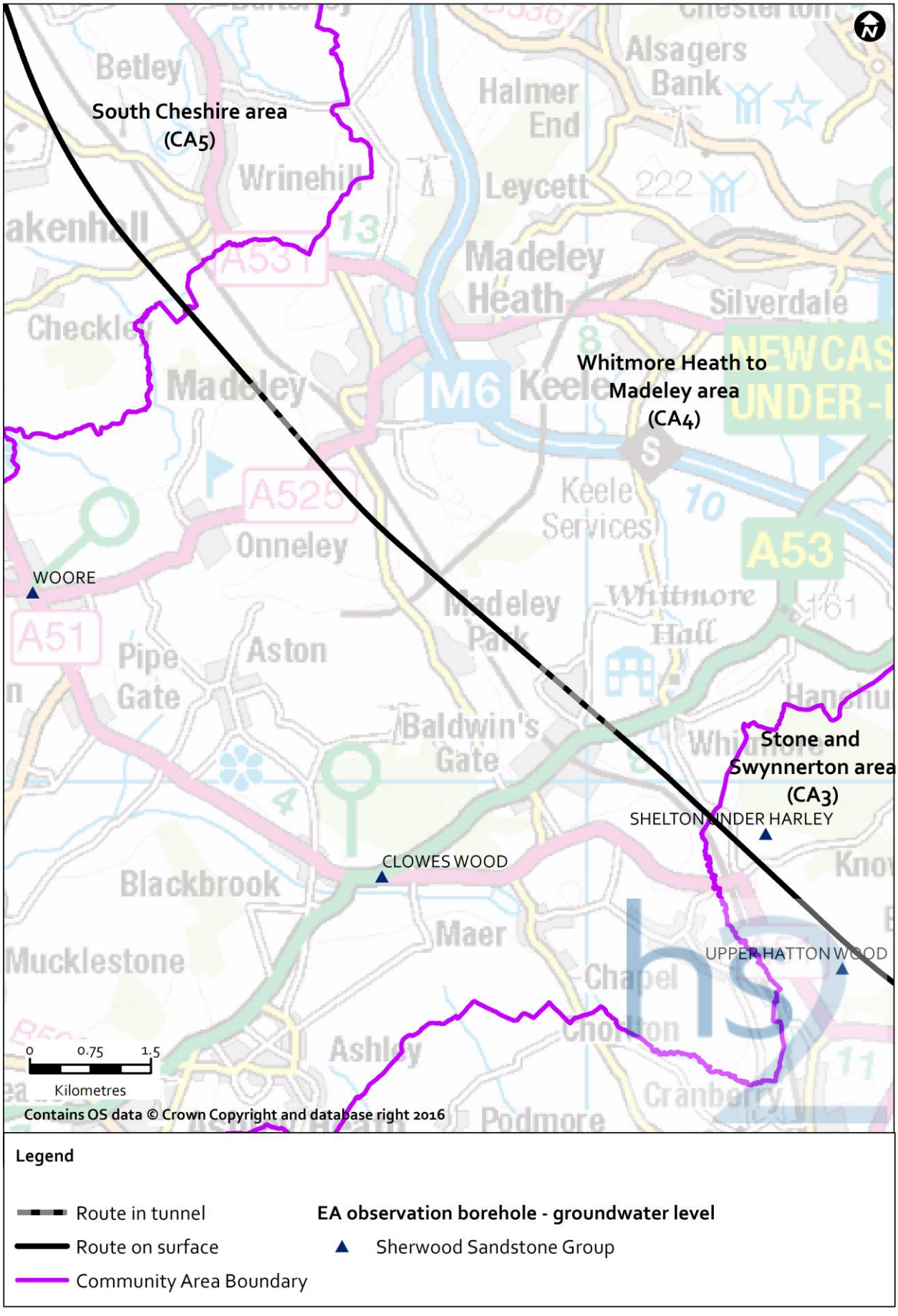
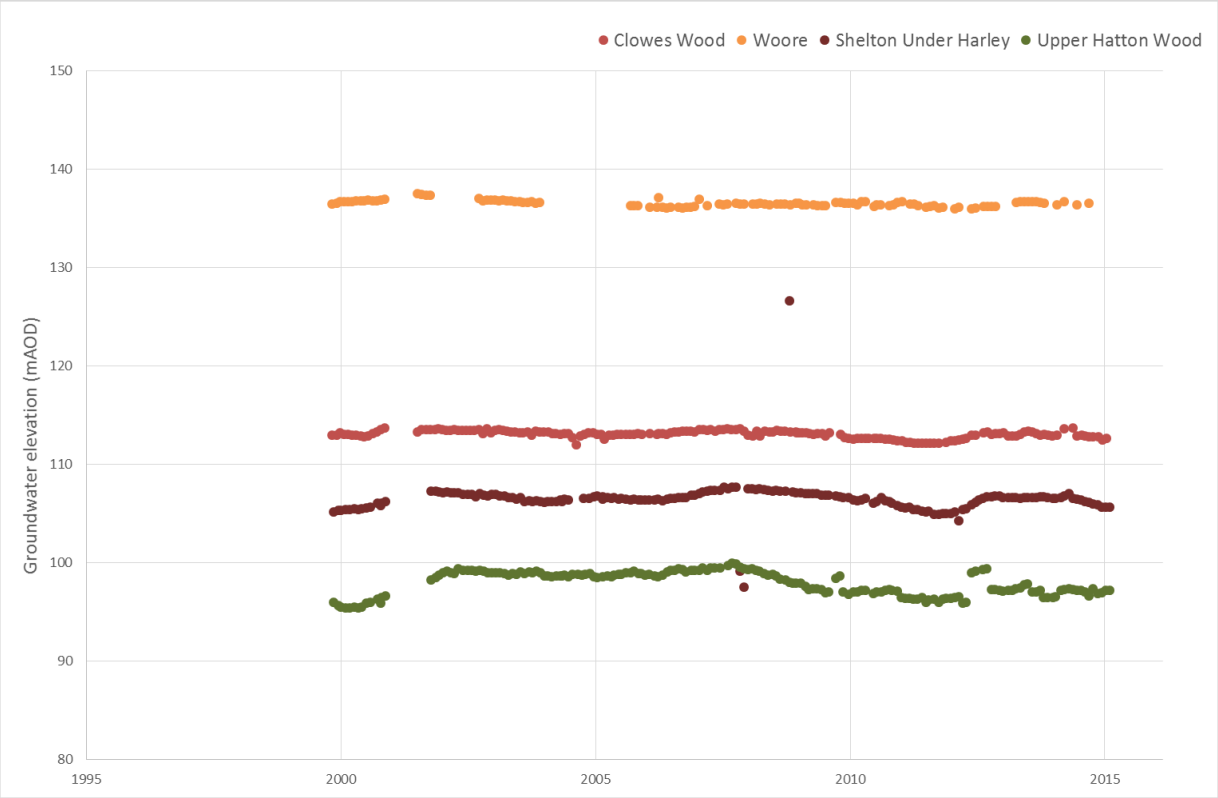


Figure 2: Groundwater elevation (Sherwood Sandstone Group) in metres above ordnance datum (mAOD)



3.2.6 The collated groundwater level data suggests that groundwater levels in the Sherwood Sandstone Group appear to be close to ground level in the valley bottom, but slightly further below ground level in areas of elevated topography, particularly where there is no superficial cover and recharge can occur directly to the bedrock. Water fluctuations at Environment Agency observation boreholes show a similar pattern, suggesting groundwater is responding in a similar way to weather and climatic conditions. The water level information in this area appears to show groundwater flow direction is to the south however this is likely to be a function of the spread of monitoring installations in the area. It is likely that flow is controlled locally by topography, recharge to the aquifer, where it is unconfined, and local groundwater abstractions.

3.2.7 No groundwater monitoring data is available for the Secondary A and Secondary B aquifers in the study area. Water strikes recorded on borehole logs have been referred to for the purpose of the assessment. Groundwater in the superficial aquifers is expected to be shallow within the river valleys and at slightly greater depth on the valley sides. The direction of groundwater flow is likely to follow the general topography and the surface watercourses are likely to act as discharge points for converging groundwater flow in the area. Where groundwater levels are not known, they have been assumed to be at or close to ground level for the purpose of a precautionary assessment

3.2.8 In the Warwickshire Group Secondary A aquifer (Halesowen Formation and Salop Formation) some groundwater flow is expected through the intergranular matrix of the sandstone units, but most groundwater flow is expected to occur through fractures or other discontinuities (dual porosity aquifer).

3.2.9 Some groundwater flow is expected in the Mercia Mudstone Group, though permeable horizons within this unit are expected to be laterally discontinuous and associated with thin siltstone and sandstone lenses called skerries. There may also be a small element of fracture flow.

3.2.10 Table 3 summarises groundwater abstractions and their locations are shown on Map WR-02-204.

3.2.11 There is one licensed groundwater abstraction for public water supply (PWS) near Whitmore, protected by a SPZ in the study area. This is a very high value receptor. The SPZ location is shown on Map WR-02-204.

3.2.12 The PWS is located 30m to the south of the route, and at its closest point HS2 will pass the site on an embankment. The PWS access road will be realigned in order to maintain access to the site throughout construction and operation. These works will be directly adjacent to the PWS.

3.2.13 There are a number of private abstractions from groundwater (licensed and unlicensed) in the study area. These do not have mapped SPZs but, where they are used for potable water supply and some other purposes, they do have a nominal SPZ1 of 50m[10]. These abstractions have all been assessed as high value receptors.

3.2.14 The unlicensed private water supply information has been provided by the local authorities (SBC and NBC). Where land access has been available, surveys have been undertaken to confirm abstraction details. Where the exact details of an abstraction are not known, a precautionary assessment has been undertaken.

3.2.15 There is the potential for further unlicensed abstractions to exist, as a licence is not required for abstraction volumes below 20m^3 per day and not all unlicensed abstractions are registered with the local authority. These may also need to be protected.

Table 3: Summary of groundwater abstractions in the Whitmore Heath to Madeley area

Name, map ID[11] (and map grid square)	**Distance and direction from route**	**Abstraction source**	**Maximum annual abstraction quantity (m^3)**	**Maximum daily abstraction quantity (m^3)**	**Purpose**	**Number of boreholes**
Public water supplies						
PWS near Whitmore Licence identifier confidential (H5 - SPZ1	30m south of the route (adjacent to the land required for construction of the Proposed Scheme)	Wilmslow sandstone (of the Sherwood Sandstone Group)	363,000	2,420	PWS	2

[10] Environment Agency (2017), *Protect groundwater and prevent groundwater pollution*. https://www.gov.uk/government/publications/protect-groundwater-and-prevent-groundwater-pollution/protect-groundwater-and-prevent-groundwater-pollution

[11] Map grid squares (for SPZs), licence numbers (for licensed abstractions), and ID numbers (for unlicensed groundwater abstractions) are stated to show feature locations on Map WR-02-204. Each group of abstraction features in the study area are listed from south to north.

Name, map ID[11] (and map grid square)	Distance and direction from route	Abstraction source	Maximum annual abstraction quantity (m^3)	Maximum daily abstraction quantity (m^3)	Purpose	Number of boreholes
location)						
Private licensed water supplies						
Netherset Hey 2568001255 (E5)	800m north-east of the route (170m north-east of the land required for construction of the Proposed Scheme)	Halesowen Formation (of the Warwickshire Group)	14,928	41	General farming and domestic	1
Manor Farm NW/068/0001/016 (E6)	380m south-west of the route (185 west of the land required for construction of the Proposed Scheme)	Halesowen Formation (of the Warwickshire Group)	23,725	65	General farming and domestic	1
Private unlicensed water supplies						
Hey House Farm Map ID: 4/GA/1 (E6)	135m north-east of the route (40m from the land required for construction of the Proposed Scheme)	Not known	Unknown	<20	Domestic	1
Hey House Lodge Map ID: 4/GA/2 (E6)	In the path of the route	'Superficial deposits'	Unknown	<20	Domestic*	1
Bower End Farm Map ID: 4/GA/3 (D6)	40m from the line of tunnel route	Chester Formation (of the Sherwood Sandstone Group)	Unknown	<20	General farming and domestic	1

*currently supplying Hey House Lodge, which is scheduled for demolition.

3.2.16 There is one consented discharge to groundwater in the study area and this has been assessed as a low value receptor. Details of this discharge are summarised in Table 4.

Table 4: Discharge consents to groundwater

Permit identifier and (map grid square)[12]	Distance and direction from route	Discharge type	Receiving water body
3/28/02/2121 (G5)	260m north-east of the route (and adjacent to the land required for construction of the Proposed Scheme)	Soakaway (domestic final/treated effluent)	Underground strata

3.3 Groundwater – surface water interaction

3.3.1 Table 5 summarises the potential groundwater – surface water interactions within the study area.

3.3.2 Along with the main surface watercourses which could have connection with groundwater, potential springs and issues have been identified within the study area from Ordnance Survey (OS) maps. Where land access has been available these have been surveyed to check if they are true expressions of groundwater (and therefore could contribute flows to surface water bodies), or if they are simply land drainage features. Where surveys have proved the latter, the features have been removed from the water resources assessment and they are not shown in the Table 5 or on Map WR-02-204. In the absence of site surveys the features have been assumed to comprise springs, which are high value receptors.

Table 5: Groundwater – surface water interaction

Feature (and map grid square)[13]	Distance and direction from route	Formation	Elevation (m AOD)	Comments
Watercourses				
Meece Brook and tributaries	Crossed by the route	Alluvium and River Terrace Deposits which are likely to be in connection with underlying Wilmslow Sandstone (Sherwood Sandstone Group)	107	Based on discussions with Severn Trent Water Ltd it is known that Meece Brook has some hydraulic connectivity with the Sherwood Sandstone Group Principal aquifer in proximity to the PWS near Whitmore. The brook is also likely to be in connection with the superficial aquifers which are adjacent to it.
River Lea and tributaries	Crossed by the route	Glaciofluvial Sheet Deposits, overlying the Halesowen Formation and Salop Formation (Warwickshire Group)	110	River Lea is likely to be in hydraulic connection with the permeable superficial deposits where it crosses them.

[12] Map WR-02-204
[13] Map WR-02-204. Watercourses cross several map grid squares and are labelled. Map grid squares are provided for the springs and potential spring locations within the study area. These features are listed from south to north.

Feature (and map grid square)[13]	Distance and direction from route	Formation	Elevation (m AOD)	Comments
Springs				
Spring west of Limepits (G5)	145m north-east of the route (within the land required for construction of the Proposed Scheme)	Salop Formation (Warwickshire Group)	145	Surveys confirmed groundwater seepage supporting a stream. This feature has therefore been assessed as a high value receptor.
Potential spring, Moat Wood (F5)	600m north-east of the route (440m north-east of the land required for construction of the Proposed Scheme, adjacent to an area of mitigation planting)	Salop Formation (Warwickshire Group)	156	Not surveyed. Assumed to be a high value receptor. The 'issue' is likely to be groundwater from the Salop Formation.
Potential spring, north of Whitmore Wood (F5)	105m north-east of the route (within the land required for construction of the Proposed Scheme, area of mitigation planting)	Salop Formation (Warwickshire Group)	148	Not surveyed. Assumed to be a high value receptor. The 'issue' is likely to be groundwater from the Salop Formation.
Potential spring, east of Netherset Hey (F5)	930m north-east of the route (500m north-east of the borrow pit east of Netherset Hey Farm)	Salop Formation (Warwickshire Group)	128	Not surveyed. Assumed to be a high value receptor until this is verified by survey. The 'issue' is not hydraulically connected with the Proposed Scheme.
Potential spring, north west of Fodderbing House (E7)	580m south-west of the route (440m south-west of the land required for construction of the Proposed Scheme)	Glacial Till	165	Not surveyed. Assumed to be a high value receptor until this is verified by survey. The 'issue' is not hydraulically connected with the Proposed Scheme.
Potential spring, Beech Wood (D7)	875m south-west of the route (850m south-west of the land required for construction of the Proposed Scheme)	Glacial Till	130	Not surveyed. Assumed to be a high value receptor until this is verified by survey. The 'issue' is not hydraulically connected with the Proposed Scheme.
Issue, west of Beechfields (D6)	370m south-west of the route (line of Madeley tunnel) (310m south-west of the land required for construction of the Proposed Scheme)	Glacial Till	129	Surveys showed the issue is likely to originate from land drainage and this has therefore been assessed as a low value receptor.
Potential spring, Lower Mill Cottage (D6)	740m north-east of the route (325m north-east of the land required for construction of the Proposed Scheme)	Glaciofluvial Deposits	92	Not surveyed. Assumed to be a high value receptor until this is verified by survey. The 'issue' is not hydraulically connected with the Proposed Scheme.

Feature (and map grid square)[13]	Distance and direction from route	Formation	Elevation (m AOD)	Comments
Potential spring, east of Grafton's Wood (D6)	400m north-east of the route (adjacent to the land required for construction of the Proposed Scheme, inline works on the WCML)	Glacial Till	105	Not surveyed. Assumed to be a high value receptor. The 'issue' is likely to be drainage from the WCML.
Potential spring, west of Grafton's Wood (D6)	250m north-east of the route (130 south-west of the land required for construction of the Proposed Scheme, WCML)	Glaciofluvial Deposits	83	Not surveyed. Assumed to be a high value receptor. The 'issue' is likely to be groundwater from the Glaciofluvial Deposits.
Potential spring, south west of Lower Thornton (D6)	790m north-east of the route (365m north-east of the land required for construction of the Proposed Scheme)	Glacial Till	104	Not surveyed. Assumed to be a high value receptor until this is verified by survey. The 'issue' is not hydraulically connected with the Proposed Scheme.

3.4 Water dependent habitats

3.4.1 There are no designated water dependent habitats in the study area.

3.4.2 Whitmore Wood is a Local Wildlife Site and is described as follows:

"Coniferous plantation and a stand of semi-natural broadleaved woodland with most of the diversity in the ground flora confined to rides and tracksides. A stream supports wet woodland vegetation".

3.4.3 Ecological surveys have shown that none of the recorded plant species in Whitmore Wood are restricted to wetland habitats. As such the woodland is not assessed as groundwater dependent and the focus of the water resources assessment is on the groundwater dependence of the nearby tributaries of the River Lea which intersect the woodland. Ecological impacts are assessed in Volume 2, Whitmore Heath to Madeley area report, Section 8.

4 Site specific surface water assessments

4.1 Summary of assessment

4.1.1 Table 6 summarises the potential impacts and effects related to surface water features, including watercourses, abstractions and discharges within the study area.

4.1.2 The WFD compliance assessment (Volume 5: Appendix WR-001-000) provides a comprehensive review of the aspects of the Proposed Scheme that have potential to cause permanent impacts on water bodies, or which could constrain the future achievement of water body objectives. Temporary construction impacts, defined as those which would last less than three years, may not have implications for WFD compliance, but may nevertheless result in significant effects related to water resources. Such temporary effects have therefore been considered in this assessment, as shown in Table 6.

4.1.3 The draft Code of Construction Practice (CoCP), referred to in Table 6, sets out the measures and standards of work that will be applied to the construction of the Proposed Scheme (see Volume 5: Appendix CT-003-000). These will provide effective management and control of such impacts during the construction period.

4.1.4 The WFD compliance assessment identifies a number of minor adverse impacts on water bodies within this study area. Because these minor adverse impacts are all associated with low value water bodies, no significant effects are anticipated. Adverse impacts on high and very high value water bodies identified in the WFD compliance assessment have been assessed as negligible as a result of the avoidance and mitigation measures incorporated into the design. These impacts and effects are not included in Table 6.

4.1.5 No potential for adverse impacts on the discharges to surface water listed in Table 2 have been identified.

Table 6: Summary of potential impacts to surface water receptors

Surface water feature/receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
Watercourses									
Meece Brook River Lea	High	- Realignments - Watercourse crossings / viaducts and bridges.	Potentially affected by pollution caused by mobilisation of contaminants by runoff from the construction area. Typically these would include sediments, hydrocarbons related to fuel oils and high alkaline substances such as cement and concrete.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measured described in the draft CoCP	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
Minor ditches	Low	- Realignments - Watercourse crossings / viaducts and bridges.	Potentially affected by pollution caused by mobilisation of contaminants by runoff from the construction area. Typically these would include sediments, hydrocarbons related to fuel oils and high alkaline substances such as cement and concrete.	Magnitude of impact - Minor Significance of effect - Negligible, not significant	None required though the CoCP will be implemented throughout construction	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
Surface water abstractions									
Unlicensed surface water abstraction - Tributary of the River Lea 4/SA/1[7] (D5)	High	- Whitmore Wood overbridge and retaining wall	The abstraction is upstream of the proposed realignment works associated with the Whitmore Wood Culvert. As such it is unlikely to be affected during construction.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required though the CoCP will be implemented throughout construction	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (Temporary)
Unlicensed surface water abstraction - River Lea 4/SA/2[7] (G6)	High	- Checkley Brook viaduct embankment	The abstraction is downstream of the Checkley Brook viaduct and would potentially be affected by pollution caused by mobilisation of contaminants by runoff from the construction area. Typically these would include sediments, hydrocarbons related to fuel oils and high alkaline substances such as cement and concrete.	Magnitude of impact - Moderate Significance of effect - Moderate adverse, significant	Implementation of measured described in the draft CoCP	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (Temporary)

5 Site specific groundwater assessments

5.1 Summary of assessment

5.1.1 Table 7 summarises all the potential impacts to hydrogeology (aquifers), abstractions, groundwater – surface water interactions and groundwater dependent terrestrial ecosystems.

5.1.2 In Table 7, potential impacts on aquifers are grouped into those associated with above or at ground design elements, and those associated with significant excavation or construction of permanent below ground features. Potential impacts on other groundwater receptors such as abstractions, discharges and springs are considered in the context of relevant design elements with a focus on those elements which have the potential to cause an impact.

5.1.3 Impacts on the springs, potential spring features and consented discharges to groundwater listed in Table 4 are only included in Table 7, where the potential for adverse impacts has been identified. No potential for the Proposed Scheme to have an adverse impact on the consented discharges to groundwater in this study area has been identified.

5.1.4 The potential impacts of future ground investigation are considered negligible, because of the measures outlined in the draft CoCP. As this assessment is applicable for all receptors it is not re-stated in Table 7.

5.1.5 Further detail of several elements of the assessment is presented in Section 5.2.

Table 7: Summary of potential groundwater impacts

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
Aquifers									
Alluvium - Secondary A aquifer	Moderate	Construction of above ground elements and shallow (<1m) excavation including: - At grade track - Stableford North embankment - Meece embankment - Checkley South embankment - Temporary works such as stockpile	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary. Temporary and permanent works are above ground or shallow and of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
		Construction involving deeper excavation (>1m below ground level (bgl) including - Meece Brook viaduct	Construction of viaduct piers has the potential to affect shallow groundwater quality and flow during construction, however this will be very localised and temporary. Potential alteration of shallow groundwater flow pathways may occur around new viaduct piers. Due to the location and minor extent of the piers within the much larger area of alluvium, the impact on groundwater flow pathways will be negligible.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
River Terrace Deposits - Secondary A aquifer	Moderate	Construction of above ground elements and shallow (<1m) excavation including: - At grade track and roads - Stableford North embankment - Meece embankment - Checkley South embankment - Lea South embankment - Temporary works such as stockpiles and compounds	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary. Temporary and permanent works are above ground or shallow and of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
		Construction involving deeper excavation (>1mbgl) including: - Meece Brook viaduct - River Lea viaduct	Construction of viaduct piers has the potential to affect shallow groundwater quality and flow during construction, however this will be very localised and temporary. Potential alteration of shallow groundwater flow pathways may occur around new viaduct piers. Due to the location and minor extent of the piers within the much larger area of aquifer, the impact on groundwater flow pathways will be	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
			negligible.						
Glaciofluvial Deposits (Glaciofluvial Sheet Deposits and Glaciofluvial Deposits, Undifferentiated) - Secondary A aquifer	Moderate	Construction of above ground elements and shallow (<1m) excavation including: - At grade track and roads - Checkley South embankment - road realignments - temporary works such as stockpiles and compounds	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary. Temporary and permanent works are above ground or shallow and of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
		Construction involving deeper (>1mbgl) excavation including: - Borrow pit west of Netherset Hey Farm - River Lea viaduct - Madeley tunnel	Construction of viaduct piers has the potential to affect shallow groundwater quality and flow during construction, however this will be very localised and temporary. Potential alteration of shallow groundwater flow pathways may occur around new viaduct piers. Due to the location and minor extent of the piers within the much larger area of aquifer, the impact on groundwater flow pathways will be negligible. See Section 5.2 for potential impacts of the borrow pit and Madeley tunnel.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP. Following ground investigation and monitoring, mitigation will be designed to manage any impacts on the River Lea, due to changes in baseflow from the Secondary A aquifer during excavation of the borrow pit west of Netherset Hey House. See Section 5.2. Design of permanent structures will include groundwater control/drainage measures where required[14].	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Sidmouth Mudstone (of the Mercia Mudstone Group) - Secondary B aquifer	Moderate	Construction of above ground elements and shallow (<1m) excavation including: - At grade track and roads - Checkley South embankment - temporary works such as stockpiles and compounds	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary. Temporary and permanent works are above ground or shallow and of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
		Construction involving deeper excavation (>1mbgl) including northern porous portal of Madeley tunnel	Potential impacts on groundwater quality, levels and flow due to construction of the tunnel. See Section 5.2.	Magnitude of impact - Moderate Significance of effect – Moderate adverse,	Implementation of measures described in the draft CoCP. Design of permanent structures will include	Magnitude of impact - Negligible Significance of effect - Negligible,	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not	Construction (temporary and permanent)

[14] Groundwater control/drainage measures are outlined in Volume 2, Whitmore Heath to Madeley area report, Section 15 and Volume 5, WFD compliance assessment, Appendix WR-001-000. These measures will be designed in detail, where required, following ground investigation and monitoring. They may include, for example, passive hydraulic bypasses at cuttings and other below ground structures or use of soakaways to promote local aquifer recharge.

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
				significant	groundwater control/drainage measures where required[14].	not significant		significant	
Sherwood Sandstone Group - Wilmslow Sandstone (Wildmoor Sandstone) - Principal aquifer	High (except where coincident with an SPZ1 where its value is very high, see abstraction impacts).	Construction of above ground elements and shallow (<1m) excavation including: - Stableford North embankment - At grade track and roads - temporary works such as compounds	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary. Temporary and permanent works are above ground or shallow and of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow. For impacts on abstraction and associated SPZ, see 'abstractions'.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
		Construction involving deeper excavation (>1mbgl) including: - Bent Lane (North) diversion and associated cutting	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary. Bent Lane (North) diversion has a small cutting located in a SPZ1 (which is associated with the abstraction near Whitmore). This cutting is however above rest groundwater levels and will not impact groundwater levels or flow. For impacts on abstractions and associated SPZ, see 'abstractions'.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP. Design of permanent structures will include groundwater control/drainage measures where required[14].	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Sherwood Sandstone Group - Wilmslow Sandstone (Wildmoor Conglomerate) – Principal aquifer	High	- Construction of above ground elements.	The unit is only crossed by the land required for construction of the Proposed Scheme where there is provision for wetland ecological mitigation in the vicinity of Meece Brook.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required, though the CoCP will be implemented during construction.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
Sherwood Sandstone Group - Wilmslow Sandstone (Wilmslow Sandstone) –- Principal aquifer	High (except where coincident with an SPZ1 where its value is very high, see abstraction impacts).	Construction of above ground elements and shallow excavation (<1m) including: - Stableford North embankment - At grade track and roads - temporary works such as stockpiles and compounds	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary. Temporary and permanent works are above ground or shallow and of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow. For impacts on abstractions and associated SPZ, see 'abstractions'.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
		Construction involving deeper excavation (>1mbgl) including: - Meece Brook viaduct piers	Construction of viaduct piers has the potential to affect shallow groundwater quality and flow during construction, however this will be very localised and temporary.	Magnitude of impact - Moderate Significance of effect – Moderate adverse,	Implementation of measures described in the draft CoCP. Design of permanent structures will include	Magnitude of impact - Negligible Significance of effect - Negligible,	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not	Construction (temporary and permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
		- Whitmore South cutting - Bent Lane (North) diversion - Whitmore Heath tunnel	The assessment of potential impacts on groundwater quality and flow, due to construction of the cutting and tunnel is set out in Section 5.2.	significant	groundwater control/drainage measures where required[14].	not significant		significant	
Sherwood Sandstone Group - Chester Formation (Kidderminster Sandstone and Conglomerate (Interbedded) - Principal aquifer	High	Construction of above ground elements and shallow (<1m) excavation including: - temporary works such as haul roads and compounds	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
		Construction involving deeper excavation (>1mbgl): - Whitmore Heath tunnel	Assessment of potential impacts on groundwater quality, level and flow due to construction of the tunnel are set out in Section 5.2.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP. Design of permanent structures will include groundwater control/drainage measures where required[14].	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Sherwood Sandstone Group - Chester Formation (Kidderminster Formation - Conglomerate) - Principal aquifer	High	Construction of above ground elements and shallow excavation (<1m) including: - temporary works such as haul roads and compounds	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
		Construction involving deeper excavation (>1mbgl) including: - Whitmore Heath tunnel - Whitmore North cutting	Assessment of potential impacts on groundwater quality, level and flow due to construction of the tunnel are set out in Section 5.2.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP. Design of permanent structures will include groundwater control/drainage measures where required[14].	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Sherwood Sandstone Group - Chester Formation (Chester Pebble Beds) - Principal aquifer	High	Construction of above ground elements and shallow (<1m) excavation including: - temporary works such as haul roads, stockpiles and compounds	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
		Construction involving deeper excavation (>1mbgl) including: - Madeley cutting - Madeley tunnel - Porous portal retaining walls	Assessment of potential impacts on groundwater quality, level and flow due to construction of the tunnel and cutting (and associated retaining wall) are set out in Section 5.2.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP. Design of permanent structures will include groundwater control/drainage measures where required[14].	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
Warwickshire Group (Salop Formation) - Secondary A aquifer	Moderate	Construction of above ground elements and shallow (<1m) excavation including: - - Lea South embankment - At grade track - temporary works such as haul roads, stockpiles and compounds	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary. Temporary and permanent works are above ground or shallow and of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
		Construction involving deeper excavation (>1mbgl) including: - Porous portal (north of Whitmore Heath tunnel) - Whitmore Wood retaining wall - Whitmore North cutting - River Lea viaduct	Construction of viaduct piers has the potential to affect shallow groundwater quality and flow during construction, however this will be very localised and temporary. Assessment of potential impacts on groundwater quality, level and flow due to construction of the tunnel and cutting (and associated retaining wall) are set out in Section 5.2.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP. Design of permanent structures will include groundwater control/drainage measures where required[14].	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Warwickshire Group (Halesowen Formation) – Secondary A aquifer	Moderate	Construction of above ground elements and shallow (<1m) excavation including: - Lea North embankment - At grade track and roads - temporary works such as haul roads, stockpiles and compounds	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary. Temporary and permanent works are above ground or shallow and of small areal extent compared to the aquifer therefore are likely to have a negligible impact on recharge and/or groundwater flow.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
		Construction involving deeper excavation (>1mbgl) including: - River Lea viaduct - Madeley cutting - Madeley tunnel	Construction of viaduct piers has the potential to affect shallow groundwater quality and flow during construction, however this will be very localised and temporary. Assessment of potential impacts on groundwater quality, level and flow due to construction of the tunnel and cutting are set out in Section 5.2.	Magnitude of impact - Major Significance of effect – Major adverse, significant	Implementation of measures described in the draft CoCP. Design of permanent structures will include groundwater control/drainage measures where required[14].	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)
Abstractions									
PWS near Whitmore protected by SPZ1, 2 and 3 Licence identifier confidential (H5[12] - SPZ1	Very high	Construction of above ground elements in SPZ1: - Stableford North embankment - Bent Lane (North) realignment and closure - Bent Lane (South) diversion	Removal of topsoil or shallow material, and construction activity has potential to cause increased turbidity and impact on groundwater quality in the SPZ1 during construction. There is thin and patchy superficial cover of the Sherwood Sandstone Group aquifer in this area therefore there is a direct pathway for contamination in close proximity to the abstraction.	Magnitude of impact - Major Significance of effect – Major adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Major Significance of effect – Major adverse, significant	It is likely that even with CoCP measures in place, there remains a risk to groundwater quality of this important water supply during the construction works. Additional mitigation is being agreed with	Magnitude of impact - Major Significance of effect – Major adverse, significant (until a mitigation strategy is agreed with the Environment Agency in consultation	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
location)							the Environment Agency in consultation with the operator.	with Severn Trent Water Limited, there is the potential for a significant effect)	
				Magnitude of impact - Moderate Significance of effect – Major adverse, significant	Implementation of measures described in the draft CoCP. The detailed design of, and maintenance regime for, the track and drainage measures within the SPZ associated with the public water supply near Whitmore will be developed in close consultation with Severn Trent Water Limited and the Environment Agency to ensure no permanent significant effect.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Additional monitoring requirements are being agreed with the operator and the Environment Agency.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (permanent)
		- Meece Brook viaduct piers in SPZ1 and SPZ2	Barriers of low permeability have potential to affect groundwater levels and flow however, the Meece Brook viaduct piers are aligned approximately parallel to the direction of groundwater flow to the PWS and will therefore not cause a permanent impact.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	The alignment of the Proposed Scheme is parallel to the predicted groundwater flow direction in the vicinity of the viaduct.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (permanent)
			Construction of viaduct piers has the potential to affect shallow groundwater quality and flow during construction, however this will be very localised and temporary. Further detail is provided in Section 5.2.	Magnitude of impact - Moderate Significance of effect – Major adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Moderate Significance of effect – Major adverse, significant	It is likely that even with contaminant control measures in place the risk to quality of this major water resource would be too great to continue supply during construction works. Additional mitigation is being agreed with the Environment Agency in consultation with the operator.	Magnitude of impact - Moderate Significance of effect – Major adverse, significant (until a mitigation strategy is agreed with the Environment Agency in consultation with Severn Trent Water Limited, there is the potential for a significant effect)	Construction (temporary)
		Construction of at/near ground level elements in SPZ2: - Meece embankment - stockpile - MAP, EAP and MPATS sites - balancing ponds	The temporary works have the potential to affect shallow groundwater quality, although this is likely to be localised and temporary.	Magnitude of impact - Major Significance of effect – Major adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant		Magnitude of impact - Minor Significance of effect – Moderate adverse, significant (until a mitigation strategy is agreed with the Environment Agency in consultation	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
								with Severn Trent Water Limited, there is the potential for a significant effect)	
		Construction of key elements in SPZ3: - Whitmore South cutting - Whitmore Heath tunnel and porous portals	Construction of below ground elements within the SPZ3 have potential to impact on groundwater levels and flow to the PWS only where they intersect groundwater. See Section 5.2 for the groundwater assumptions and assessment at cutting locations, including temporary dewatering requirements and long term impacts on groundwater level.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
				Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP. Design of permanent structures will include groundwater control/drainage measures where required[14].	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (permanent)
			The temporary works have the potential to affect shallow groundwater quality in the SPZ3 although this is likely to be localised and temporary.	Magnitude of impact - Minor Significance of effect – Major adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Additional mitigation is being agreed with the Environment Agency in consultation with the operator.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant (until a mitigation strategy is agreed with the Environment Agency in consultation with Severn Trent Water Limited, there is the potential for a significant effect)	Construction (temporary)
Licensed abstraction Netherset Hey 2568001255 (E5)[12]	High	Borrow pit west of Netherset Hey Farm	The borrow pit will be excavated to a maximum depth of 17.8mbgl (assumed average depth 4.3mbgl) through the superficial deposits, and restored with less permeable material. The abstraction is >200m from the borrow bit and water is abstracted from the underlying Halesowen Formation (rest water level approximately 22mbgl) therefore water quantity at the abstraction will not be impacted. Construction activity has the potential to impact on groundwater quality if the superficial deposits and unsaturated zone act to provide a pathway to the underlying aquifer.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
Licensed abstraction	High	- Manor Road overbridge - Lea North embankment	Borehole log SJ74/70 shows that the borehole abstracts from a horizon between 42mbgl and 65mbgl (approximately 98mAOD to 75mAOD) in	Magnitude of impact - Minor	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible	None required	Magnitude of impact - Negligible	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
Manor Farm NW/068/0001/016 (E6)[12]		- Temporary stockpile - Madeley cutting - Borrow pit west of Netherset Hey Farm	the Halesowen Formation, and the material above is cased off. Rest water level in this horizons was recorded at 32mbgl (approximately 108mAOD) at the time of drilling. There is potential for the other construction works associated with nearby design elements to degrade water quality, particularly where there is no superficial cover, or a permeable unsaturated zone. Due to distance of construction works from the abstraction point, the impact magnitude has been assessed as minor. Madeley cutting is 560m to the north of the abstraction and has a maximum cut depth between 128mAOD and 108mAOD (with maximum depths to the north). Therefore it is not expected to cause an impact on quantity of water available for the abstraction. The borrow pit will be excavated in a different aquifer and is 820m from the abstraction therefore will also not cause an impact.	Significance of effect – Moderate adverse, significant		Significance of effect - Negligible, not significant		Significance of effect - Negligible, not significant	
Unlicensed private water supply Hey House Farm 4/GA/1 (E6)[12]	High	- Lea North embankment - Manor Road overbridge - Borrow pit west of Netherset Hey Farm	The depth to groundwater and abstraction horizon is not known at this location. At the location of the abstraction and nearby design elements Glaciofluvial Sheet Deposits, overlie the Halesowen Formation. Quantity of groundwater in the catchment of the private water supply is not likely to be impacted by the above ground works however stripping of topsoil, general construction activity and borrow pit excavation could cause increases in turbidity of groundwater supplying this site (See Section 5.2).	Magnitude of impact - Major Significance of effect - Major adverse, significant	Implementation of measures described in the draft CoCP. Further investigation and monitoring. Where monitoring indicates that construction would impact on the groundwater source this will be discussed with the landowner concerned with a view to a permanent new supply being provided if necessary.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
			Without knowing further details of the abstraction it is assumed that there could be potential to impact on groundwater quantity and quality at the abstraction due to permanent changes in local drainage associated with the design elements.	Magnitude of impact - Major Significance of effect - Major adverse, significant		Magnitude of impact - Negligible Significance of effect - Negligible, not significant		Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (permanent)
Unlicensed private water supply Hey House Lodge 4/GA/2 (E6)[12]	High	- Lea North embankment - Manor Road overbridge	The abstraction is in the path of the route and currently supplies Hey House Lodge, which is scheduled for demolition.	Magnitude of impact - Major Significance of effect - Major adverse, significant	Appropriate backfill and decommissioning of the borehole in consultation with the owner.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (permanent)
Unlicensed private water supply	High	- Madeley tunnel and porous portals	The tunnel has a maximum depth approximately 40mbgl and is only 40m from the abstraction. Although the tunnel will be constructed in closed	Magnitude of impact - Major	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible	None required	Magnitude of impact - Negligible	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
Bower End Farm 4/GA/3 (D6)[12]			face mode, there may be a risk to the quantity and quality of the water abstracted from this borehole during construction. See Section 5.2.	Significance of effect - Major adverse, significant	Further investigation and monitoring. Where monitoring indicates that construction could impact on the groundwater source this will be discussed with the landowner concerned with a view to a permanent new supply being provided if necessary. As well as providing a water supply for a private owner the borehole is also used by the Environment Agency as a water quality monitoring borehole. It is recommended that the borehole is not decommissioned and backfilled, but left as a monitoring point.	Significance of effect - Negligible, not significant		Significance of effect - Negligible, not significant	
			Due to the proximity of the tunnel it is possible that borehole yield will be permanently impacted as flow paths may be altered within the aquifer in proximity to the tunnel. See Section 5.2.	Magnitude of impact - Major Significance of effect - Major adverse, significant				Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (permanent)
Groundwater – surface water interaction									
Meece Brook and tributaries	Very High	- Stableford North embankment - Meece embankment - Meece Brook viaduct - At grade features - Temporary construction features such as stockpiles and compounds	Potential construction impacts on local groundwater quality, which may affect the baseflow water quality to Meece Brook.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
		- Meece Brook viaduct	Construction of viaduct piers has the potential to affect shallow groundwater quality and flow during construction, however this will be very localised and temporary.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
		- Meece Brook viaduct	Potential alteration of shallow groundwater flow pathways may occur around new viaduct piers. Due to the location and minor extent of the piers within the much larger area of the aquifers, the impact on groundwater flow pathways will be negligible in the context of baseflow to Meece Brook.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required, though the CoCP will be implemented during construction.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (permanent)
Tributaries of the River Lea (to the north and south of Whitmore Wood)	Low	- Whitmore North cutting - Whitmore Wood retaining wall - Northern porous portal of Whitmore Heath tunnel	Potential temporary local changes to baseflow to the tributary south of Whitmore Wood and the tributary north of Whitmore Wood from the Salop Formation Secondary A aquifer due to construction dewatering. See Section 5.2.	Magnitude of impact - Moderate Significance of effect – Minor adverse, not significant	Implementation of measures described in the draft CoCP. If ground investigation and monitoring demonstrate a connection between groundwater and surface	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
					water, an appropriate dewatering and discharge plan will be designed in consultation with the Environment Agency.				
			Potential changes to baseflow to the tributary south of Whitmore Wood and the tributary north of Whitmore Wood from the Salop Formation Secondary A aquifer due to below ground structures. See Section 5.2.	Magnitude of impact - Moderate Significance of effect – Minor adverse, not significant	Implementation of measures described in the draft CoCP. Design of permanent structures will include groundwater control/drainage measures where required[14].	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (permanent)
River Lea	High	- Borrow pit west of Netherset Hey Farm	Potential reduction in baseflow, and potential loss of water from the River Lea to ground as the hydraulic gradient is reversed in the surrounding Secondary A aquifer Glaciofluvial Deposits during excavation dewatering of the borrow pit. See Section 5.2.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP. A 50m buffer has been assigned around the River Lea, where no excavation will take place.	Magnitude of impact - Minor Significance of effect - Moderate, significant	Additional mitigation to be designed following ground investigation and monitoring. Mitigation could involve groundwater cut off structures, re-circulation of water or temporary re-alignment of the River Lea during the construction phase. Measures will be designed in consultation with the Environment Agency.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
			Potential reduction in baseflow to the River Lea and the tributary that crosses the borrow pit as Secondary A aquifer sand and gravel is replaced with less permeable material when the borrow pit is restored.	Magnitude of impact - Moderate Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP. Detailed drainage design will ensure water is transmitted across the restored borrow pit area, to the surface watercourses so that there is no permanent reduction of baseflow[14].	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (permanent)
Spring, west of Limepits (G5) [12]	High	- Area of mitigation planting adjacent to the spring	Potential minor impacts on water quality during construction. Works will be at the surface.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effects	Duration of effect
Potential spring, Moat Wood (F5) [12]	High	- Area of mitigation planting adjacent to the spring	Potential minor impacts on water quality during construction. Works will be at surface.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
Potential spring, north of Whitmore Wood (F5) [12]	High	- Whitmore North cutting - Whitmore Wood retaining wall - Mitigation planting	Potential minor impacts on water quality during construction due to adjacent mitigation planting. Works will be at surface. No impacts from Whitmore North cutting and Whitmore Wood retaining wall are predicted (see Section 5.2).	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
Issue, west of Beechfields (D6) [12]	Low	- Madeley tunnel	Potential changes to groundwater levels in proximity to the spring due to tunnel construction (see Section 5.2). If groundwater contributes to drainage at this location it is likely to issue from a thin permeable horizon in the Glacial Till, and is likely to have limited, if any connection with the underlying Sherwood Sandstone Group aquifer.	Magnitude of impact - Minor Significance of effect - Negligible, not significant	None required though the CoCP will be implemented throughout construction.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
Potential spring, east of Grafton's Wood (D6) [12]	High	- WCML Intervention I	The potential spring is not hydraulically connected with aquifers in proximity to the route of the Proposed Scheme however it could be hydraulically connected with the WCML where construction work is proposed. Potential impact on water quality due to works on the WCML. Works are at the surface and contained within the existing corridor of the WCML.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
Potential spring, west of Grafton's Wood (D6) [12]	High	- WCML Intervention I	Potential impact on water quality due to works on the WCML. Works are at the surface and contained within the existing corridor of the WCML.	Magnitude of impact - Minor Significance of effect – Moderate adverse, significant	Implementation of measures described in the draft CoCP.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Not applicable

5.2 Detailed assessment

5.2.1 In support of the impact assessment presented in Table 7, further detail is provided in this section to demonstrate the methodology and assumptions used in relation to specific design elements and locations along the route of the Proposed Scheme. Within the Whitmore Heath to Madeley area, detailed assessments are presented demonstrating the likely impact on groundwater from tunnels, cuttings, viaduct and overbridge piers and the borrow pit west of Netherset Hey Farm.

Impact to groundwater from tunnels

Whitmore Heath Tunnel

5.2.2 The location of Whitmore Heath tunnel is shown in Volume 2: Map Series CT-05 and Map Series CT-06. The tunnel consists of four main elements which are considered in the groundwater assessment, from south to north. These are the southern porous portal, Whitmore Heath cut and cover tunnel, Whitmore Heath twin bore tunnel and the northern porous portal. The tunnel details and groundwater assessment parameters are detailed in Table 8. The term 'porous portal' is used in the name of the design elements in reference to the tapered, perforated, reinforced concrete structures, which reduce air pressure effects created as trains enter a tunnel (see Volume 1, Introduction to the Environmental Statement). The term is not used in reference to hydraulic properties of the portal. For the groundwater assessment the porous portal sections of tunnels are assessed in the same way as cuttings.

Table 8: Summary of Whitmore Heath Tunnel parameters for the groundwater assessment

Tunnel parameters	**Parameter details**	
Length (km)	Southern porous portal	0.15
	Whitmore Heath cut and cover tunnel	0.24
	Whitmore Heath twin bore tunnel	0.69
	Northern porous portal	0.15
Maximum depth (m)	Southern porous portal	-
	Whitmore Heath cut and cover tunnel	17
	Whitmore Heath twin bore tunnel	50
	Northern porous portal	-
Strata intercepted	Southern porous portal and Whitmore Heath cut and cover tunnel	Wilmslow Sandstone of the Sherwood Sandstone Group (Principal aquifer)
	Whitmore Heath cut and cover tunnel	Chester Formation of the Sherwood Sandstone Group (Principal aquifer)
	Whitmore Heath twin bore tunnel and Northern porous portal	Chester Formation of the Sherwood Sandstone Group (Principal aquifer) and
	Northern porous portal	Salop Formation of the Warwickshire Group (Secondary A aquifer)

Tunnel parameters	Parameter details	
Lowest element level (mAOD)	Southern porous portal	121
	Whitmore Heath cut and cover tunnel	122
	Whitmore Heath twin bore tunnel	123
	Northern porous portal	126
Groundwater level(s) (mAOD)	There is no groundwater level monitoring in the Principal aquifer in the vicinity of the tunnel but maximum rest water levels in proximity to the PWS near Whitmore are expected to be around 110mAOD, and groundwater monitoring from the nearest Environment Agency observation boreholes (Shelton under Harley and Clowes Wood) would suggest groundwater at a maximum elevation of approximately 115mAOD. There is no groundwater level monitoring in the Secondary A aquifer in the vicinity of the cutting. The spring to the west of Limepits, is thought to issue from this aquifer up gradient of the tunnel at around 145mAOD suggesting that there may be shallow groundwater draining towards local topographic depressions. On the line of the route, in proximity to the tunnel, the minimum topographic low point is 128mAOD. The hydraulic connection between the Salop Formation and Sherwood Sandstone Group is not known though there is likely to be some continuity of flow where there are permeable layers in the Salop Formation. For the purpose of the assessment (which is precautionary) it is therefore assumed that the groundwater level in the north is 130mAOD and gradually decreases to the south. Assumed groundwater levels used for this assessment are shown on Figure 3. Groundwater levels will need to be confirmed following ground investigation and seasonal monitoring.	
Principal receptors (in Whitmore Heath to Madeley area)	Sherwood Sandstone Group Principal aquifer, Salop Formation Secondary Aquifer SPZ 3 (PWS abstraction near Whitmore) Tributaries of the River Lea and the surface water abstraction Spring west of Limepits	

5.2.3 Figure 3 shows the long section of the route at the location of the Whitmore Heath tunnel, along with the geology and assumed groundwater levels used in this assessment. The assessment detail below is set out from south to north.

5.2.4 Based on the assumptions outlined above, the groundwater level in the Sherwood Sandstone Group is below the southern porous portal and Whitmore Heath cut and cover tunnel, and construction of these two elements will not disrupt groundwater flow. Application of the CoCP will ensure materials and fluids used during construction are managed so that there is negligible impact on groundwater quality and associated receptors.

5.2.5 It is likely that even with application of the CoCP there could be a minor impact on water quality at the PWS near Whitmore, due to the location of the tunnel within the SPZ3. As this abstraction is a very high value receptor, this has been assessed as a temporary moderate significant effect. Additional mitigation is being agreed with the Environment Agency in consultation with Severn Trent Water Ltd.

5.2.6 As shown in Figure 3 the groundwater level is expected to be below the base of the Whitmore Heath twin bore tunnel, except potentially the northern most 350m section.

5.2.7 The Whitmore Heath twin bored tunnel will be constructed using a Tunnel Boring Machine (TBM) through the Sherwood Sandstone Group Principal aquifer. The TBM is designed to construct a tunnel lining behind itself as it advances through the ground. This means that the lining is fully constructed using a precast concrete unit at 10m to 15m behind the face of the excavation. The 10m to 15m section between the constructed tunnel lining and the face of the excavation is protected by a 'steel can' which is effectively 100% watertight. As the TBM advances, the excavation face in front of the tunnel will also be pressurised to balance the groundwater pressure and the soil pressure. The cross passages will be constructed using ground improvement, where required, to avoid groundwater ingress. Therefore, no dewatering is expected during construction.

5.2.8 The tunnel is designed to achieve 100% water tightness, so potential loss of groundwater into the tunnel is considered negligible, with negligible impact to the existing groundwater levels in the long term.

5.2.9 Construction of the tunnel will create a cylinder of no flow through the Principal aquifer if it intersects the saturated zone, potentially decreasing the hydraulic conductivity of the aquifer in the area immediately adjacent to the tunnel lining. However, the tunnel bores have diameters of approximately 10.2m, in an aquifer which has an unconfined surface area of several hundred square kilometres and extends vertically below the tunnel more than 50m. The tunnel will therefore have a negligible impact on recharge to the aquifer and groundwater throughflow. Any changes in groundwater level due to the barrier to flow will be highly localised and will have a negligible impact in context of the Principal aquifer as a whole.

5.2.10 At the northern end of the bored tunnel there may be little or no unsaturated zone therefore a greater potential impact to groundwater quality in this area. However, operation of the TBM in closed face mode will limit any pollution pathways and mitigation measures considered within the embedded design and CoCP will reduce the residual impacts to negligible.

5.2.11 The northern porous portal is assumed to be founded within the saturated zone of the Sherwood Sandstone Group Principal aquifer and the Salop Formation Secondary A aquifer. With the assumed groundwater levels outlined above and in Figure 3, groundwater flow in the vicinity of the porous portal would be temporarily disrupted, as groundwater dewatering would be required during construction. This is quantitatively assessed below in the cuttings assessment, effectively as an extension of the Whitmore North cutting. Groundwater dewatering and discharge arrangements will be designed in detail following ground investigation and monitoring in this area, and will ensure negligible impacts on the aquifer.

5.2.12 The aquifers extend more than 50m below the base of the porous portal and are laterally extensive. Therefore potential local changes in groundwater level to the maximum portal elevation of 126mAOD are assessed as having a negligible impact on the Principal aquifer and Secondary A aquifer.

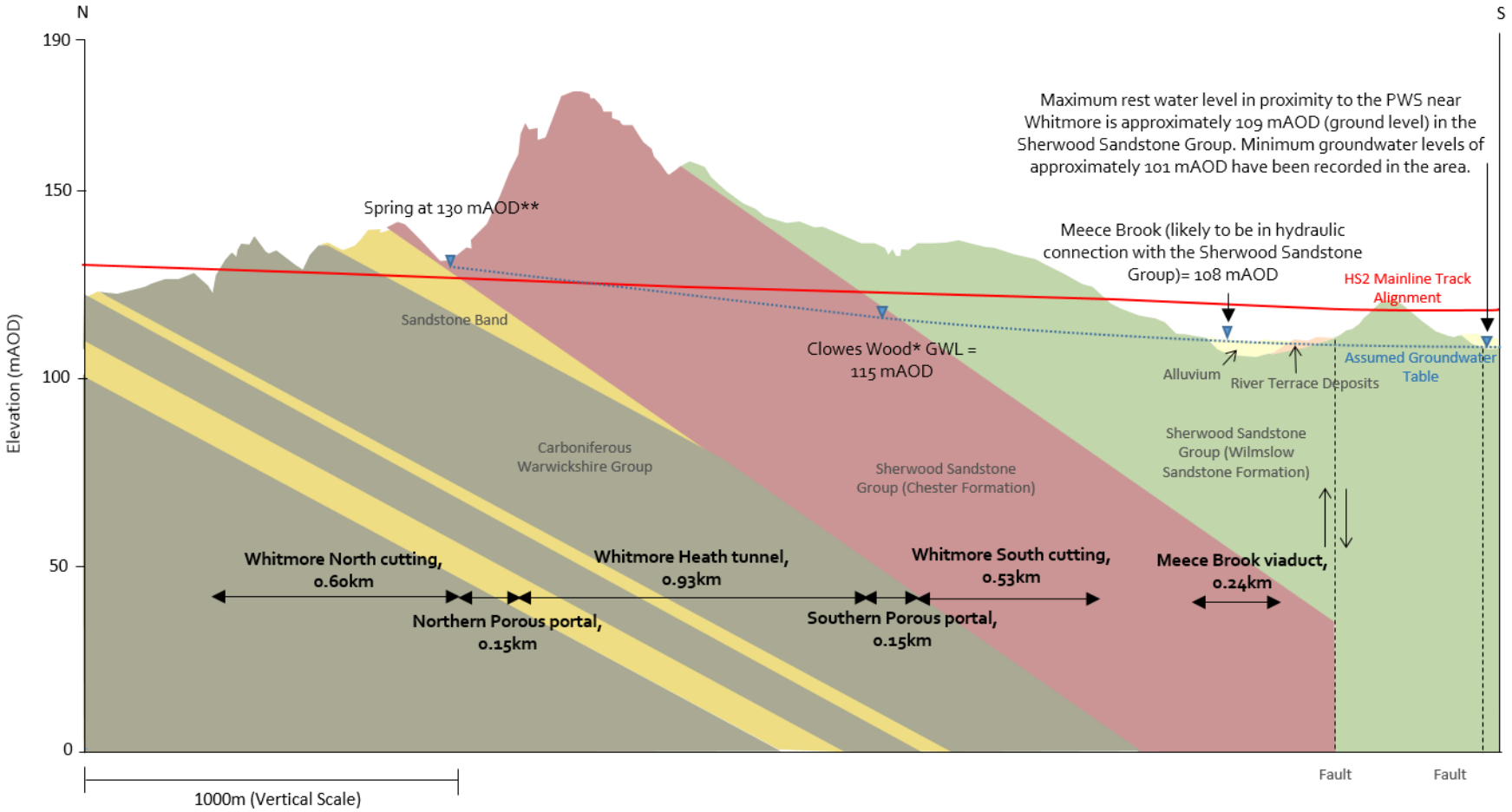
5.2.13 Mitigation may be required during construction to protect the volume of baseflow to the tributary of the River Lea (a low value receptor), which crosses the route at the Snape Hall Road drop inlet culvert. If relevant, dewatering and discharge arrangements will be designed in detail following site investigation, in consultation,

and ensuring appropriate permits are in place, with the Environment Agency. The resulting impact on baseflow to the tributary of the River Lea will be negligible.

5.2.14 The spring to the west of Limepits is approximately 200m from the porous portal, up the topographic gradient and assumed hydraulic gradient, and there will be no impact on water quality of this feature resulting from the construction of the porous portal or other elements of the Whitmore Heath tunnel. The spring is also outside of the potential dewatering radius of influence (see cuttings assessment below) and there will be negligible impact on water quantity.

5.2.15 At the northern porous portal there may be little or no unsaturated zone therefore a greater potential impact for groundwater quality in the Principal aquifer or Secondary A aquifer here during construction. Application of the pollution prevention measures outlined in the draft CoCP will also ensure materials and fluids used during construction are managed appropriately, and permanent drainage design will ensures that there is negligible impact on the Principal aquifer quality or the water quality of baseflow to the tributary of the River Lea.

Figure 3: Long-section showing assumed groundwater levels along Whitmore Heath tunnel



N.B. Where shown, groundwater levels (GWL) presented are maximum observed levels.
* The EA observation borehole at Clowes Wood is approximately 3.7km south west of the line of the section.
**This spring may issue from the Sherwood Sandstone Group, however it may also issue from a shallow discontinuous permeable horizon, or be from surface drainage from the valley to the east of the route. For a precautionary assessment it is assumed to issue from the Sherwood Sandstone Group, however true groundwater levels will need to be confirmed with ground investigation and monitoring.

Madeley Tunnel

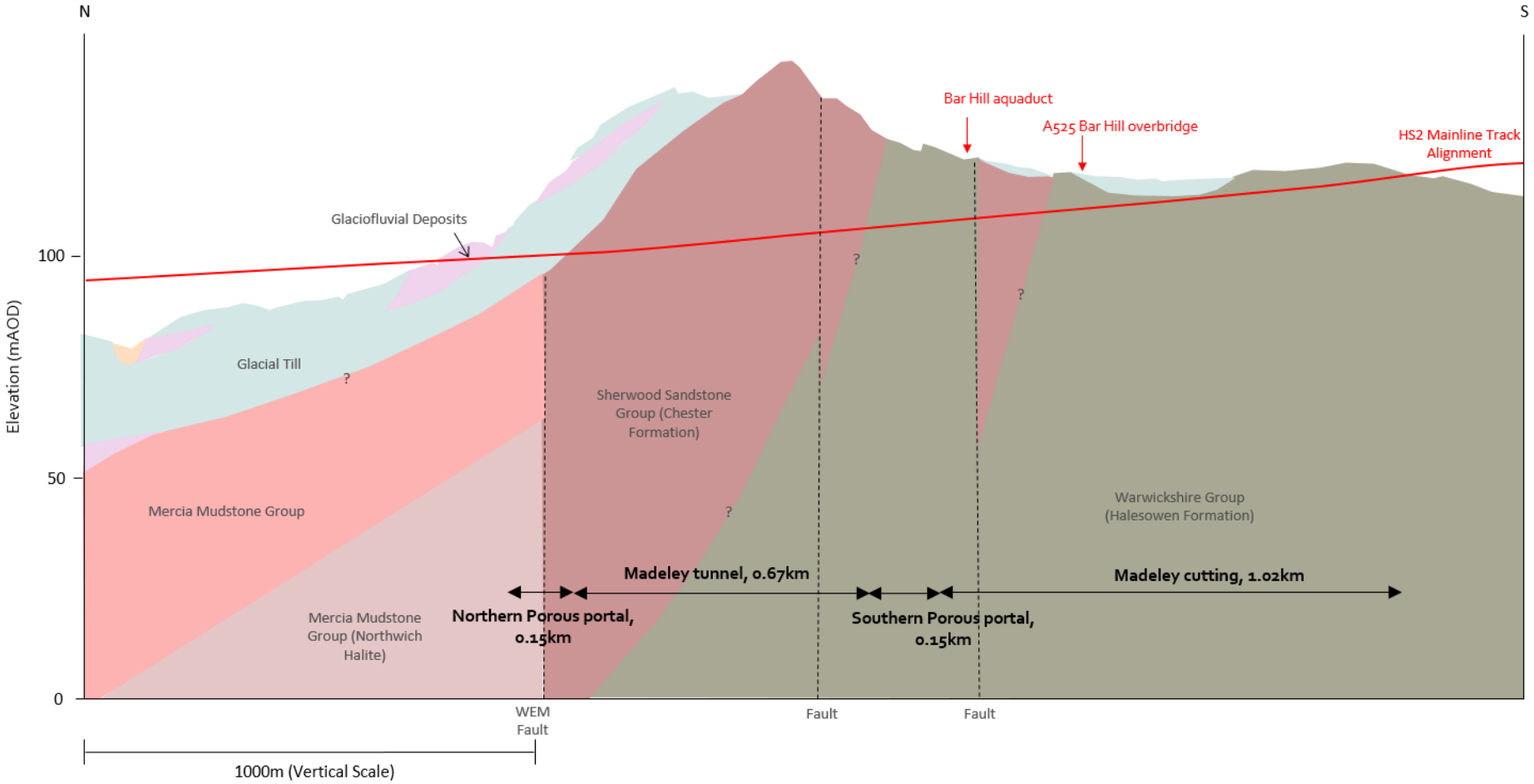
5.2.16 The Madeley tunnel consists of three main elements which are considered in the groundwater assessment. From south to north these are the southern porous portal, Madeley twin bore tunnel and the northern porous portal. The tunnel details and groundwater assessment parameters are detailed in Table 9.

Table 9: Summary of Madeley Tunnel parameters for the groundwater assessment

Tunnel parameters	**Parameter details**	
Length (km)	Southern porous portal Madeley tunnel Northern porous portal	0.15 0.67 0.15
Maximum depth (m)	Madeley tunnel	38
Strata intercepted	Southern porous portal and associated retaining wall, and Madeley tunnel Northern porous portal	Halesowen Formation (Secondary A aquifer) and Chester Formation of the Sherwood Sandstone Group (Principal aquifer Chester Formation of the Sherwood Sandstone Group (Principal aquifer), Mercia Mudstone Group (Secondary B aquifer) and Glaciofluvial Deposits (Secondary A aquifer)
Lowest element level (mAOD)	Southern porous portal Madeley tunnel Northern porous portal	105 99 98
Groundwater level(s) (mAOD)	There is no groundwater level monitoring in any of the aquifers in the vicinity of the Madeley tunnel. Groundwater level monitoring of the Sherwood Sandstone Group at the closest Environment Agency observation borehole (Woore), shows groundwater level up to 138mAOD. The borehole log for the Bower End Farm unlicensed private water supply does not contain any groundwater level information though discussions with the landowner suggest that levels could be up to 3mbgl (129mAOD) at the abstraction. For a precautionary assessment is it therefore assumed that groundwater level in all aquifers is at or near surface and follows the topographic gradient. The maximum depth of the tunnel below ground level is 38m.	
Principal receptors (in the Whitmore Heath to Madeley area)	Sherwood Sandstone Group Principal aquifer, Halesowen Formation Secondary aquifer, Mercia Mudstone Group Secondary B aquifer, Glaciofluvial Deposits Secondary A aquifer. Issue west of Beechfields Tributary of the River Lea (down gradient of the issue west of Beechfields) Bower End Farm unlicensed private water abstraction	

5.2.17 Figure 4 shows the long-section of the route at the location of Madeley tunnel, along with the geology and topography (the assumed groundwater level used in this assessment).

Figure 4: Long-section showing Madeley tunnel



N.B. Limited water level information in area, so it is assumed that rest groundwater levels are at ground level for a precautionary approach.

5.2.18 Based on the groundwater level assumptions set out in Table 9, the following assessment is based on groundwater levels assumed to be at or close to ground level in all aquifers crossed by the Madeley tunnel and porous portals. The features are assumed to be constructed in the saturated zone of the aquifers.

5.2.19 Construction of the Madeley tunnel, which is a twin bore tunnel, will use the methods outlined above for the Whitmore Heath tunnel. As such, the impacts on groundwater level due to dewatering will be negligible. Due to the significant lateral and vertical extent of the Sherwood Sandstone Group Principal aquifer and the Halesowen Formation Secondary A aquifer in comparison to the tunnel, potential permanent impacts on groundwater level and flow due to the creation of a zone of no flow around the tunnel itself, are considered to be negligible.

5.2.20 As it is assumed that no unsaturated zone will be present in this area, there is a greater potential impact on the quality of groundwater in the Principal aquifer or Secondary A aquifer during construction. Application of the pollution prevention measures outlined in the draft CoCP will ensure materials and fluids used during construction are managed, and drainage design will ensure that there is negligible impact on the groundwater quality in the context of the aquifers.

5.2.21 However, taking a precautionary approach due to the proximity of the Bower End Farm private water abstraction, impact magnitude has been assessed as major due to potential changes in groundwater flow and quality. This will be discussed with the landowner concerned, with a view to a permanent new supply being provided if necessary such that there will be no significant effect.

5.2.22 The issue to the west of Beechfields, which is approximately 37m from the tunnel alignment, has been surveyed and is thought to be supplied by land drainage. If there is an element of groundwater discharge at this location it is likely to issue from a shallow permeable horizon within the Glacial Till. With the tunnel construction measures outlined above and implementation of the CoCP, the impact on water flow to this issue is assessed as negligible.

5.2.23 For the purposes of the groundwater assessment the porous portal to the south of the Madeley tunnel has been assessed as an extension of the Madeley cutting. The assessment is set out in the section below. A maximum lateral impact distance of 43.5m from the cutting is estimated due to dewatering. As there are no water dependent features within this extent the impacts of potential cutting and portal dewatering on the water environment will be negligible. The dewatering assessment provides a worst case lateral impact zone. In reality the retaining wall may limit dewatering requirements during construction. In the permanent case the retaining wall could cause a barrier to groundwater flow. Following ground investigation and monitoring, where appropriate, suitable drainage measures would be incorporated into the design to manage groundwater flow. This would ensure a negligible impact on groundwater flow in the context of the aquifer.

5.2.24 Under the scenario of shallow groundwater levels, there is a greater potential for impact on groundwater quality during construction of the porous portal. Application of the pollution prevention measures in the draft CoCP will ensure materials and fluids

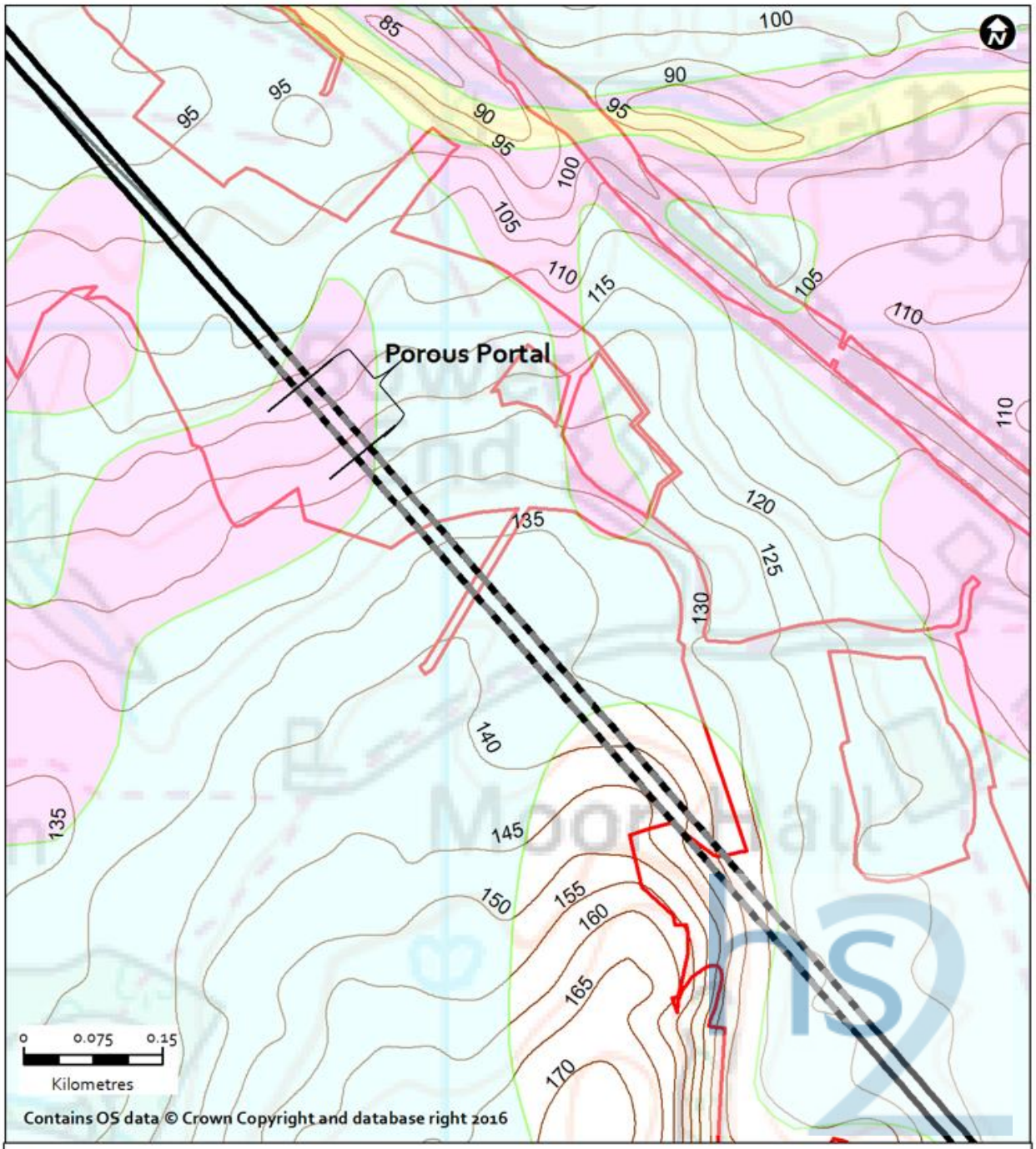
used during construction are managed, and permanent drainage design ensures that there will be negligible impact on aquifer quality.

5.2.25 The porous portal to the north of the Madeley tunnel will cut through Glaciofluvial Deposits (a Secondary A aquifer) and potentially, the Sherwood Sandstone Group Principal aquifer, as well as Glacial Till (a low permeability Unproductive unit). The top several metres of Mercia Mudstone Group Secondary B aquifer (which is covered by a layer of Glacial Till), may also be intersected.

5.2.26 Assuming groundwater levels are close to ground in the aquifer units, the porous portal will require construction dewatering. Groundwater flow in the vicinity of the porous portal would be temporarily disrupted. The Sherwood Sandstone Group aquifer extends more than 50m below the base of the porous portal and is laterally extensive. Therefore potential local changes in groundwater level to the maximum portal depth of 105mAOD are assessed as negligible, in terms of impact on the Principal aquifer. Impacts on groundwater flow in the Mercia Mudstone Group are also assessed as negligible, as only a couple of metres of Mercia Mudstone Group (which is also laterally and vertically extensive) may be intersected by the tunnel. The Mercia Mudstone Group it is also overlain by Glacial Till and groundwater from this aquifer is not expected to issue at surface or support any local abstractions.

5.2.27 The Glaciofluvial Deposits in this area are shallow, and they are not laterally continuous. The Glaciofluvial Deposits are likely to provide some baseflow to the tributary of the River Lea (down gradient of the issue west of Beechfields). However, at the location where the porous portal crosses the Glaciofluvial Deposits, these deposits are down gradient of where the tributary is in connection with the Glaciofluvial Deposits (Figure 5). The tributary will also receive flow from the surface water catchment at this location and the impact has therefore been assessed as negligible.

Figure 5: Madeley tunnel northern porous portal and the Glaciofluvial Deposits Secondary A aquifer



Legend

- Route on Surface
- 1km Buffer around Mainline Route
- Consolidated Construction Boundary
- Topography Contours (5m)

Superficial Deposits

- *ALLUVIUM - CLAY, SILT, SAND AND GRAVEL [UNLITHIFIED DEPOSITS CODING SCHEME]*
- *GLACIOFLUVIAL DEPOSITS, DEVENSIAN - SAND AND GRAVEL [UNLITHIFIED DEPOSITS CODING SCHEME]*
- *TILL, DEVENSIAN - DIAMICTON*

Impact on groundwater from cuttings

5.2.28 The location of cuttings is shown in Volume 2: Map Series CT-05 and Map Series CT-06. The cuttings have been initially characterised to determine whether groundwater elevations are likely to be above the base of the cutting. Parameters for the groundwater assessment of the cuttings are shown in Table 10 to Table 15 below. Where the groundwater elevation is not known or where the elevation has been found to be above the base of the cutting a further detailed assessment of the likely maximum zone of influence from dewatering has been undertaken.

Initial characterisation of cuttings

Hatton South cutting

Table 10: Summary of the Hatton South cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	1.325
Maximum depth (m)	10
Strata intercepted	Wilmslow Sandstone of the Sherwood Sandstone Group (Principal aquifer)
Lowest track level (mAOD)	123
Groundwater level(s) (mAOD)	104.3 to 107.7 (at the Shelton under Harley monitoring borehole)
Principal receptors (in the Whitmore Heath to Madeley area)	Sherwood Sandstone Group Principal aquifer SPZ 3 (PWS abstraction near Whitmore)

5.2.29 The cutting would penetrate the Sherwood Sandstone Group Principal aquifer in an area where the maximum recorded groundwater levels are approximately 15m below the cutting. Groundwater flow will therefore not be disrupted. Application of the CoCP will ensure materials and fluids used during construction are managed so that there is negligible impact on groundwater quality.

Hatton North cutting

Table 11: Summary of the Hatton North cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	0.695
Maximum depth (m)	5
Strata intercepted	Wilmslow Sandstone of the Sherwood Sandstone Group (Principal aquifer)
Lowest track level (mAOD)	119

Cutting parameters	Parameter details
Groundwater level(s) (mAOD)	104.3 to 107.7 (at the Shelton under Harley monitoring borehole)
Principal receptors (in the Whitmore Heath to Madeley area)	Sherwood Sandstone Group Principal aquifer, SPZ3 (PWS abstraction near Whitmore)

5.2.30 The cutting would penetrate the Sherwood Sandstone Group Principal aquifer in an area where the maximum recorded groundwater levels are approximately 11m below the cutting. Groundwater flow will therefore not be disrupted. Application of the CoCP will ensure materials and fluids used during construction are managed so that there is negligible impact on groundwater quality.

Whitmore South cutting

Table 12: Summary of the Whitmore South cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	0.530
Maximum depth (m)	14
Strata intercepted	Wilmslow sandstone of the Sherwood Sandstone Group (Principal aquifer)
Lowest track level (mAOD)	121
Groundwater level(s) (mAOD)	There is no monitoring in the vicinity of the cutting but rest water levels at the PWS of around 110mAOD and groundwater monitoring from the nearest Environment Agency observation boreholes (Shelton under Harley and Clowes Wood) would suggest groundwater at a maximum of around 115mAOD.
Principal receptors	Sherwood Sandstone Group Principal aquifer SPZ3 (PWS abstraction near Whitmore) Meece Brook

5.2.31 The cutting would penetrate the Sherwood Sandstone Group Principal aquifer in an area where the maximum groundwater levels are expected to be approximately 6m below the maximum cutting depth. Groundwater flow will therefore not be disrupted. Application of the CoCP will ensure materials and fluids used during construction are managed so that there is negligible impact on groundwater quality. Further ground investigation is required to confirm groundwater levels in this location.

Whitmore North cutting

Table 13: Summary of the Whitmore North cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	0.600
Maximum depth (m)	13
Strata intercepted	Salop Formation of the Warwickshire Group (Secondary A aquifer)
Lowest track level (mAOD)	127
Groundwater level(s) (mAOD)	There is no monitoring of groundwater in this aquifer in the vicinity of the cutting. The spring to the west of Limepits, issues from the aquifer up gradient at around 145mAOD suggesting that there may be shallow groundwater.
Principal receptors	Salop Formation Secondary A aquifer, Chester Formation (Sherwood Sandstone Group) Principal aquifer Spring west of Limepits Spring to the north of Whitmore Woods Tributary of the River Lea (to the south of Whitmore Wood) Tributary of the River Lea (to the north of Whitmore Wood) (and associated unlicensed surface water abstraction)

5.2.32 The cutting would penetrate the Salop Formation Secondary A aquifer, and potentially a small part of the Sherwood Sandstone Group Principal aquifer at depth, in an area where the maximum groundwater levels could potentially be shallow. Until further ground investigation information is available, a precautionary assessment has been undertaken, assuming groundwater levels are at ground level. Under this scenario groundwater flow in the vicinity of the cutting may be temporarily disrupted, as groundwater dewatering may be required during construction. Further assessment is demonstrated in the following section (assessment of cuttings below groundwater level).

Madeley cutting

Table 14: Summary of the Madeley cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	1.020
Maximum depth (m)	17
Strata intercepted	Halesowen Formation of the Warwickshire Group (Secondary A aquifer), overlain by the Sherwood Sandstone Group Principal aquifer for approximately 75m at the northern extent of the cutting.

Cutting parameters	Parameter details
Lowest track level (mAOD) (including the porous portal of Madeley tunnel)	108
Groundwater level(s) (mAOD)	There is no monitoring of groundwater in the Secondary A aquifer in the vicinity of the cutting. For a precautionary assessment, groundwater levels in the Secondary A aquifer are assumed to be close to ground level at this location. No groundwater level data is available for the Sherwood Sandstone Group in this area. Based on the Environment Agency monitoring data provided, it is assumed that groundwater level in the Sherwood Sandstone Group could be in connection with the permeable units in the Halesowen Formation and groundwater level could be within the cutting.
Principal receptors	Halesowen Formation Secondary A aquifer Sherwood Sandstone Group Principal aquifer Hey House Lodge unlicensed private water abstraction Hey House unlicensed private water abstraction

5.2.33 The cutting would penetrate the Halesowen Formation Secondary A aquifer and Sherwood Sandstone Group Principal aquifer in an area where the maximum groundwater levels could potentially be shallow. Until further ground investigation information is available, a precautionary assessment has been undertaken, assuming groundwater levels are at ground level. Under this scenario groundwater flow in the vicinity of the cutting may be temporarily disrupted, as groundwater dewatering may be required during construction, and groundwater levels may be permanently lowered in the vicinity of the cutting. Further assessment is demonstrated in the following section (assessment of cuttings below groundwater level).

Assessment of cuttings below groundwater level

5.2.34 Assessment of the likely maximum zone of influence from dewatering of the cuttings which may be below existing groundwater level has been made using Sichardt's formula.

5.2.35 The methodology follows the Environment Agency guidance[15] and the methodology set out in CIRIA C750[16], as summarised in the Environmental Impact Assessment Scope and Methodology (SMR) Addendum, Volume 5: Appendix CT-001-002.

5.2.36 Sichardt's formula is presented below:

$$Lo = C \times h \times \sqrt{k}$$

Where; Lo = distance of influence from linear structure (m)

k = hydraulic conductivity (m/s)

[15] Environment Agency (2007), *Hydrogeological impact appraisal for dewatering abstractions*
[16] Preene, M., Roberts, T.O.L. and Powrie, W. (2016), *Groundwater control: design and practice*. CIRIA Publication C750

h = drawdown (m)

C = empirical calculation factor taken to be 1750[17]

5.2.37 Hydraulic conductivity values from the high end of the range presented in literature have been used in the assessment to provide a conservative estimate of the dewatering zone of influence. Where groundwater levels are not known the worst case assumption, that groundwater is at ground level, has been used.

5.2.38 Where an assessment of the zone of influence has been undertaken, cuttings are assumed to be open and any permanent engineering works such as retaining walls or drainage measures do not form part of the quantitative assessment.

5.2.39 Based on these precautionary assumptions, the zone of influence is likely to be overestimated. However, for the purpose of this preliminary assessment, this precautionary approach is considered to be appropriate.

Whitmore North cutting

5.2.40 Assuming a hydraulic conductivity of a permeable sandstone[18,19] (1×10^{-5}m/s), the maximum zone of influence from the cutting (Lo) is estimated at 116.2m. This is based on precautionary assessment using a maximum cutting depth of 21m (including the northern porous portal of the adjacent Whitmore Heath Tunnel) and a rest water level at ground level. The aquifers extend more than 50m below the cutting depth and is laterally extensive. Therefore potential local changes in groundwater level to the maximum cutting depth of 21mbgl are assessed as having a negligible impact on the Secondary A aquifer and Principal aquifer.

5.2.41 Any water which may be removed from the aquifers during construction (dewatering), would be discharged back to the catchment to prevent deterioration of the surface watercourses. Dewatering and discharge arrangements would be designed in detail following site investigation in consultation with, and ensuring appropriate permits are in place with the Environment Agency. This would ensure that, if the surface water features (tributaries of the River Lea) which fall within the zone of influence are dependent on groundwater baseflow, there would be negligible impact on these features.

5.2.42 The spring to the north of Whitmore Wood and the unlicensed surface water abstraction in this area, fall within the maximum calculated zone of influence for the length of cutting. However, in this area the maximum cutting depth is only 7m therefore a smaller zone of influence of 39m is estimated in this area. Therefore these features will not be impacted by dewatering of the cutting.

5.2.43 Due to lack of groundwater monitoring around this location the local hydraulic gradient is not known. Based on an assumed shallow groundwater level, it is therefore assumed that in reality the hydraulic gradient is in the direction of the topographic slope towards the tributaries of the River Lea.

---

[17] Cashman, P.M. and Preene, M. (2001) *Groundwater Lowering in Construction, a Practical Guide*

[18] British Geological Survey (BGS) (1997), *The aquifer properties of major aquifers in England and Wales*. Technical Report WD/97/34, Environment Agency R&D Publication 8

[19] Domenico, P. A. and Schwartz, F. W. (1990), *Physical and chemical hydrogeology*. John Wiley & Sons

5.2.44 Whitmore Wood retaining wall will span the eastern side of the Whitmore North cutting, therefore in the permanent case this could disrupt continuity of flow across the cutting, and potentially create damming of groundwater on the eastern 'upslope' side of the cutting. The spring to the west of Limepits, unlicensed surface water abstraction, and the potential spring north of Whitmore Wood are up gradient and would not be impacted. Downstream of these features, the tributary of the River Lea to the south of Whitmore Wood, and the tributary of the River Lea to the north of Whitmore Wood (both low value receptors), could be impacted by changes in groundwater levels. Following ground investigation, if groundwater damming is expected, the drainage across the cutting will be designed to prevent rising water levels up-gradient of the retaining wall. Design may take the form of a passive bypass structure and will ensure there are negligible impacts on baseflow to these surface watercourses, and across the aquifer.

5.2.45 Under the scenario of shallow groundwater levels, there would be little or no unsaturated zone and therefore a greater potential for impacts on groundwater quality during construction. Application of the pollution prevention measures outlined in the draft CoCP and the drainage design will ensure that any impacts on groundwater quality are negligible.

5.2.46 Further ground investigation and monitoring is required to confirm groundwater levels in this location. This will inform the detailed design and management of groundwater during construction.

Madeley cutting

5.2.47 Assuming a hydraulic conductivity of a permeable sandstone[18,19] (1×10^{-5}m/s). The maximum zone of influence from the cutting (L0) is estimated at 117.9m. This is based on precautionary assessment using a maximum cutting depth of 21.3m (including the southern porous portal of the adjacent Madeley tunnel) and a rest water level at ground level.

5.2.48 As there are no water dependent features within this extent the cutting is assessed as having negligible impact on the water environment. The aquifers extend more than 50m below the cutting depth and are laterally extensive. The potential local changes in groundwater level to the maximum cutting depth of 21.3mbgl are assessed as negligible in terms of impact on the Principal and Secondary A aquifers.

5.2.49 Due to lack of groundwater monitoring around this location the local hydraulic gradient is not known. Based on an assumed shallow groundwater level, it is therefore assumed that the hydraulic gradient is in the direction of the topographic slope, towards the north-east.

5.2.50 As summarised above, the dewatering assessment provides a precautionary lateral impact zone. In reality the retaining wall at the porous portal may limit dewatering requirements during construction in the northern part of the cutting. In the permanent case the retaining wall could cause a barrier to groundwater flow, which would be a moderate impact on the Principal aquifer. However, following ground investigation and monitoring, suitable drainage measures will be incorporated into the design to manage groundwater flow in this area where required, and ensure negligible impact on the aquifer.

5.2.51 Under the scenario of shallow groundwater levels, there would be little or no unsaturated zone and therefore a greater potential for impacts on groundwater quality during construction. Application of the pollution prevention measures outlined in the draft CoCP and the drainage design will ensure that any impacts on groundwater quality are negligible.

5.2.52 Further ground investigation and monitoring is required to confirm groundwater levels in this location. This will inform the detailed design and management of groundwater during construction.

Impact to groundwater quality from viaduct and overbridge piling

5.2.53 Piling can affect groundwater quality where the works are carried out in a formation with hydraulic connection to an aquifer, or in the aquifer itself. Underground works within aquifers can have a direct impact on any nearby groundwater sources. The main issues are considered to be losses of circulation fluid, turbidity resulting from the breakdown of in-situ aquifer material, and possible contamination by hydraulic fluids and greases from machinery. There is likely to be a more rapid transfer of these materials through fracture or fissure flow. Where such movement occurs in the catchment supplying a groundwater abstraction then the degraded groundwater quality may make the source unsuitable for use. Such catchments are indicated by the SPZ1 and SPZ2 areas defined by the Environment Agency around all PWS. In the Whitmore Heath to Madeley area the Hey House Lodge private water supply is in the line of the route close to Manor Road overbridge. As mitigation will likely involve the borehole being decommissioned as part of the works (see Table 7) the impact of the viaduct piers is not discussed further here. The other abstraction in the Whitmore Heath to Madeley area to potentially be impacted by viaduct piers is the PWS near Whitmore.

5.2.54 The Meece Brook viaduct, sits mostly within SPZ2 with a slight overlap into the north of the SPZ1. The potential impacts from the construction piling can be mitigated by using bentonite in the process to reduce fluid loss. Many methods of piling can also be facilitated by the use of temporary casing, which is generally more useful to stop losses to immediately adjacent watercourses. Implementation of the CoCP will ensure that materials in contact with groundwater will be selected, and method statements developed, to control any potential contaminants. Monitoring will take place before, during and after construction until the groundwater quality has stabilised to levels agreed with Severn Trent Water Ltd and the Environment Agency.

5.2.55 Nonetheless, there is a residual risk that the groundwater quality at the PWS could be impacted during construction. The impact on this very high value receptor is potentially major if there are significant fractures linking the pier locations and the abstraction site, this will be likely to give rise to a major adverse significant effect. As summarised in Table 7 there are also potential major significant effects associated with impacts on groundwater quality (due to shallow works within the SPZ1 during construction). Additional mitigation is required, and the temporary removal of the abstraction from supply, during the construction phase. Options for temporarily replacing the water supply from other sources are being discussed with Severn Trent Water Ltd and the Environment Agency.

Temporary construction impacts to groundwater and associated receptors from the borrow pit west of Netherset Hey Farm

5.2.56 The borrow pit west of Netherset Hey Farm will involve the excavation of sand and gravel down to a maximum depth of 17.8mbgl, and an assumed average depth of 4.3mbgl. The excavation will be through the Secondary A aquifer Glaciofluvial Deposits and therefore has the potential to impact on the Secondary A aquifer and receptors which rely on this as a water resource. These include the River Lea which is adjacent to the borrow pit area and two unlicensed private water abstractions at Hey House Farm and Hey House Lodge. The potential impacts on the licensed groundwater abstraction at Netherset Hey Farm have also been assessed. A tributary of the River Lea which crosses the borrow pit area will be temporarily diverted within the footprint of the borrow pit in accordance with the CoCP. The impact on this water feature is assessed in the WFD compliance assessment (Volume 5, Appendix WR-001-000).

5.2.57 There is no groundwater level monitoring in the vicinity of the borrow pit however observations summarised in a hydrogeological desk top study undertaken in the area in 2008[20] suggest that groundwater levels in the superficial deposits are shallow. Flow follows the direction of the topographic contours, and may also be influenced by the rockhead profile of the underlying Salop Formation but is generally towards the River Lea. It is assumed that the shallow groundwater is in connection with the River Lea and its tributary and provides an element of baseflow to these watercourses.

5.2.58 It is assumed that during excavation of the sand and gravels the entire area may need to be dewatered to allow for safe working. CoCP measures will be implemented throughout the works to manage drainage and protection of water quality.

5.2.59 Dewatering of the excavation may reverse the hydraulic gradient between the aquifer and the River Lea and without additional mitigation the surface water body could lose water to the ground. This would be a moderate (significant) effect (for excavation to both assumed and maximum mineral excavation depths).

5.2.60 The additional mitigation proposed includes ground investigation and pre-construction monitoring of the Secondary A aquifer and the River Lea and its tributary, to inform construction mitigation measures which will protect the River Lea from loss of water. The type of mitigation measures could include:

- installation of a groundwater cut off;
- creation of a new lined channel and temporary diversion of the River Lea; or
- wet working, with continuous circulation of water from the borrow pits back into the River Lea.

5.2.61 Mitigation measures would be designed in consultation with the Environment Agency.

[20] Enviroarm Ltd (2008), *Netherset Hey - Hydrogeological Desk Top Study Assessment Report*

5.2.62 The licensed groundwater abstraction at Netherset Hey Farm is more than 200m from the construction footprint of the borrow pit and water is abstracted from the Salop Formation Secondary A aquifer beneath the Glaciofluvial Deposits Secondary A aquifer. According to the available borehole record, the borehole is cased and sealed down to 52mbgl and is open between 52mbgl and 73mbgl. Rest water level within the Salop Formation was recorded at 22mbgl on completion of drilling the borehole. As the aquifer from which water is abstracted is significantly below the base of the borrow pit excavation and dewatering depth, and must be separated by a low permeability layer, there will be negligible impact to the water quantity abstracted at this receptor. It is possible that the superficial aquifer and bedrock aquifer do have some connection and using a precautionary assessment groundwater quality at the abstraction site therefore has the potential to be impacted. However, as the unsaturated zone in the Salop Formation and the lower permeability layers will provide protection of the aquifer with implementation of CoCP measures the impacts on the water quality at the abstraction are assessed as negligible.

5.2.63 The private water abstraction at Hey House Farm is approximately 300m from the borrow pit. The borehole is located in an area with similar ground level to the borrow pit, and is separated from the borrow pit by the River Lea, and the WCML. The borehole abstraction at Hey House Farm has not had land access available for survey. No borehole logs or further information about the abstraction unit or borehole depth are currently available. A precautionary assessment has been undertaken and it is assumed there could be an impact on the water flow and quality at this abstraction during construction. Impacts of other nearby elements of the Proposed Scheme have also been assessed as having potential to cause a significant (major adverse) effect. This will be discussed with the landowner concerned with a view to a permanent new supply being provided if necessary such that there will be no significant effect.

5.2.64 The borehole abstraction at Hey House Lodge is directly underneath the route of HS2. It will therefore be permanently removed. Potential impacts specifically from the borrow pit are therefore not significant in the context of the wider Proposed Scheme and impact assessment.

Permanent construction impacts to groundwater and associated receptors from the borrow pit west of Netherset Hey Farm

5.2.65 The borrow pit will be restored to current levels and land use including restoration of the tributary of the River Lea.

5.2.66 As the area of permeable sand and gravel will be replaced with material of lower permeability the restoration plans will include land drainage measures to ensure no groundwater flooding up gradient of the infilled site, and continued water discharge to the River Lea and it's tributary. The detail of the restoration plan will be designed following ground investigation and monitoring of the hydraulic gradient across the borrow pit area and hydrometric monitoring of the River Lea and the tributary. The resulting permanent impact of the Proposed Scheme on the River Lea and the tributary crossing the borrow pit area will be negligible.

5.2.67 The impact of permanent loss of this area of Secondary A aquifer is assessed as negligible because the sand and gravels do not form part of the main WFD groundwater body in this area (the Manchester and East Cheshire Carboniferous Aquifers), see the WFD compliance assessment report (Volume 5, Appendix WR-001-

000) and mitigation will be embedded in the design and construction methodology to protect the surface water receptors of value for which the Secondary A aquifer may provide a source of baseflow.

6 Site specific highways drainage assessments

6.1 Introduction

6.1.1 The majority of highway works comprise minor realignments, with no significant increase in impermeable paved areas. The Proposed Scheme makes provision for two methods for draining these new sections of highway: direct runoff to soakaway and drainage via an attenuation pond to an existing watercourse. An assessment has been made of whether the highway works proposed have implications for pollution risk within the Whitmore Heath to Madeley area.

6.2 Methodology and assessment criteria

Routine runoff pollution risk

6.2.1 Where highway drainage is discharged to local watercourses, the assessment for determining whether routine runoff is likely to have a detrimental impact on water quality uses the Highways England's (HE) (formerly Highways Agency) Water Risk Assessment Tool, HAWRAT, Method A in Volume 11, Section 3, Part 10 HD 45/09 of the Design Manual for Road and Bridges (DMRB). Where highway realignments are to discharge to curb side ditches which do not have a baseflow, the Groundwater Assessment (Method C) in Volume 11, Section 3, Part 10 HD 45/09 of the DMRB has been used.

6.2.2 The significance of the impact of the predicted effects on surface water and groundwater receptors has been assessed in accordance with the methodology described in the SMR, Volume 5: Appendix CT-001-001.

Spillage pollution risk

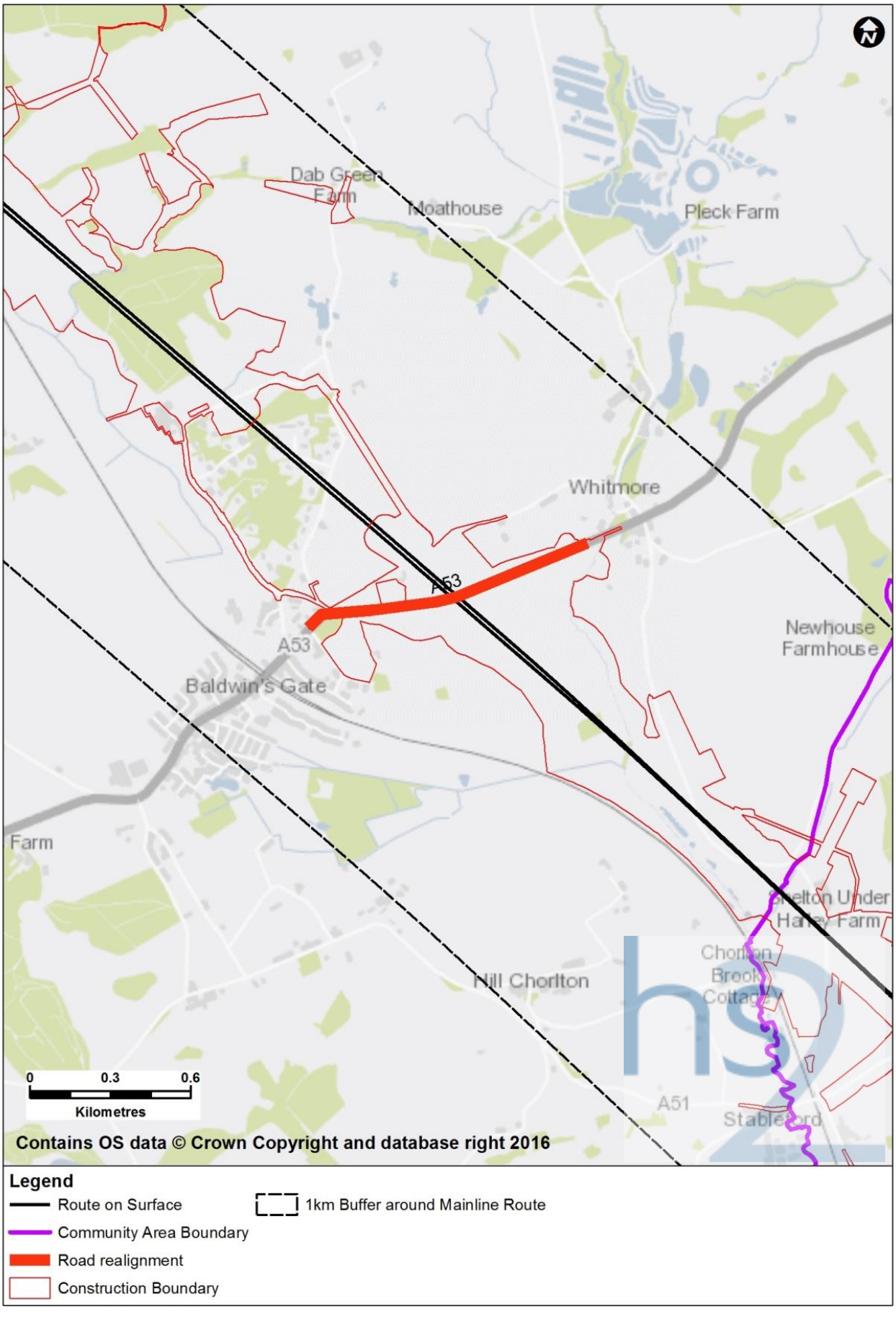
6.2.3 In addition to assessing the potential for adverse effects of routine surface water runoff from highways, an assessment of the potential spillage risk to water quality should also be undertaken qualifying highway realignment. The methodology for assessing spillage risk follows the Spillage Risk Assessment (Method D) presented in Volume 11, Section 3, Part 10 HD 45/09 of the DMRB.

6.3 Assessment

Screening results

6.3.1 A screening exercise identified the need for a single runoff and pollution risk assessments in the Whitmore Heath to Madeley area. This is related to proposed modifications to the A53 Newcastle Road as shown on Figure 6.

Figure 6: A53 Newcastle Road reinstatement



Routine runoff pollution risk

6.3.2 The modification to the A53 Newcastle Road between Baldwin's Gate and Whitmore involves the realignment of the carriageway along a total length of 0.75km and complete replacement of the existing drainage. The road is surrounded by farmland and situated on hill at the eastern boundary of Baldwin's Gate. The surrounding land falls to south and east towards Meece Brook, which flows to the south-east. It is proposed to construct like for like highway drainage comprising kerbside linear gully drains that will divert runoff to Meece Brook. The assessments identified that the diluting capacity of Meece Brook watercourse is sufficient to prevent pollution from occurring as a result of routine runoff from this section of highway, the magnitude of impact is assessed as negligible, such that there would be no significant effects. negligible.

Highways spillage risk assessment

6.3.3 The evaluation of the spillage risk for the A53 Newcastle Road is presented below in Table 15. The risk of a serious pollution incident occurring is identified to be negligible. These highway realignments will not result in significant effects related to spillage risk and no further mitigation is required.

Table 15: Spillage risk assessment of A53 Newcastle Road

Water body type	**Surface water**	**Notes**
Length of road draining to outfall (km)	0.75	The length of the road was measured based on CP2+ general arrangement drawings.
Road Type (A-road or Motorway)	A	
If A road, is site urban or rural?	Rural	
Junction type	No junction	
Location	< 1 hour	A response time of less than 1 hour is expected for emergency services to reach the source of the surface water pollution incident.
Traffic flow (AADT two way)	50,000	The traffic flow (AADT two way) upper limit of 50,000 was used to represent the worst case scenario.
% HGV	2	The percentage of HGV traffic was selected from the AADT HGV hotspot situated nearest to the A51 alteration.
Spillage factor (no/109HGVkm/year)	0.29	The spillage factor was taken from Table D1.1 as presented in Volume 11 Section 3 Part 10 HD 45/09 of the DMRB.
Risk of accidental spillage	0.0001%	This represents the total annual probability of a spillage.
Risk of pollution incident	0.01%	This represents the total annual probability of a spillage causing a pollution incident.
Is risk greater than 0.01?	Y	This is the considered overall risk for the length of the A51 realignment.

7 References

British Geological Survey (BGS) (1997), *The aquifer properties of major aquifers in England and Wales.* Technical Report WD/97/34, Environment Agency R&D Publication 8.

Cashman, P.M. and Preene, M. (2001), *Groundwater Lowering in Construction, a Practical Guide.*

Design Manual for Roads and Bridges (2009), *Road Drainage and the Water Environment*. Volume 11 Environmental Assessment, Section 3 Environmental Assessment Techniques, Part 10, HD45/09

Domenico, P. A. and Schwartz, F. W. (1990), *Physical and chemical hydrogeology*. John Wiley & Sons.

Enviroarm Ltd (2008), *Netherset Hey - Hydrogeological Desk Top Study Assessment Report*

Environment Agency (2007), *Hydrogeological impact appraisal for dewatering abstractions*. Environment Agency

Environment Agency (2017), *Protect groundwater and prevent groundwater pollution*. Available online at: https://www.gov.uk/government/publications/protect-groundwater-and-prevent-groundwater-pollution/protect-groundwater-and-prevent-groundwater-pollution

HS2 Ltd (2017), *High Speed Two (HS2) Phase 2a (West Midlands – Crewe), Background Information and Data, Hydraulic Modelling Reports, BID WR- 004*. Available online at: www.gov.uk/hs2

Preene, M., Roberts, T.O.L. and Powrie, W. (2016), *Groundwater control: design and practice*. CIRIA Publication C750.