

High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

CA5: South Cheshire

Water resources assessment (WR-002-005)

High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

CA5: South Cheshire

Water resources assessment (WR-002-005)



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



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.

© High Speed Two (HS2) Limited, 2017, except where otherwise stated.

Copyright in the typographical arrangement rests with High Speed Two (HS2) Limited.

This information is licensed under the Open Government Licence v2.0. To view this licence, visit www.nationalarchives.gov.uk/doc/open-government-licence/version/2 **OGL** or write to the Information Policy Team, The National Archives, Kew, London TW9 4DU, or e-mail: psi@nationalarchives.gsi.gov.uk. Where we have identified any third-party copyright information you will need to obtain permission from the copyright holders concerned.



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

Contents

1	Introduction	1
1.1	Structure of the water resources and flood risk appendices	1
1.2	Scope, assumptions and limitations	1
1.3	Study area description and key features	3
2	Stakeholder engagement	4
3	Baseline data	5
3.1	Surface water	5
3.2	Groundwater	7
3.3	Groundwater – surface water interaction	9
3.4	Water dependent habitats	12
4	Site specific surface water assessments	13
4.1	Summary of assessment	13
5	Site specific groundwater assessments	16
5.1	Summary of assessment	16
5.2	Detailed assessment	23
6	References	34

List of figures

Figure 1: Location of assessed lengths of Crewe South cutting and corresponding cross-sections along route	25
Figure 2: Cross-sections through assessed areas of Crewe South cutting	26

List of tables

Table 1: Surface water abstractions	5
Table 2: Consented discharges to surface water	6
Table 3: Summary of groundwater abstractions in the South Cheshire area	8
Table 4: Discharge consents to groundwater	9

Table 5: Groundwater – surface water interaction	9
Table 6: Water dependent habitats	12
Table 7: Summary of potential impacts to surface water receptors	14
Table 8: Summary of potential groundwater impacts	17
Table 9: Summary of the Crewe South cutting parameters for the groundwater assessment	23
Table 10: Summary of the Blakenhall Northbound Spur cutting parameters for the groundwater assessment	27
Table 11: Summary of the Blakenhall Southbound Spur cutting parameters for the groundwater assessment	27
Table 12: Summary of the WCML cuttings parameters for the groundwater assessment	28
Table 13: Summary of Crewe South portal parameters for groundwater assessment	31

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 South Cheshire area (CA5), the area specific appendices comprise:

- a water resources assessment (i.e. this appendix); and
- a flood risk assessment (Volume 5: Appendix WR-003-005).

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

1.1.4 Maps (WR-01 and WR-02) referred to throughout this 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 assessment are set out in Volume 1 (Section 8), the Scope and Methodology Report (SMR)² and the SMR Addendum³.

1.2.2 The South Cheshire area covers a 6.6km long section of the Proposed Scheme immediately south of Crewe. 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 surface water features in the urban area of Crewe, this extent was reduced to 500m. Betley Mere Site of Special Scientific Interest (SSSI) and Ramsar site has been included in the assessment. For the purposes of this assessment this spatial scope is defined as the study area.

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

- 1.2.3 The assessment considers the construction and operational features of the Proposed Scheme within this study area. These are shown on Volume 2: Map Series CT-05 and Map Series CT-06. The civil engineering works proposed to connect the West Coast Main Line (WCML) to HS2, and the works at Crewe Station, including a new island platform, are included. The proposed tunnel beneath Crewe is not included in this assessment, but will form part of Phase 2b of HS2. Crewe South portal (retained cutting), part of the Crewe tunnel, is therefore the northernmost structure of the main line included in the assessment.
- 1.2.4 This assessment covers the potential impacts of the Proposed Scheme on existing surface water and groundwater resources, including consideration of:
- surface waters⁴;
 - 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 Bridges⁵. 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 that the South Cheshire area does not include any highway realignments which meet these criteria and so an assessment of highway pollution has not been necessary in this community area.
- 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.

⁴ Ponds are not included in the water resources assessment, these are assessed as ecological receptors in Volume 2, South Cheshire 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

1.3 Study area description and key features

1.3.1 The study area is predominantly rural, except for Crewe, Chorlton (a village to the east of the WCML) and Hough (a village to the west of the Proposed Scheme). The WCML follows the north to south alignment of the study area and the route of the Proposed Scheme is crossed by the Newcastle Road.

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

- Checkley Brook, the River Lea, Wistaston Brook⁶ and their associated tributary watercourses;
- the permeable superficial Alluvium, River Terrace Deposits and Glaciofluvial Deposits Secondary A aquifers;
- the Mercia Mudstone Group, a Secondary B aquifer;
- two potential spring features within the area required for construction of the Proposed Scheme;
- Betley Mere Site of Special Scientific Interest (SSSI), which is also a Ramsar site;
- three licensed surface water abstractions; and
- two licensed private groundwater abstractions from the Glaciofluvial Deposits Secondary A aquifer.

⁶ The Wistaston Brook is the name used within the River Basin Management Plan for the purposes of the WFD. The name of this watercourse varies along its length and is variously known as Mere Gutter, Basford Brook and Gresty Brook

2 Stakeholder engagement

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

- the Environment Agency;
- Natural England with regard to Betley Mere SSSI and borrow pit mitigation;
- Cheshire East Council (CEC) and Newcastle-Under-Lyme Borough Council (NBC), with regard private unlicensed water abstractions;
- water companies to confirm details of public water abstractions (if and where present in the study area) and associated water resource management plans; 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, South Cheshire area report, Section 15. The receptor values attributed to each individual watercourse, based on the methodologies set out in the SMR², as applied in the WFD compliance assessment (Volume 5, Appendix WR-001-000) are also provided.

3.1.2 Table 1 summarises the surface water abstractions within the study area. Their locations are shown on Map WR-01-107b and Map WR-01-108. There are three licensed surface water abstractions, which have all been assessed as high value receptors. None of these abstractions are for public water supply (PWS). Records of unlicensed private water abstractions, which comprise those for quantities less than 20m³ per day, have been obtained from the local authorities. This data indicates that there are no registered 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

Name, licence number (and map grid square) ⁷	Distance and direction from route	Abstraction source	Maximum annual abstraction quantity (m ³)	Maximum daily abstraction quantity (m ³)	Purpose
Private licensed supplies					
The Grange 2568001258 (F7)	706m west of the route (593m west of the land required for construction of the Proposed Scheme)	Checkley Brook	60,000	1,000	General agriculture
Weston Hall Estate 2568001262 (I4)	744m east of the route (90m northeast of the land required for construction of the Proposed Scheme)	Mere Gutter	40,915.85	31.29	General agriculture
Crewe and Alsager College 2568001226 (E4)	992m east of the route (992m east of the land required for construction of the Proposed Scheme)	Valley Brook	9,092	454.6	Industrial/ commercial/ energy/public services

⁷ As shown on Map WR-01-107b and WR-01-108

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

Table 2: Consented discharges to surface water

Permit identifier (and map grid square)	Distance and direction from route	Discharge type	Receiving water body
16891614 (D6) ⁸	110m west of the route (within the land required for construction of the Proposed Scheme, area of soft landscaping)	Sewage – not water company, final/treated effluent	Tributary of River Weaver
16810049 (D5) ⁸	321m east of the route (299m east of the land required for construction of the Proposed Scheme)	Sewage discharges – final / treated effluent - water company	Mere Gutter
16810049 (D5) ⁸	321m east of the route (299m east of the land required for construction of the Proposed Scheme)	Sewage discharges - storm overflow/storm tank - water company	Mere Gutter
16881712 (H5) ⁹	497m east of the route (313m east of the land required for construction of the Proposed Scheme)	Sewage-water company, pumping station	Basford Brook
16891954 (F6) ⁹	243m west of the route (315m west of the land required for construction of the Proposed Scheme)	Miscellaneous discharges – surface water	Gresty Brook
0168/820 (F5) ⁹	Adjacent to the WCML (within the land required for construction of the Proposed Scheme)	Sewage discharges – final / treated effluent - not water company	Gresty Brook
16891918 (F6) ⁹	437m west of the route (503m west of the land required for construction of the Proposed Scheme)	Trade discharges - process effluent - not water company	Gresty Brook
16891798 (G4) ⁹	783m east of the route (669m east of the land required for construction of the Proposed Scheme)	Sewage discharges - pumping station - water company	Tributary of Gresty Brook
16810413	193m east of the route (82m east of the land required for construction of the	Trade discharges - cooling water	Gresty Brook

⁸ Map WR-01-107b. Discharges in the study area are listed from south to north.

⁹ Map WR-01-108. Discharges in the study area are listed from south to north.

Permit identifier (and map grid square)	Distance and direction from route	Discharge type	Receiving water body
(F5) ⁹	Proposed Scheme)		

3.2 Groundwater

- 3.2.1 A summary of the geological units present in the South Cheshire area is presented in the Land quality section in ES Volume 2, South Cheshire area report, Section 10. The hydrogeological characteristics of the geological units is summarised in the Water resources and flood risk section in the Volume 2, South Cheshire area report, Section 15, and further detail is provided in the following sections.
- 3.2.2 Map WR-02-205 (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 is one bedrock aquifer in the study area, the Sidmouth Mudstone Formation of the Mercia Mudstone Group. This formation comprises structureless mudstone and siltstone and is classified as a Secondary B aquifer. This aquifer is overlain by a significant thickness of Glacial Till which is Unproductive. There are two halite-rich horizons present in the Sidmouth Mudstone Formation in the study area: the Wilksley Halite Member and the Northwich Halite Member. These are classified as Unproductive.
- 3.2.5 There are no Environment Agency observation boreholes which monitor groundwater level within the study area.
- 3.2.6 Groundwater in the superficial aquifers in the study area 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.
- 3.2.7 In the superficial Secondary A aquifers (Alluvium, River Terrace Deposits and Glaciofluvial Deposits) most groundwater flow is expected to be through the intergranular matrix of these unconsolidated deposits. Further detail regarding the hydrogeology of the area around Betley Mere SSSI is presented in Appendix 1 of the Habitats Regulations Assessment (HRA) for Betley Mere SSSI¹⁰.
- 3.2.8 Some groundwater flow is expected in the Mercia Mudstone Group, though permeable horizons within this unit are expected to be laterally discontinuous and

¹⁰ HS2 Ltd (2017), *Habitats Regulations Assessment screening report for Midland Meres and Mosses Phase 1 Ramsar site addendum - Betley Mere Site of Special Scientific Interest component*, (Appendix EC-017-002)

associated with thin siltstone and sandstone lenses called skerries. There may also be a small element of fracture flow.

- 3.2.9 Table 3 summarises groundwater abstractions and their locations are shown on Map WR-02-205.
- 3.2.10 There are no licensed groundwater abstractions for PWS and there are no mapped source protection zones (SPZ) in the study area.
- 3.2.11 There are two licensed private groundwater abstractions 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 50m¹¹. These abstractions have all been assessed as high value receptors.
- 3.2.12 The unlicensed private water supply information has been provided by the local authorities (CEC and NBC). There are no unlicensed private groundwater abstractions registered with the local authorities in the study area. There is the potential for further unlicensed abstractions to exist, as a licence is not required for abstraction volumes below 20m³ per day and not all of the unlicensed abstractions are registered with the local authority. These may also need to be protected.

Table 3: Summary of groundwater abstractions in the South Cheshire area

Name, licence number (and map grid square) ¹²	Distance and direction from route	Abstraction source	Maximum annual abstraction quantity (m ³)	Maximum daily abstraction quantity (m ³)	Purpose	Number of boreholes
Private licensed water supplies						
The Grange 2568001067 (16)	360m south-west of the route (170m north-west of the land required for construction of the Proposed Scheme)	Glaciofluvial Deposits	9,092	25	General farming and domestic	1 (Well)
The Grange NW/068/0001/007 (16)	360m south-west of the route (185m north-west of the land required for construction of the Proposed Scheme)	Glaciofluvial Deposits	59,000	320	General farming and domestic	1

- 3.2.13 There are two consented discharges to groundwater in the study area and these have been assessed as low value receptors. These are summarised in Table 4.

¹¹ 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>

¹² As shown on Map WR-02-205

Table 4: Discharge consents to groundwater

Permit identifier (and map grid square) ¹³	Distance and direction from route	Discharge type	Receiving water body
16892573 (H6)	305m north-east of the route (60m east of the land required for construction of the Proposed Scheme)	Soakaway (domestic final/treated effluent)	Groundwater
NPSWQD008929 (E6)	>2km north the route (adjacent to the land required for construction of the Proposed Scheme)	Soakaway (domestic final/treated effluent)	Groundwater

3.3 Groundwater – surface water interaction

3.3.1 Table 5 summarises the potential groundwater – surface water interactions identified 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 below or on Map WR-02-205. 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) ¹⁴	Distance and direction from route	Formation	Elevation (mAOD)	Comments
Watercourses				
Checkley Brook and tributaries	Crossed by the route at the southern extent of the study area	Alluvium which is likely to be in connection with Glaciofluvial Deposits	75	Checkley Brook is likely to be in hydraulic connection with the underlying and adjacent permeable superficial deposits.
Mere Gutter and tributaries	To the east of the route, becomes Basford Brook in northern end of study area	Alluvium and Glaciofluvial Deposits	Variable	These watercourses are likely to be in hydraulic connection with the underlying and adjacent permeable superficial deposits.

¹³ Map WR-02-205. Discharges in the study area are listed from south to north.

¹⁴ Map WR-02-205. 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.

Appendix WR-002-005

Feature (and map grid square) ¹⁴	Distance and direction from route	Formation	Elevation (mAOD)	Comments
Basford Brook and tributaries	To the east of the route	Alluvium and Glaciofluvial Deposits	Variable	
Gresty Brook and tributaries (including Swill Brook)	Gresty Brook is found to the north-east of the route	Alluvium and River Terrace Deposits, overlying Glacial Till	59	

Springs

Potential spring south of Yew Tree Farm (H6)	740m south-west of the route (230m south of the land required for construction of the Proposed Scheme for main utility works)	Glacial Till	77	Not surveyed. Assumed to be a high value receptor until this is verified by survey. The 'issue' is from Glacial Till (Unproductive), which is likely to have low permeability and is a significant distance from the Proposed Scheme.
Potential spring, Ash Tree Farm (H7)	800m south-west of the route (200m south-west of the land required for construction of the Proposed Scheme, for main utility works)	Glacial Till	75	Not surveyed. Assumed to be a high value receptor until this is verified by survey. The 'issue' is from Glacial Till (Unproductive), which is likely to have low permeability, and is a significant distance from the Proposed Scheme.
Potential spring, east of Manor Farm (H6)	Crossed by HS2 spur (northbound) (within the land required for construction of the Proposed Scheme)	Glacial Till	77	Not surveyed. Assumed to be a high value receptor, although this is likely to be land drainage feature.
Potential spring, near Basford House (F6)	325m north-east of the route (within the land required for construction of the Proposed Scheme)	Glaciofluvial Deposits	63	Not surveyed. Assumed to be a high value receptor. The 'issue' is likely to be from the Glaciofluvial Deposits.
Potential spring, Weston Hall (F5)	895m north-east of the route (245m north-east of the land required for construction of the Proposed Scheme)	Glaciofluvial Deposits	63	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.

Appendix WR-002-005

Feature (and map grid square) ¹⁴	Distance and direction from route	Formation	Elevation (mAOD)	Comments
Potential spring, north of Weston Hall (F5)	800m north-east of the route (395m south-east of the land required for construction of the Proposed Scheme)	Glaciofluvial Deposits	58	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, Crotia Mill Farm (E5)	795m north-east of the route (770m north-east of the land required for construction of the Proposed Scheme)	Glacial Till	54	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, Savoy Road (E5)	615m north-east of the route (270m south-west of the land required for construction of the Proposed Scheme)	Glacial Till	51	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 Table 6 summarises the water dependent habitats within the study area.

3.4.2 Ecological impacts are assessed in Volume 2, South Cheshire are report, Section 8. Potential impacts to the hydrology and hydrogeology of these habitats are assessed in this appendix.

Table 6: Water dependent habitats

Name (and map grid square) ¹²	Distance from route	Designation	Comments
Betley Mere (H5)	950m north-east of route (300m north-east of the land required for construction of the Proposed Scheme)	Site of Special Scientific Interest, Ramsar Site	Betley Mere is designated as a nationally and internationally important site. It is one of the few natural standing waters in Staffordshire and occupies a shallow valley in glacial deposits, bound on three sides by extensive peat deposits on which a wide range of vegetation types has developed. It supports a series of open water and peatland sites, with rare wetland plant species. The mere is found at an approximate surface elevation of 60mAOD, down hydraulic gradient of the Proposed Scheme. It receives some surface water drainage from minor watercourses adjacent to the Proposed Scheme as well as some baseflow from the Glaciofluvial Deposits which are also crossed by the Proposed Scheme. Detailed assessment of the baseline hydrology and hydrogeology is provided in the HRA ¹⁰ , and is summarised in Section 5.2.

4 Site specific surface water assessments

4.1 Summary of assessment

- 4.1.1 Table 7 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 7.
- 4.1.3 The draft Code of Construction Practice (CoCP), referred to in Table 7, 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 7.
- 4.1.5 Table 7 does not include Betley Mere SSSI, as this is covered within the assessment of groundwater dependent habitats.
- 4.1.6 Table 7 includes all consented discharges to surface water within the area required for construction of the Proposed Scheme listed in Table 2. It only includes those outside of this area where the potential for the Proposed Scheme to have an adverse impact on them has been identified.

Table 7: 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									
Checkley Brook – Upper & River Lea	Very high	- Checkley Brook viaduct	Potentially affected by pollution caused by the 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 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)
Minor ditches	Low	- Realignments - Drop inlet structures and culverts	Potentially affected by pollution caused by the 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 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)
Surface water abstractions									
The Grange 2568001258 Checkley Brook (F7) ⁷	High	- Checkley Brook viaduct	Located 706m west of land required for the construction of the Proposed Scheme downstream of the works at the Checkley Brook viaduct. There is potential for impacts on water quality in Checkley Brook during construction, caused by the 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 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)
Weston Hall Estate 2568001262 Mere Gutter (I4) ⁷	High	- Newcastle Road construction laydown	Located immediately east of the land required for construction of the Proposed Scheme, and downstream of where the land required for construction of the Proposed Scheme meets the Mere Gutter. There is potential for impacts on water quality in Mere Gutter during construction, caused by the 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 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)
Crew and Alsager College 2568001226 Valley Brook (E4) ⁷	High	- Crewe station	Located 992m outside of the land required for construction of the Proposed Scheme, and upstream of any works. No interaction between the works and the abstraction is expected.	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)
Discharges to surface water									
Discharge 16891614 (D6) ⁸	Low	- Gonsley drop inlet culvert	Located within the land required for construction of the Proposed Scheme. This outfall has potential to be physically affected by construction work.	Magnitude of impact - Moderate Significance of effect - Minor adverse, not 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)

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
Discharge 0168/820 (F5) ⁹	Low	- Crewe Railway (WCML) Depot	Located within the land required for construction of the Proposed Scheme. This outfall has potential to be physically affected by construction work.	Magnitude of impact - Moderate Significance of effect - Minor adverse, not 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)

5 Site specific groundwater assessments

5.1 Summary of assessment

- 5.1.1 Table 8 summarises all the potential impacts to hydrogeology (aquifers), abstractions, groundwater – surface water interactions and groundwater dependent terrestrial ecosystems.
- 5.1.2 In Table 8 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 the relevant design elements with a focus on those elements which have the potential to cause an impact.
- 5.1.3 No potential for adverse impacts on the consented discharges to groundwater listed in Table 4 were identified. Impacts on the springs and potential spring features listed in Table 5 are only included in Table 8 where the potential for adverse impacts has been identified.
- 5.1.4 The potential impacts of future ground investigations 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 8.
- 5.1.5 Further detail of several elements of the assessment is presented in Section 5.2.

Table 8: 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
Hydrogeology (aquifers)									
Alluvium – Secondary A aquifer	Moderate	Construction involving deeper excavation (>1m below ground level (bgl)): - Checkley 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 alluvium, the impact on groundwater flow pathways will be negligible.	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 (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.	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)
Glaciofluvial Deposits - Secondary A aquifer	Moderate	Construction of above ground elements and shallow excavation (<1m) including: - at grade track and roads - Crewe South cutting (at grade and embankment sections) - HS2 Spur (southbound) - HS2 Spur (northbound) - Newcastle Road realignment - 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: - Borrow pit north of Checkley Lane - Crewe South cutting - Crewe South portal (retained)	The temporary works have the potential to affect groundwater flow and quality, although this is likely to be localised and temporary. Excavation of the borrow pit will be above the water table and will therefore have a negligible impact on groundwater flow (see Section 5.2). The permanent below ground features, such as	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	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
		cutting) - Overbridge foundations - Blakenhall Northbound Spur cutting - Blakenhall Southbound Spur embankment, cutting - Chorlton Viaduct	cuttings, may alter groundwater flow (see Section 5.2).		measures where required. ¹⁵				
River Terrace Deposits - Secondary A aquifer	Moderate	- River Terrace Deposits are not crossed by the Proposed Scheme but are likely to be hydraulically connected to the Alluvium and Glaciofluvial Deposits so could potentially be impacted by works in proximity to these units (see design elements for Alluvium and Glaciofluvial Deposits above).	The temporary works have the potential to affect groundwater flow and quality, although this is likely to be localised and temporary. The permanent below ground features may alter groundwater flow (see Section 5.2).	Magnitude of impact - Minor Significance of effect – Minor adverse, significant	Implementation of measures described in the draft CoCP. Design of permanent structures will include groundwater control/drainage measures where required ¹⁵ .	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary)
Sidmouth Mudstone (of the Mercia Mudstone Group) - Secondary B aquifer	Moderate	- All elements	There is significant thickness of Unproductive Glacial Till (low permeability) overlying the Sidmouth Mudstone. Cuttings and below ground features will only extend into the Glacial Till which will protect the Sidmouth Mudstone in terms of both groundwater flow and quality.	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 negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (temporary and permanent)

Abstractions

The Grange 2568001067 (16) ¹²	High	- Borrow pit north of Checkley Lane - Crewe South cutting - Blakenhall Northbound Spur cutting - Blakenhall Southbound embankment, cutting	The depth of the Crewe South cutting, Blakenhall Northbound Spur cutting and Blakenhall Southbound Spur embankment (which has a short section of cutting) are considered to be above the groundwater levels in the area based on water strikes from borehole logs. Potential impacts from cutting dewatering are assessed as negligible, as explained in Section 5.2. The borrow pit will be excavated and may be restored with less permeable material. Negligible permanent impacts to groundwater quantity and quality are expected (see Section 5.2). The borrow	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required though the CoCP will be implemented throughout construction.	Negligible impact Negligible effect, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (permanent)
--	------	---	--	--	--	---	---------------	--	--------------------------

¹⁵ Groundwater control/drainage measures are outlined in Volume 2, South Cheshire 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
			pit will be filled with clean, natural backfill material.						
			<p>The borrow pit will be excavated above the water table and the cuttings assessment (see Section 5.2) predicts negligible impact on water quantity at this abstraction.</p> <p>Construction activity in proximity to the abstraction has the potential to have a major impact on groundwater quality if the superficial deposits and unsaturated zone in the vicinity of the cuttings and borrow pit act to provide a pathway to the underlying aquifer (see Section 5.2).</p>	<p>Magnitude of impact - Major</p> <p>Significance of effect - Major adverse, significant</p>	<p>Further investigation and risk assessment by the contractor (as outlined in the draft CoCP). If required, mitigation proposals will be developed and discussed with the owner, with a view to an alternative supply being provided.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	<p>None required</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	<p>Construction (temporary)</p>
The Grange NW/068/0001/007 (16) ²²	High	<ul style="list-style-type: none"> - Borrow pit north of Checkley Lane - Crewe South cutting - Blakenhall Northbound Spur cutting - stockpiles 	<p>Borehole log SJ74NW8 shows that the borehole abstracts from a horizon between 28mbgl and 53mbgl (approximately 52mAOD to 27mAOD). The material above this is cased off but consists of potential permeable sandy layers. During drilling, water was struck at 8.5mbgl and rest water level on completion of the borehole was recorded at 7.5mbgl (approximately 72.5mAOD) at the time of drilling.</p> <p>Potential impacts from cutting dewatering are assessed as negligible, as explained in Section 5.2.</p> <p>The borrow pit will be excavated and may be restored with less permeable material. Negligible permanent impacts to groundwater quantity and quality are expected (see Section 5.2). The borrow pit will be filled with clean natural backfill material.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	<p>None required though the CoCP will be implemented throughout construction.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	<p>None required</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	<p>Construction (permanent)</p>
			<p>The borrow pit will be excavated above the water table and the cuttings assessment (see Section 5.2) predicts negligible impact on water quantity at this abstraction.</p> <p>Construction activity in proximity to the abstraction has the potential to have a major impact on groundwater quality if the superficial deposits and unsaturated zone in the vicinity of the cuttings and borrow pit act to provide a pathway to the underlying aquifer (see Section 5.2).</p>	<p>Magnitude of impact - Major</p> <p>Significance of effect - Major adverse, significant</p>	<p>Further investigation and risk assessment by the contractor (as outlined in the draft CoCP). If required, mitigation proposals will be developed and discussed with the owner, with a view to an alternative supply being provided.</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	<p>None required</p>	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	<p>Construction (temporary)</p>

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
----------	----------------	----------------	--	--	-----------------------------------	--	---------------------------	------------------	--------------------

Discharges to groundwater

16892573 (H6) ¹³	Low	- Crewe South cutting - HS2 Spur (southbound)	The discharge is likely to be into the Glaciofluvial Deposits. It is 80m from the nearest construction works and 400m from the HS2 main line. Due to its distance from the Proposed Scheme, the impact on this discharge will be negligible.	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 and permanent)
NPSWQD008929 (E6) ¹³	Low	- Crewe Station	The discharge is within an area of Glacial Till. It is not within the footprint of the Proposed Scheme or in close proximity to any below ground works and therefore the impact on this discharge will be negligible.	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 and permanent)

Groundwater – surface water interaction

Checkley Brook and tributaries	High	- Checkley 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 alluvium, the impact on groundwater flow pathways will be negligible in the context of baseflow to Checkley Brook.	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 (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.	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)
		- Checkley North embankment	Potential construction impacts on local groundwater quality, which may affect the baseflow water quality to Checkley 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)

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
Tributary of Mere Gutter	Low	- Blakenhall cutting (WCML)	Potential for reductions in baseflow to this watercourse because groundwater may be intercepted by the cutting, as set out in Section 5.2. The tributary of Mere Gutter is within the cutting dewatering zone of influence.	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 and permanent)
Basford Brook and tributaries	High	- Crewe South cutting - Crewe South portal - Borrow pit north of Checkley Lane	Temporary construction works have the potential to affect the quality of baseflow to Basford Brook, because the Glaciofluvial Deposits are assumed to be in hydraulic connection with this watercourse. The borrow pit will be excavated above groundwater levels and will therefore not affect the baseflow to Basford Brook or its tributaries (see Section 5.2 and the HRA for Betley Mere ¹⁰). The permanent impacts of the cuttings are assessed as negligible because Basford Brook is outside the area assessed as having the potential to be affected by changes in groundwater level (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 and permanent)
Gresty Brook and tributaries (including Swill Brook)	High	- WCML on network modifications	All works in the vicinity of Gresty Brook (to the north of the route) and the connected Alluvium or River Terrace Deposits are in the existing footprint of the WCML or are of minor extent. The potential impact on this watercourse resulting from groundwater interactions is assessed as negligible.	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 and permanent)
		- Crewe South cutting	The cutting assessment (Section 5.2) shows that Swill Brook is outside the dewatering zone of influence, therefore impacts on the quantity of baseflow will be negligible. However as the local hydraulic gradient is not known, there could be a pathway for potential pollution from associated construction activities, and therefore the water quality at Swill Brook has the potential to be affected.	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 east of Manor Farm (H6) ¹²	High	- Crewe South cutting - Den Lane West viaduct - Blakenhall Northbound Spur cutting	This potential spring is in the direct path of HS2 Spur (northbound). It will be lost during construction. If surveys prove this to be a true expression of groundwater, then this may affect baseflow to the local watercourse.	Magnitude of impact - Major Significance of effect - Major adverse, significant	Gonsley Drop Inlet Culvert will intercept both the spring and the local watercourse to maintain the existing baseflow regime.	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	None required	Magnitude of impact - Negligible Significance of effect - Negligible, not significant	Construction (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
Potential spring near Basford House (F6) ¹²	High	<ul style="list-style-type: none"> - Crewe South cutting - Newcastle Road realignment - Crewe South portal 	The cuttings assessment (Section 5.2) shows that this feature is outside of the potential dewatering zone of influence therefore the spring will not be affected by any permanent dewatering.	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required though the CoCP will be implemented throughout construction.	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (permanent)
			Water quality could be impacted during construction, as the potential spring is located directly next to a stockpile area.	<p>Magnitude of impact - Major</p> <p>Significance of effect - Major adverse, significant</p>	Implementation of measures described in the draft CoCP.	<p>Magnitude of impact - Minor</p> <p>Significance of effect – Moderate adverse, significant</p>	The potential spring will be surveyed and its value reviewed. Mitigation options for its protection or replacement will be implemented in consultation with the Environment Agency.	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (temporary)

Water dependent habitats

Betley Mere SSSI site (H5) ¹²	Very High	- Borrow pit north of Checkley Lane	There is the potential for the restored borrow pit area to affect the supply of water to the mere as a result of changes in the permeability of the restored borrow pit infill material.	<p>Magnitude of impact - Minor</p> <p>Significance of effect - Moderate adverse, significant</p>	Following ground investigation and monitoring the restoration plans will include appropriate drainage design to ensure negligible impact on flows to Betley Mere SSSI from this part of the catchment. This will be carried out in consultation with the Environment Agency and Natural England (see Section 5.2).	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (permanent)
			<p>The borrow pit will be excavated above groundwater levels and will therefore not affect groundwater flow to Betley Mere (see Section 5.2 and the HRA for Betley Mere¹⁰).</p> <p>There is potential for impacts on water quality during the construction phase.</p>	<p>Magnitude of impact - Minor</p> <p>Significance of effect - Moderate adverse, significant</p>	Implementation of measures described in the draft CoCP.	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	None required	<p>Magnitude of impact - Negligible</p> <p>Significance of effect - Negligible, not significant</p>	Construction (temporary)

5.2 Detailed assessment

- 5.2.1 In support of the impact assessment presented in Table 8, 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 South Cheshire area detailed assessments are presented demonstrating the likely impacts on groundwater from several cuttings, the Crewe South portal (retained cutting) and the borrow pit north of Checkley Lane.

Impact on groundwater from cuttings

- 5.2.2 The location of cuttings is shown in Volume 2: Map Series CT-05 and Map Series CT-06. The cuttings which intersect aquifers 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 9 to Table 13. 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

Crewe South cutting

Table 9: Summary of the Crewe South cutting parameters for the groundwater assessment

Cutting parameters (the full length of Crewe South cutting)	Parameter details
Length (km)	5.5
Maximum depth (m)	9.5
Strata intercepted	Glacial Till Deposits (Unproductive) and Glaciofluvial Deposits (Secondary A aquifer)
Lowest track level (mAOD)	55 (at northern extent of cutting)
Groundwater level(s) (mAOD)	No groundwater level monitoring information is available in this area. Several historical borehole logs document shallow groundwater strikes but others do not record any groundwater. For a precautionary assessment groundwater level in the superficial deposits is assumed to be at ground level.
Principal receptors	Glaciofluvial Deposits Secondary A aquifer (part of the Weaver and Dane Quaternary Aquifer WFD groundwater body) Basford Brook Spring, Basford House Licensed groundwater abstractions at The Grange

- 5.2.3 Although the Crewe South cutting is 5.5km long, for most of its length it crosses Unproductive Glacial Till or is only a very shallow cut on the periphery of Glaciofluvial Deposits, where there is no interaction with other water receptors. The only section of

the cutting where there may be more than negligible interaction with the Glaciofluvial Deposits Secondary A aquifer, is a 300m length close to the divergence of the spurs and over a 600m section immediately south of the Crewe South portal. These sections of the cutting are shown on Figure 1 and Figure 2 and they have been assessed using the methodology outlined above.

- 5.2.4 Until further ground investigation 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 cuttings would be temporarily disrupted, as groundwater dewatering would be required during construction. Further assessment is demonstrated in the following section (assessment of cuttings below groundwater level).

Figure 1: Location of assessed lengths of Crewe South cutting and corresponding cross-sections (Figure 2 below) along route

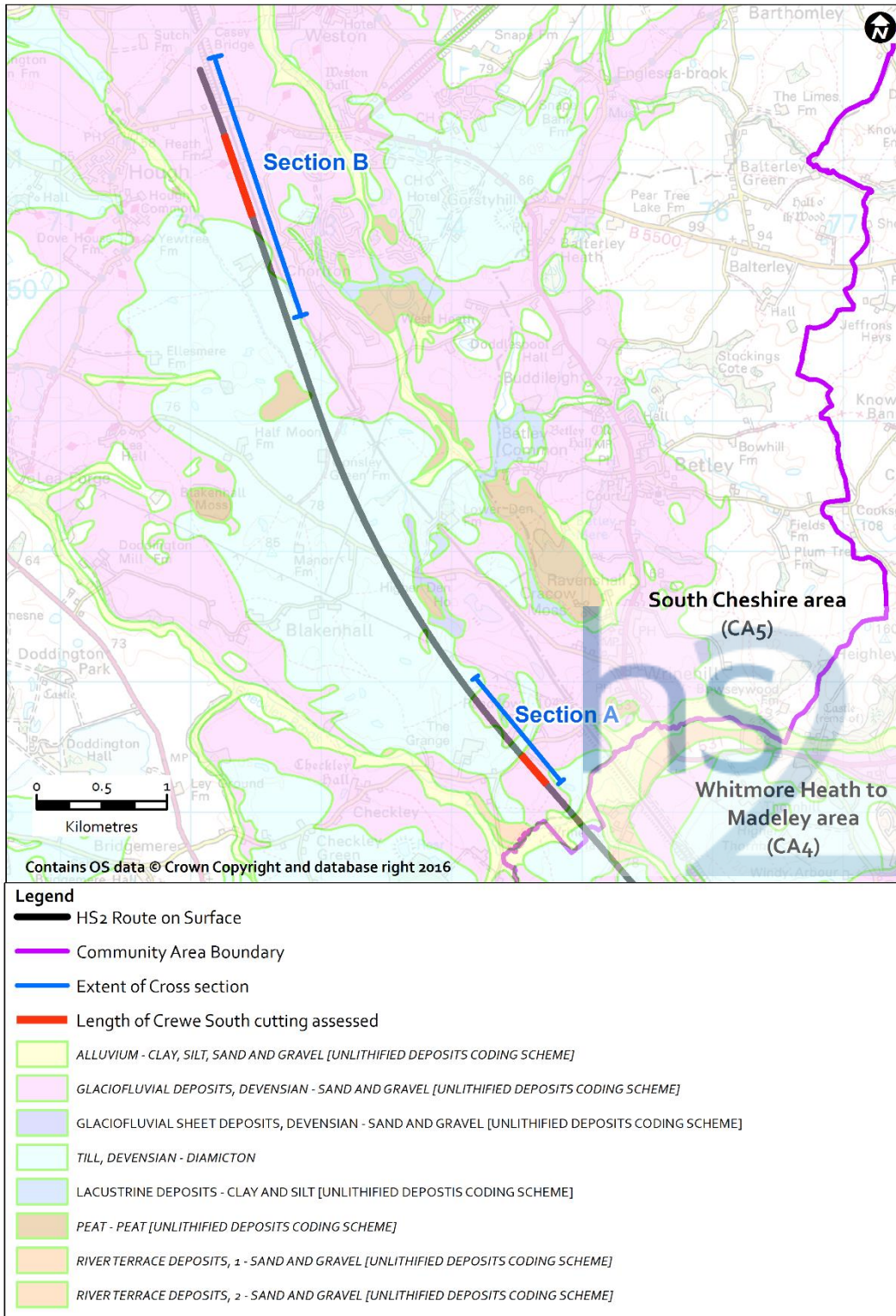
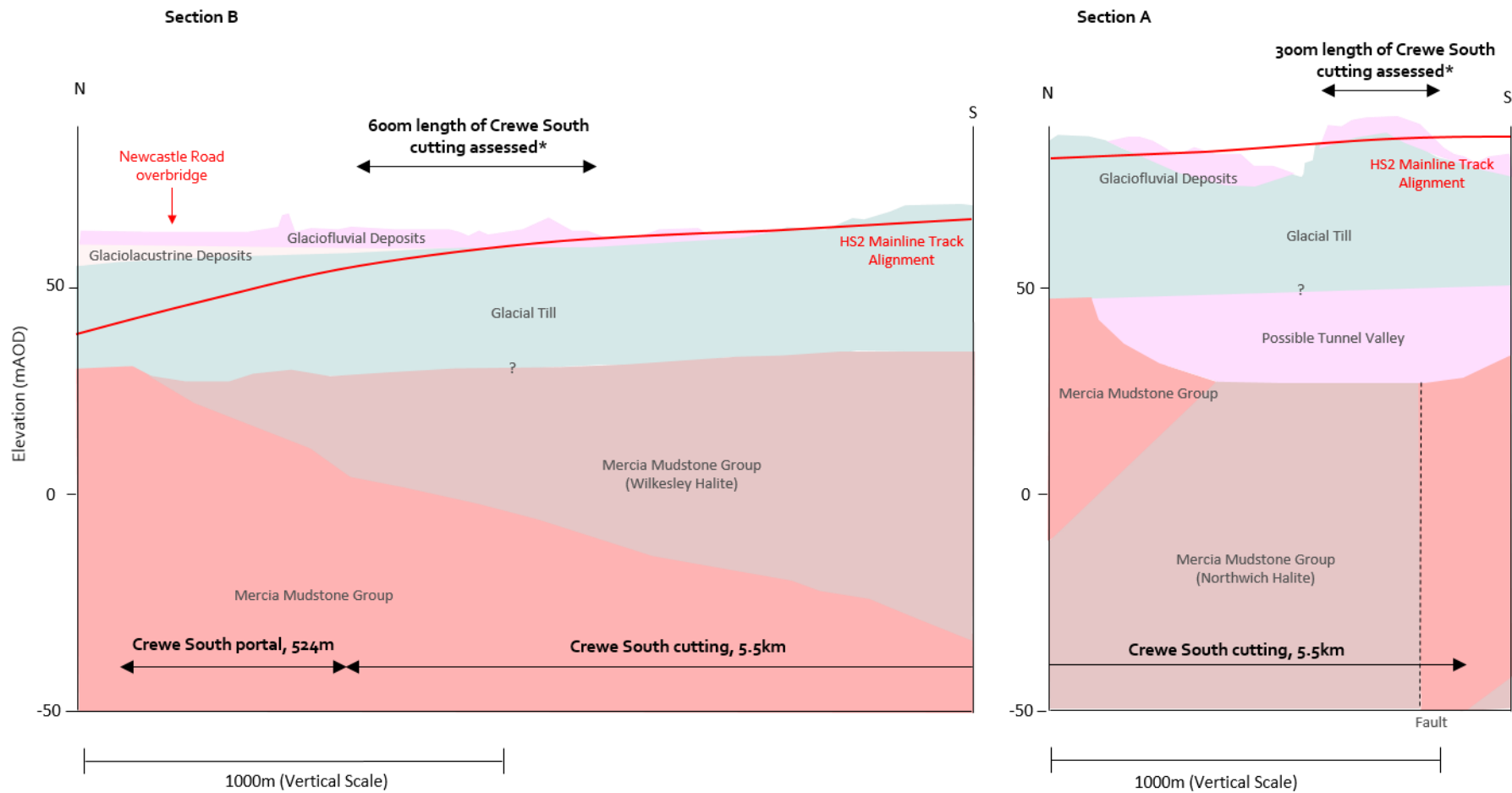


Figure 2: Cross-sections through assessed areas of Crewe South cutting



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

Blakenhall Northbound Spur cutting

Table 10: Summary of the Blakenhall Northbound Spur cutting parameters for the groundwater assessment

Cutting parameters (the full length of the named cutting)	Parameter details
Length (km)	1.8
Maximum depth (m)	5
Strata intercepted	Glacial Till Deposits (Unproductive) and Glaciofluvial Deposits (Secondary A aquifer)
Lowest track level (mAOD)	81.4
Groundwater level(s) (mAOD)	No groundwater level monitoring information is available in this area. Several historical borehole logs document shallow groundwater strikes but others do not record any groundwater. For a precautionary assessment groundwater level in the superficial deposits is assumed to be at ground level.
Principal receptors	Glaciofluvial Deposits Secondary A aquifer Licensed groundwater abstractions at The Grange

5.2.5 The design element which is referred to as Blakenhall Northbound Spur cutting, is actually a combination of cutting, at grade and embanked sections. The quantitative assessment of potential dewatering impacts is focussed on the area of cutting to the north of Randilow North culvert, which is approximately 650m in length. Although it is likely that most of the cutting is through low permeability Glacial Till, for a precautionary assessment, the material is assumed to be Glaciofluvial Deposits, with the water level at ground level. Further assessment is demonstrated in the following section (assessment of cuttings below groundwater level).

Blakenhall Southbound Spur embankment, cutting

Table 11: Summary of the Blakenhall Southbound Spur cutting parameters for the groundwater assessment

Cutting parameters	Parameter details
Length (km)	0.6
Maximum depth (m)	8
Strata intercepted	Glacial Till Deposits (Unproductive) and Glaciofluvial Deposits (Secondary A aquifer)
Lowest track level (mAOD)	81.6
Groundwater level(s) (mAOD)	No groundwater level monitoring information is available in this area. Several historical borehole logs document shallow groundwater strikes but others do not record any groundwater. For a precautionary assessment groundwater level in the superficial deposits is assumed to be at ground level.

Cutting parameters	Parameter details
Principal receptors	Glaciofluvial Deposits Secondary A aquifer Licensed groundwater abstractions – The Grange

5.2.6 The design element which is referred to as Blakenhall Southbound Spur embankment, is actually a combination of cutting, at grade and embankment sections. The quantitative assessment of potential dewatering impact is focussed on the area of cutting, which is approximately 600m in length, to the north of Randilow North culvert. Although it is likely that most of the cutting is through low permeability Glacial Till, for a conservative assessment, the material is assumed to be Glaciofluvial Deposits, with the water level at ground level. Further assessment is demonstrated in the following section (assessment of cuttings below groundwater level).

WCML cuttings

Table 12: Summary of the WCML cuttings parameters for the groundwater assessment

Cutting parameters	Cutting name	Parameter details
Length (km)	Blakenhall cutting	1.7
	Chorlton cutting	2
	Basford cutting	0.52
Maximum depth (m)	Blakenhall cutting	5
	Chorlton cutting	4
	Basford cutting	4
Strata intercepted	As above	Glacial Till Deposits (Unproductive) and Glaciofluvial Deposits (Secondary A aquifer)
Groundwater level(s) (mAOD)	As above	No groundwater level monitoring information is available in this area. Several historical borehole logs document shallow groundwater strikes but others do not record any groundwater. For a precautionary assessment groundwater level in the superficial deposits is assumed to be at ground level.
Principal receptors	As above	Glaciofluvial Deposits Secondary A aquifer Tributary of Mere Gutter (a low value receptor)

5.2.7 Blakenhall cutting, Chorlton cutting and Basford cutting are shallow cuttings which will be constructed along the WCML. As groundwater levels are assumed to be above the base of the cutting depth, they have been assessed. This is summarised in the following section (assessment of cuttings below groundwater level).

Assessment of cuttings below groundwater level

5.2.8 Assessment of the likely maximum zone of influence from dewatering of the cuttings which may be below existing groundwater level (as set out above) has been made using Sichardt's formula.

- 5.2.9 The methodology follows Environment Agency guidance¹⁶ and the methodology set out in CIRIA C750¹⁷, as summarised in the SMR addendum³, Volume 5: Appendix CT-001-002.
- 5.2.10 Sichardt's formula is presented below:
- $$L_o = C \times h \times \sqrt{k}$$
- Where;
- L_o = distance of influence from linear structure (m)
 - k = hydraulic conductivity (m/s)
 - h = drawdown (m)
 - C = empirical calculation factor taken to be 1750¹⁸
- 5.2.11 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.
- 5.2.12 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.
- 5.2.13 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.

Crewe South cutting

- 5.2.14 Assuming a hydraulic conductivity at the high end of the range for a sand or silty sand¹⁹ (3×10^{-4} m/s), the maximum zone of influence (L_o) from the 300m cutting, which has a maximum depth of 5m and a mean depth of 3.2m, is estimated at 151.6m. This is based on a precautionary assessment using the maximum cutting depth of 6.3 m and a water level at ground level. The L_o of the 600m cutting further to the north, is estimated at 191.0m.
- 5.2.15 As there are no water dependent features within this extent, and as the Secondary A aquifer is extensive in comparison to the small area where groundwater levels may be lowered, dewatering of the cutting is assessed as having a negligible impact.
- 5.2.16 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 in the Secondary A aquifer during construction. Application of the pollution prevention measures outlined in the draft CoCP and the drainage design will ensure that any impacts on aquifer quality are negligible.

¹⁶ Environment Agency (2007), *Hydrogeological impact appraisal for dewatering abstractions*

¹⁷ Preene, M., Roberts, T.O.L. and Powrie, W. (2016), *Groundwater control: design and practice*. CIRIA Publication C750.

¹⁸ Cashman, P.M. and Preene, M. (2001), *Groundwater Lowering in Construction, a Practical Guide*

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

- 5.2.17 Further ground investigation and monitoring is required to confirm groundwater levels in these locations. This will inform the detailed design and management of groundwater during construction.

Blakenhall Northbound Spur cutting

- 5.2.18 Assuming a hydraulic conductivity at the high end of the range for a sand or silty sand¹⁹ (3×10^{-4} m/s), the maximum zone of influence from this cutting (Lo) is estimated at 151.6m. This is based on a maximum cutting depth of 5m and a water level at ground level, as this is considered to be most representative of assumed dewatering depths across the cutting.
- 5.2.19 As there are no water dependent features within this extent, and as the Secondary A aquifer is extensive in comparison to the small area where groundwater levels may be lowered, dewatering of the cutting is assessed as having a negligible impact.
- 5.2.20 Under the scenario of shallow groundwater levels, there would be little or no unsaturated zone and therefore a greater potential impact on groundwater quality in the Secondary A aquifer during construction. Application of the pollution prevention measures outlined in the draft CoCP and the drainage design will ensure that there is negligible impact on aquifer quality.
- 5.2.21 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.

Blakenhall Southbound Spur embankment, cutting

- 5.2.22 Assuming a hydraulic conductivity at the high end of the range of a sand or silty sand (3×10^{-4} m/s¹⁹), the maximum zone of influence from the cutting (Lo) is estimated at 242.5m. This is based on an approximate mean cutting depth of 8m and a water level at ground level, as this is considered to be most reflective of assumed dewatering depths across the cutting.
- 5.2.23 As there are no water dependent features, within this extent, and as the Secondary A aquifer is extensive in comparison to the small area where groundwater levels may be lowered, dewatering of the cutting is assessed as having a negligible impact.
- 5.2.24 Under the scenario of shallow groundwater levels, there would be little or no unsaturated and therefore a greater potential impact to groundwater quality of the Secondary A aquifer during construction if not properly managed. Application of the pollution prevention measures outlined in the draft CoCP and the drainage design will ensure that there is negligible impact on aquifer quality.
- 5.2.25 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.

WCML cuttings

- 5.2.26 Assuming a hydraulic conductivity at the high end of the range for of a sand or silty sand (3×10^{-4} m/s¹⁹), the maximum zone of influence from any of the cuttings (Lo) is estimated at 152m. This is based on the approximate maximum cutting depths outlined in Table 12 and a rest water level at ground level.

- 5.2.27 The tributary of Mere Gutter is within 152m of the Blakenhall cutting, and there may be loss of baseflow to this surface watercourse during construction dewatering, and permanent seepage into the cutting. This is assessed as a minor impact on a low value receptor and therefore a negligible effect (not significant). As the Secondary A aquifer is extensive in comparison to the small area where groundwater levels may be lowered, dewatering of the cutting is assessed as having a negligible impact.
- 5.2.28 Under the scenario of shallow groundwater levels, there would be little or no unsaturated and therefore a greater potential impact to groundwater quality of the Secondary A aquifer during construction if not properly managed. Application of the pollution prevention measures outlined in the draft CoCP and the drainage design will ensure that there is negligible impact on aquifer quality.
- 5.2.29 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 from the tunnel approach

- 5.2.30 The Crewe South portal (retained cut) consists of a deep cut structure which will be constructed using a diaphragm wall. The Crewe South portal details and groundwater assessment parameters are detailed in Table 13.

Crewe South Portal (retained cutting)

Table 13: Summary of Crewe South portal parameters for groundwater assessment

Portal parameters	Parameter details
Length (m)	524
Maximum depth (m)	22
Strata intercepted	Glacial Till and Glaciofluvial Deposits
Lowest element level (mAOD)	42.7 (northern extent of the Proposed Scheme)
Groundwater level(s) (mAOD)	No groundwater level monitoring information is available in this area. Several historical borehole logs along the A500 document shallow groundwater strikes but others do not record any groundwater. For a precautionary assessment groundwater level in the superficial deposits is assumed to be at ground level.
Principal receptors	Glaciofluvial Deposits Secondary A aquifer (part of the Weaver and Dane Quaternary Aquifer WFD groundwater body) Basford Brook Spring, Basford House

- 5.2.31 A simple quantitative assessment has been undertaken to assess the potential impacts of construction dewatering at the portal. Taking a precautionary approach, the portal has been assessed as an open cutting, and the potential linear distance of

impact (in terms of groundwater lowering and change in flow direction towards the cutting) has been calculated using Sichardt's formula.

- 5.2.32 Material in the area is expected to consist of a mixture of sand, gravel, silty sand and clay. For the assessment the hydraulic conductivity of a fine to medium sand has been used ($1 \times 10^{-5} \text{m/s}^{29}$), the maximum zone of influence from this cutting (Lo) is estimated at 122m. This is based on an approximate maximum cutting depth of 22m and a rest water level at ground level. The maximum depth has been used on a precautionary basis.
- 5.2.33 As there are no water dependent features within this extent, and as the Secondary A aquifer is extensive in comparison to the small area where groundwater levels may be lowered, dewatering of the cutting is assessed as having a negligible impact.
- 5.2.34 Similarly the potential impact on the water environment due to the permanent below ground retained structure, is assessed as negligible.

Assessment of impacts from the borrow pit north of Checkley Lane

- 5.2.35 The borrow pit north of Checkley Lane will require the extraction of an area of Glaciofluvial Deposits which are classed as Secondary A aquifer. There are several groundwater receptors in proximity to the borrow pit including: Betley Mere SSSI, which is 280m north-east of the borrow pit at its nearest point, tributaries of Mere Gutter, which is approximately 320m to the north, Checkley Brook which is approximately 650m to the south-east, the licensed abstractions at The Grange, which is 400m to the south-west, and a discharge to groundwater which is 200m to the north.
- 5.2.36 The detailed baseline hydrogeology of the area of this borrow pit is set out in the Appendix 1 of the HRA for Betley Mere SSSI¹⁰. There is little local information about groundwater levels in the Glaciofluvial Deposits in this area, although it is assumed that groundwater is present and there is potential groundwater connection to all groundwater receptors, where the permeable superficial deposits are continuous.
- 5.2.37 Specific measures will be adopted throughout the construction phase to ensure negligible impact on groundwater flow and quality in this area and negligible impact on the receptors listed above. These measures include:
- provision of a one metre vertical buffer between the base of the borrow pit excavations and the groundwater level. This will ensure that there are no impacts on groundwater flows;
 - adherence to the measures described in the draft CoCP; and
 - such reasonable ancillary measures as may be required.
- 5.2.38 Before borrow pit extraction commences, detailed hydrological and hydrogeological investigations will be undertaken using boreholes to establish the safe depth of the extraction to ensure there are no effects on the groundwater flow to the mere. The details of the mitigation will be agreed with the Environment Agency and in consultation with Natural England with regards Betley Mere SSSI.
- 5.2.39 Surface water runoff intercepted by the borrow pit will also be recirculated into the downstream catchment at an appropriate rate and location to ensure any temporary

changes to the local surface water catchment, will not result in loss of water to a different catchment. This will ensure negligible impact on flow to Betley Mere SSSI and other surface watercourses. Surface runoff will be treated as appropriate to ensure negligible impact on the quality of surface water or groundwater where this is discharged. Further detail regarding assessment of impacts on the surface water bodies is provided in the route-wide WFD assessment (Volume 5, Appendix WR-001-000).

- 5.2.40 There is the possibility that alternative methods of avoidance to those specified above may be developed in the period prior to excavation that would be equally effective in preventing the likelihood of significant effects on Betley Mere SSSI. If that were to be the case, HS2 Ltd. would secure the Environment Agency approval, in consultation with Natural England, to such an alternative prior to the excavation commencing.
- 5.2.41 A groundwater and surface water monitoring programme will be developed to ensure that there is no effect on groundwater and that the correct volume and quality of discharge to surface water bodies is maintained throughout construction.
- 5.2.42 Although the borrow pit is expected to result in negligible impact on the licensed abstractions at The Grange, in combination with the other construction works in proximity to this abstraction (see Table 7) the temporary impacts on water quality have been assessed as major, a major significant effect. As set out in the draft CoCP this risk will be assessed by the contractor. If required a suitable replacement water source with an alternative or mains water supply would be provided.
- 5.2.43 The borrow pit will be restored with natural, clean excavated material of lower permeability. The restoration design of the borrow pit area will ensure drainage is maintained and there will be negligible permanent impact on the water quantity and quality flowing to Betley Mere SSSI and the other receptors listed above.

Impact to groundwater flow from permanent retaining walls

- 5.2.44 In the South Cheshire area there are nine permanent retaining walls. Seven of these will be installed in low permeability Glacial Till and the impact on groundwater quality, flow and levels is assessed as negligible. Two retaining walls (Chorlton retaining wall 6 and Crewe South portal retaining wall) will be installed within the Glaciofluvial Deposits Secondary A aquifer. As there is little groundwater level information available in this area, the local hydraulic gradient in this aquifer is not known at this stage. It is assumed that groundwater levels are high (close to or at ground level) and therefore it is assumed that water flows in the direction of local topography towards the low points in catchments.
- 5.2.45 Placing a low permeability retaining wall through the aquifer could create a barrier to groundwater flow. There are no surface water receptors or other receptors such as groundwater abstractions in proximity to the two retaining walls, therefore there will be negligible impact. The Glaciofluvial Deposits Secondary A aquifer is part of the Weaver and Dane Sand and Gravel Aquifers WFD groundwater body and therefore the impact on the aquifer as a potential resource has also been assessed in the route-wide WFD assessment (Volume 5, Appendix WR-001-000). If ground investigation and monitoring show that the retaining wall may present a significant barrier to flow, drainage measures will be designed to ensure that water balance in the aquifer is maintained. The effect on the aquifer is therefore assessed as negligible.

6 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*. CRC Press.

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.

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), *Habitats Regulations Assessment screening report for Midland Meres and Mosses Phase 1 Ramsar site addendum - Betley Mere Site of Special Scientific Interest component* (EC-017-002).

HS2 Ltd (2017), *High Speed Two (HS2) Phase 2a (West Midlands - Crewe) Baseline Hydrogeology - Betley Mere SSSI and Surrounding Area report* (EC-017-002).

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

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

