M60/M62/M66 Simister Island Interchange

TR010064

ENVIRONMENTAL STATEMENT APPENDICES

APPENDIX 13.4 GROUNDWATER ASSESSMENT REPORT

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ENVIRONMENTAL STATEMENT APPENDICES
APPENDIX 13.4 GROUNDWATER ASSESSMENT REPORT

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Appendix 13.4 Groundwater assessment report

1 Introduction

1.1.1 This document presents the assessment of groundwater impacts for the M60/M62/M66 Simister Island Interchange (the 'Scheme').

1.1.2 The aim of this document is to provide an outline of the baseline groundwater characteristics within the study area (defined as a 2km buffer in all directions around the Order Limits) and assess any significant environmental effects it may have on the groundwater regime and any associated receptors. This includes the impacts from dewatering during construction on groundwater flow and quality. This report has informed Chapter 13: Road Drainage and the Water Environment of the Environment Statement (TR010064/APP/6.1).

2 Limitations, assumptions and data gaps

2.1 Design assumptions

2.1.1 At this stage of assessment only preliminary design details are available and excavation and piling depths and extents quoted would be subject to refinement during the detailed design stage.

2.1.2 No excavations required for the diversion of buried services.

2.1.3 Maximum depth of soil stripping would be 0.5mbgl.

2.1.4 Haul roads and site compounds would be constructed at grade and will not require excavation, dewatering or embankments.

2.1.5 Three haul roads would be permanent features and used as access routes for maintenance of the ponds following construction. Two are located running parallel with the M62 carriageway, west of M60 J18. One is located south of M60 J18, north of Heaton Park Golf Club.

2.1.6 Haul roads and site compounds will utilize temporary construction drainage which will not discharge to ground.

2.1.7 Wick drains, also known as Prefabricated Vertical Drains (PVD) are prefabricated geotextile filter-wrapped plastic strips with molded channels. These act as drainage paths to take pore water out of soft compressible soil so it consolidates faster. No excavation or dewatering would be required for install. They will be used beneath the footprint of two areas of embankment to speed up consolidation of soft clays and silts: the Northern Loop free flow link and the M66 slip road, from approximate chainages 950 to 1150 and 300 to 450, respectively. Anticipated depths and spacings are 7mbgl and 1m respectively. Settlement beneath the embankments are expected to be greater in these areas, potentially ranging from 200 to 500mm. Locations and details of the wick drains would be finalised during detailed design.

2.1.8 Sheet piles would be installed in association with the M60 eastbound, around the Haweswater Aqueduct, and the M66 northbound. Maximum depth of sheet piles would be 15mbgl. Maximum length is expected be 200m. Excavations or dewatering will not be required to install the sheet piles.

2.1.9 All ponds would be lined, and linear drainage features would be sealed. It is assumed there would be no discharge to ground as part of the Scheme temporary and permanent drainage design.

2.1.10 There would be no excavations below the water table required for drainage outfalls and headworks.

2.1.11 Gantries would be installed to a maximum depth of approximately 30mbgl. Gantry foundations will comprise of one bored pile either side. It is assumed that no new excavation beyond existing earthworks is required. Modified gantries do not require any piling and/or excavation. Gantries to be removed would be removed down to finished floor level.

2.1.12 It is assumed that bored piles would be required for bridge abutments for both the Simister Pike Fold Bridge and Simister Pike Fold Viaduct. The maximum depth of bored piles would be approximately 30mbgl and may intersect bedrock.

2.1.13 No deeper excavation beyond existing earthworks would be required for bridge abutment pile foundations.

2.1.14 There are no borrow pits or flood compensation measures for the Scheme.

2.2 Groundwater assumptions

2.2.1 Bedrock is assumed to be approximately 25 to 30mbgl.

2.2.2 The shallowest groundwater data recorded at a borehole, either as monitoring data or as a groundwater strike, is assumed to be the shallowest groundwater level within the borehole location.

2.2.3 It is assumed that all surface water features are in some degree of hydraulic continuity with the surrounding groundwater.

2.2.4 It is assumed that all superficial deposits are in hydraulic continuity, where superficial deposits present are not classified as 'Unproductive'.

2.2.5 It is assumed that there is some degree of hydraulic continuity between the bedrock and superficial deposits, where superficial and bedrock deposits present are not classified as 'Unproductive'.

2.2.6 For the dewatering calculations, it is assumed that ground conditions within, and surrounding, the radius of influence are homogenous.

2.3 Data limitations and data gaps

2.3.1 Groundwater monitoring data was collected using electronic dip meter between August 2021 and February 2022, with exception of the months of November and December 2021. In some locations, there is also groundwater monitoring available in May 2023. Therefore, the groundwater monitoring is limited, and does not extend over one recharge period. This likely means that the full range of groundwater levels is not captured within the data. Groundwater levels are likely to fall outside of the range captured by the monitoring. However, this is unlikely to affect the findings of the study.

2.3.2 No monitoring installations have been installed within the bedrock. This means that groundwater levels and flows within the bedrock, and interactions between the bedrock and superficial deposits, cannot be commented on.

2.3.3 Not all groundwater features (springs, issues etc) were surveyed within 250m of the Order Limits. This was due to access issues. This means that the presence of some of the features has not been ground-truthed.

2.3.4 Private Water Supply (PWS) questionnaires have been sent out to all landowners with land holdings situated within 250m of the Order Limits to confirm the presence of PWS. 10 out of 38 PWS questionnaires have been returned. PWS have also been identified by reference to Ordnance Survey (OS) maps. PWS have not been surveyed through site visits. Therefore, it is possible that additional PWS exist than have been identified at the time of reporting.

3 Hydrogeology baseline

3.1 Geology and aquifers

Superficial and bedrock geology

3.1.1 A detailed description of the geology in the vicinity of the Scheme is included in Section 9.7 of Chapter 9: Geology and Soils of the Environmental Statement (TR010064/APP/6.1), summarised here.

3.1.2 Geological maps are presented in Figure 9.1: Bedrock Geology, Figure 13.3: Bedrock Aquifer Designations and Figure 13.4: Superficial Aquifers and Groundwater Receptors and Features of the Environmental Statement Figures (TR010064/APP/6.2).

3.1.3 Areas of Made Ground, worked ground, and infilled ground within the study area are associated with both existing and historical land uses including landfill sites. Details of historical land use and contaminated land are discussed in Chapter 9: Geology and Soils of the Environmental Statement (TR010064/APP/6.1). Made ground deposits are extensive throughout the Order Limits, which is to be expected given the presence of the existing motorway and motorway junctions.

3.1.4 The study area is mostly underlain by superficial deposits comprising glacial till (diamicton) and hummocky (moundy) glacial deposits (British Geological Survey (BGS), 2023). Lesser areas of head, glacio-fluvial / glaciofluvial ice contact deposits, glacio-lacustrine deposits, and peat are present within the Order Limits. Elsewhere (located in the north, east, south and west of the groundwater study area), are localised deposits of alluvium and river terrace deposits.

3.1.5 Underlying the superficial deposits across most of the study area is the Chester Formation and the Pennine Coal Measures Group (hereafter referred to as the 'Coal Measures'). The latter of which comprises the Pennine Lower, Middle, and Upper Coal Measures Formations. Units of the Manchester Marls Formation are shown to have been thrust between the sandstone bearing strata of the Chester Formation, by extensive faulting in the area. Subcrops of the Collyhurst Sandstone Formation (in the south and west of the study area) and Rossendale Formation (in the north-east) are also present (BGS, 2023).

3.1.6 There are multiple inferred faults cutting across the bedrock throughout the study area (BGS, 2023). Most of the faults are orientated in an approximately northwest-southeast direction and extend across the full length of the study area. BGS mapping shows several coal seams and marine bands in the south-west and north-east of the study area. Glacial drumlin features are also mapped in the centre and east of the study area, with the largest covering Boz Park and its surrounding area. In addition, landslip deposits are shown to be present in and around the Philips Park, Hollins Vale and Pilsworth areas.

Coal mining

3.1.7 As described in Chapter 9: Geology and Soils of the Environmental Statement (TR010064/APP/6.1), underground coal mining last took place in 1970, in a coal seam located within 250m of the Order Limits (western extent), and between 430 and 460m depth. Groundwater regimes would therefore have likely equilibrated since cessation of the works. However, mine entry points, abandoned mines, and development high risk areas are also shown in and around M60 J17 (Coal Authority, 2023). With the Order Limits situated within the centre of multiple coal seams, the potential for underground coal mining and unrecorded mine workings, shafts, or adits cannot be discounted.

Aquifer designations and characteristics

3.1.8 The Environment Agency designates superficial and bedrock aquifers with the following classifications (Department for Environment, Food and Rural Affairs (Defra), 2023):

- Principal – These are layers of rock or drift deposits that have high intergranular and/or fracture permeability – meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale.
- Secondary A – Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers;
- Secondary B – predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.
- Secondary Undifferentiated – is assigned in cases where it has not been possible to attribute either category A or B to a rock type;
- Unproductive Strata – These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

3.1.9 Table 3.1 summarises aquifer designations and characteristics for each geological unit, both superficial and bedrock, within the study area. The superficial and bedrock aquifer designations and sensitivities are included in Figure 13.3: Bedrock Aquifer Designations and Figure 13.4: Superficial Aquifer and Groundwater Receptors and Features (TR010064/APP/6.2).

Table 3.1 Superficial and bedrock aquifer designations and characteristics

Geological Unit	Description	Location	Aquifer designation (Sensitivity)	Flow Mechanism and Permeability	Hydrogeology
Superficial aquifers					
Glacio-fluvial/ glaciofluvial ice contact deposits	Sand and gravel, locally with lenses of silt, clay or organic material.	Present throughout the study area, particularly in the west.	Secondary A (High)	Intergranular flow, very high to high permeability	Sand and gravel constituents may locally yield significant groundwater volumes where deposits are of sufficient thickness. The aquifer may contain perched water tables above discontinuous clay lenses. Local groundwater abstraction possible.
Alluvium	Typically soft to firm, consolidated compressible silty clay, that can contain layers of silt, sand, peat, basal gravel, and a desiccated surface zone.	Present surrounding watercourses, including the River Irk in the south, River Roch in the north, and Whittle / Hollins Brook in the north-east.	Secondary A (High)	Intergranular flow, high to very low permeability	Where sand/gravel layers are thick and continuous, groundwater yields would be high, making local groundwater abstraction possible, although the dominance of clay in this unit may limit its potential as an aquifer.
River terrace deposits	Sand and gravel, locally with lenses of silt, clay and peat.	Present in the north-west and south-west of the study area, surrounding the Rivers Roch and Irwell respectively.	Secondary A (High)	Intergranular flow, very high to high permeability	Sand and gravel deposits will typically comprise high porosity and high permeability and can locally yield significant groundwater volumes if clay lenses are infrequent and sand/gravel deposits are of sufficient thickness. Local groundwater abstraction possible.

Geological Unit	Description	Location	Aquifer designation (Sensitivity)	Flow Mechanism and Permeability	Hydrogeology
Glacial till (diamicton)	Variable lithology, typically sandy, silty clay, with pebbles, but can contain gravel-rich, or laminated sand layers.	Widespread throughout the study area, particularly in the centre and north.	Secondary Undifferentiated (Medium)	Mixed flow, high to low permeability	Typically acts as an aquitard or aquiclude but can locally comprise productive sand and gravel horizons, which may yield limited amounts of groundwater, although groundwater abstraction is unlikely.
Hummocky (moundy) glacial deposits	Lithologically diverse deposits, composed of rock debris, clayey till and poorly-to well-stratified sand and gravel.	Widespread throughout the study area, particularly in the north and south.	Secondary Undifferentiated (Medium)	Intergranular flow, very high to high permeability	Sand and gravel layers are the productive horizons, but the dominance of clay likely causes this unit to act locally as an aquitard. Groundwater abstraction is unlikely.
Head	Comprises sand and gravel, locally with lenses of silt, clay or peat and organic material.	Isolated areas in the north and south-east of the study area, surrounding watercourses such as Hollins Brook and Castle Brook.	Secondary Undifferentiated (Medium)	Mixed flow, high to very low permeability	The extent and thickness of these deposits limits the available groundwater yield contained within the more productive sand and gravel horizons and groundwater abstraction is therefore unlikely. The unit may contain multiple perched water tables above discontinuous clay/peat lenses.
Peat	An accumulation of wet, dark brown, partially decomposed vegetation, or an organic rich clay.	Isolated areas in the centre of the study area surrounding the M60 J18.	Unproductive strata (Low)	Mixed flow, low to very low permeability	Typically comprises 90% water and acts as an aquitard, limiting groundwater discharge. Permeability varies with the degree of decomposition and soil compression and often reduces with depth.

Geological Unit	Description	Location	Aquifer designation (Sensitivity)	Flow Mechanism and Permeability	Hydrogeology
Glacio-lacustrine deposits	Devensian clay and silt.	Small isolated area in the centre of the study area immediately north-west of the M60 J18.	Unproductive strata (Low)	Intergranular flow, very high to high permeability	Clay constituent typically causes this unit to act as an aquitard or aquiclude. Despite containing occasional productive silt/sand horizons, the limited extent and thickness of these deposits makes groundwater abstraction unlikely.
Bedrock aquifers					
Chester Formation	Permo-Triassic coarse to fine-grained sandstone	Across the centre of the study area.	Principal (Very high)	Mixed flow, high to moderate permeability	Part of the Sherwood Sandstone Group and is in hydraulic continuity with the other four formations in this group. Stratification due to layers of siltstones and mudstones can isolate sandstone layers, creating perched water tables throughout the formation. Mudstone beds are laterally discontinuous and unlikely to constitute regional hydraulic barriers
Collyhurst Sandstone Formation	Permian soft red sandstone with a millet seed texture (aeolian origin)	Localised areas in the west and far south of the study area.	Principal (Very high)	Intergranular flow, high permeability	Poorly cemented sandstone with a high hydraulic conductivity. Its increased thickness and intense faulting in the Manchester area permits a free interflow at many points with the Sherwood Sandstone Group above

Geological Unit	Description	Location	Aquifer designation (Sensitivity)	Flow Mechanism and Permeability	Hydrogeology
Pennine Lower Coal Measures Formation	Carboniferous mudstone, siltstone and sandstone	Widespread throughout the study area.	Secondary A (High)	Fracture flow, high to low permeability	Complex multi-layered aquifer. Argillaceous strata dominate, acting as aquitards or aquicludes, isolating the occasional sandstone horizons which act as separate aquifers and constitute up to a third of the succession in the Manchester area. This is where most of the groundwater storage / movement occurs as both intergranular and fracture flow. Faulting has split the once continuous sandstone horizons into discrete blocks, to which no direct recharge can occur. The mining of numerous coal seams has been extensive and has largely disrupted the natural hydrogeological conditions, by the creation of open shafts which have for example connected layers which were previously isolated
Pennine Middle Coal Measures Formation			Secondary A (High)	Fracture flow, moderate to low permeability	
Pennine Upper Coal Measures Formation			Secondary A (High)	Fracture flow, moderate to low permeability	
Rossendale Formation (Rough Rock Formation)	Carboniferous fine to very coarse-grained and pebbly sandstone, interbedded with siltstone, mudstone, marine shales, thin coals and seatearths	Localised areas in the north-east of the study area.	Secondary A (High)	Fracture flow, low permeability	Constitutes an important aquifer horizon in the Lower Coal Measures

Geological Unit	Description	Location	Aquifer designation (Sensitivity)	Flow Mechanism and Permeability	Hydrogeology
Manchester Marls Formation	Permian fine-grained marl (mudstone), with beds of coarser material and thin, carbonate-rich deposits including evaporites	Localised areas in the centre and south of the study area.	Secondary B (Medium)	Fracture flow, low permeability	Consists mainly of mudstones of low hydraulic conductivity which inhibit vertical hydraulic continuity in the Manchester area. Predominantly an aquitard in this area

3.1.10 The mapped superficial deposits within the groundwater study area are classified mainly as Secondary A and secondary undifferentiated aquifers (Defra, 2023), with pockets of unproductive strata and a high degree of variation in permeability.

3.1.11 Secondary A superficial aquifers comprise the Alluvium, River Terrace Deposits, Glacio-fluvial and Glaciofluvial ice contact deposits located in patches throughout the study area, and in the centre and west of the Order Limits. Secondary undifferentiated aquifers associated with the Glacial Till, Hummocky (moundy) glacial deposits and Head deposits are widespread throughout most of the study area and Order Limits.

3.1.12 Within the secondary undifferentiated superficial aquifers, groundwater is more likely to be found in small, isolated bodies in the more permeable sandy layers. The widespread extent of these deposits will offer some degree of protection from surface pollution to the Secondary A superficial aquifer units (where overlain), as well as the underlying bedrock aquifers at depth.

3.1.13 Localised patches of unproductive strata (comprising peat and glaciolacustrine deposits) are shown in the centre of the study area surrounding the M60 J18. These will have a low sensitivity given their impermeable nature. They are also likely to provide a degree of protection to the underlying Secondary A and Secondary Undifferentiated superficial aquifers, as well as the deeper bedrock aquifers.

3.1.14 The principal bedrock aquifers associated with the Chester and Collyhurst Sandstone Formations are generally located in the centre of the Order Limits and study area (at depth). The remainder of the study area is underlain by Secondary A bedrock aquifers (Coal Measures and the Rossendale Formation). The exception is the units of Secondary B bedrock aquifer associated with the Manchester Marls Formation, thrust between the Principal and Secondary A bedrock aquifers by extensive faulting.

3.1.15 Areas underlain by the Principal and Secondary A bedrock aquifers will have a very high and high sensitivity, respectively given their regional and local importance. However, all bedrock aquifers are expected to be afforded a degree of protection from surface pollution due to the extent and thickness of the overlying superficial aquifers within both the Order Limits and the wider study area.

3.2 Groundwater levels and flows

Ground investigation specific data review

3.2.1 Three phases of ground investigation (GI) have been undertaken since June 2021, with groundwater monitoring data collected until May 2023 used within this assessment. See Chapter 9: Geology and Soils of the Environmental Statement (TR010064/APP/6.1), and the Ground Investigation Report (Appendix 9.3 of the Environmental Statement Appendices (TR010064/APP/6.3)) for further details. The GI covered the following geographical areas:

- Phase 1: West of M60 J17 Whitefield Interchange to M60 J18 Simister Island, and M66 north of M60 J18 Simister Island (south of Hollins Brook) to south of M60 J18 Simister Island (north of Heaton Park)
- Phase 2: M60 J17 Whitefield Interchange to M60 J18 Simister Island
- Phase 3: West of M60 J17 Whitefield Interchange and east of M66 at Unsworth.

3.2.2 Groundwater strikes or seepages recorded in exploratory holes during the GI are summarised in Table 3.2. It was generally within the window sample holes and cable percussive holes that the strikes were recorded. However, the use of water flush during rotary drilling meant that determining groundwater strikes was not always possible. Trial pits typically reached 1.7m depth and therefore water strikes were less common, although this could also indicate that the deposits encountered were of low permeability.

Table 3.2 Groundwater strikes recorded within the Order Limits

Hole type	Total number of holes	No. of holes* recording a water strike	Percentage (%) of holes recording a water strike
Trial pit (TP)	4	0	0
Cable percussion (CP)	57	20	35
Window sample (WLS)	54	23	42
Cable percussion and rotary open hole follow on (CP + RO)	1	1	100
Cable percussion and rotary core follow on (CP + RC)	3	2	66
Dynamic sample borehole and cable percussion follow on (WLS + CP)	6	0	0
Dynamic sample borehole and rotary open hole follow on (WLS + RO)	1	1	100
Dynamic sample borehole and rotary open hole follow on (WLS + RC)	2	2	100
Open hole (OP)	3	0	0
Inspection pit (IP)	13	0	0
All holes	144	49	34

*Some holes recorded multiple groundwater strikes which is signposted below in the relevant sections.

3.2.3 Groundwater strikes/seepages were recorded within 4m of the ground surface in 24 out of 68 instances (35%), as shown in Table 3.3. The shallowest groundwater strikes (less than 2mbgl) were found to be located north-east of M60 J18 Simister Island (north of Egypt Lane) and to the west of M60 J18 Simister Island (east of Marston Close). However, there were also 15 groundwater strikes (22%) recorded at depths of more than 16mbgl. The deepest of which was 39.2mbgl (BH-N01A), located to west of M60 J18 Simister Island and just south of Heybrook Close.

Table 3.3 Water strike depths across the Order Limits

Water strike depth (mbgl)	No. of holes*
0 to <2	13
2 to <4	11
4 to <6	9
6 to <8	4
8 to <10	6
10 to <12	4
12 to <14	2
14 to <16	4
Deeper than 16	15

*Multiple groundwater strikes were recorded in some boreholes. Therefore, the total number of holes/trial pits reported here is larger than in Table 3.2.

3.2.4 Typically, where groundwater was encountered, the hole was left to stand, and the water level measured again after 20 minutes to record the rise in groundwater level.

3.2.5 The data show that generally, little rise in the groundwater level was recorded in the 20 minutes, with a rise of less than 2m recorded in 43 out of 68 boreholes (63%). The largest rise (10.75m) was associated with BH-G01, located in the far north of the Order Limits, east of Hollins Vale.

3.2.6 Artesian or sub-artesian conditions were not identified by strike data in any borehole within the Order Limits.

3.2.7 Across the Order Limits, groundwater strikes in the superficial deposits were mostly encountered in the Glacial Till deposits (see Table 3.4). The second highest groundwater strike count was recorded in the Made Ground deposits. Two groundwater strikes were also recorded in bedrock, one in a mudstone layer and the other in a sandstone, both associated with the Coal Measures. There is the potential that more strikes were encountered in bedrock however, these might have been masked by the drilling technique.

Table 3.4 Geological horizon in which water strikes were encountered

Recent Deposits/Aquifer Designation	Horizon of water strike	No. of holes
Recent	Topsoil	4
	Made ground	10
Secondary A	River terrace deposits	0
	Glaciofluvial deposits	3
	Glacial ice contact deposits	7
	Coal measures	2
Secondary Undifferentiated	Glacial till	29
	Hummocky glacial deposits	5
	Head deposits	0
Unproductive Aquifers	Peat	1
	Glaciolacustrine	7

3.2.8 Groundwater monitoring has taken place in 46 out of 144 boreholes (33%). All groundwater monitoring installations had response zones screened in the superficial deposits. As such, there were no monitoring standpipes installed in the bedrock aquifers and hence no bedrock groundwater monitoring data are available for the Scheme (see Table 3.5).

3.2.9 Out of the 46 monitored boreholes, 13 comprised dual monitoring installations (i.e., two monitoring standpipes installed within one borehole). Nine of the dual installations consisted of one monitoring standpipe screened within the Glacial Till (69%). Of these, six consisted of a second standpipe also screened within Glacial Till (66%),

Table 3.5 Geological horizon in which monitoring was installed

Recent Deposits/Aquifer Designation	Horizon of monitoring	No. of monitoring installations
Recent	Topsoil	0
	Made ground	8
Secondary A	River terrace deposits	0
	Glaciofluvial deposits	4
	Glacial ice contact deposits	9
	Coal measures	0
Secondary Undifferentiated	Glacial till	27

Recent Deposits/Aquifer Designation	Horizon of monitoring	No. of monitoring installations
	Hummocky glacial deposits	3
	Head deposits	0
Unproductive Aquifers	Peat	4
	Glaciolacustrine	4
	Glaciolacustrine	4

3.2.10 Groundwater monitoring data are available as manual dip measurements collected sporadically between August 2021 and May 2023 (data loggers have not been used). The number of manual dips also varies between boreholes. Therefore, partially incomplete, discrete groundwater level monitoring data are available over part of only one groundwater recharge period (i.e., where groundwater levels are expected to be at their highest; typically September to April).

3.2.11 Out of 46 boreholes, the highest groundwater monitoring level recorded was between 0 and 2 mbgl in 20 boreholes (43%), as shown in Table 3.6. The 16 boreholes are located north-east and west of M60 J18. Two of the boreholes are located north of Heaton Park Golf Course.

3.2.12 Based on limited data, groundwater fluctuations typically changes less than 1m which indicate the absence of a dynamic groundwater environment. On average, the highest groundwater levels were recorded during the month of February 2022.

Table 3.6 Highest groundwater levels recorded in boreholes

Highest groundwater level recorded (mbgl)	No. of boreholes
0 to 2	20
2 to 6	14
6 to 9	7
>9	4
Dry	1

3.2.13 Shallow groundwater present in the superficial deposits is expected to generally reflect the ground surface contours. Groundwater is expected to flow towards the rivers including Parr Brook, Castle Brook and Hollins Brook. However, the drainage network for the existing M60 and the road structure itself may have altered some shallow flows in close proximity to the road.

3.2.14 Groundwater is likely to flow through the more permeable units such as the glaciofluvial deposits. Within the glacial till which is present across the majority of the study area (not necessarily at the surface) groundwater is likely to be found in discreet, isolated bodies within more permeable layers.

3.3 Connection to hydrological features

3.3.1 The local groundwater may be connected (either directly or indirectly) to watercourses (as baseflow, sinks, sources, spreads, collects, issues etc.), and spring discharges. Changes to groundwater quality and levels beneath the Scheme may therefore influence water quality and / or flows in these watercourses/hydrological features.

3.3.2 Table 3.7 provides details of the springs, sinks, spreads, and collects identified from OS maps/historical maps within the 250m of the Order Limits. The locations of the groundwater features are displayed on Figure 13.4: Superficial Aquifers and Groundwater Receptors and Features of the Environmental Statement Figures (TR010064/APP/6.2).

3.3.3 Springs and issues within 250m of the Order Limits were surveyed as part of hydrogeological site walkovers in December 2021 and April 2023, where access was agreed. Surveys were carried out to validate the presence and type of groundwater features present.

3.3.4 Only one spring/issue which was identified on OS maps/historical maps was located during the hydrogeological site walkover – an issue located north of Brindle Road (National Grid Reference (NGR): SD832053).

3.3.5 Features which were not located during the surveys will not be assessed further. Features which were not surveyed will be conservatively treated as high value receptors throughout the rest of the groundwater assessment.

Table 3.7 Locations of springs, issues, sinks and spreads

Location	NGR	Survey Results
Springs		
North of Simister Lane	SD8359706127	Not surveyed.
M60 Eastbound	SD7990604469	Not located during survey.
Unsworth Cricket Club	SD8225606866	Not located during survey.
Hollins Vale South	SD8189208221	Not located during survey.
Parrenthorn Road North	SD8224505532	Not located during survey.
Issues		
Brindle Road North	SD832053	Located during survey.
West of Nutt Lane	SD836055	Not located during survey.
South of Pike Fold Golf Course	SD827064	Not surveyed.
North of Church Meadow	SD820079	Not located during survey.
Sinks		
Pike Fold Golf Course East	SD8348206914	Not surveyed.

Location	NGR	Survey Results
Spreads		
Egypt Lane East	SD835069	Not Surveyed

*There were no collects within the 250m buffer.

3.4 Groundwater as a resource

3.4.1 There are no Source Protection Zones (SPZs) within the groundwater study area or its vicinity (Defra, 2023). The nearest SPZ is located 5.9km south-west of the Order Limits. This indicates that there are no licensed groundwater abstractions used for public water supply.

3.4.2 Six licensed groundwater abstractions of very high sensitivity have been identified within the groundwater study area for the Scheme (Defra, 2023). These are shown on Figure 13.4: Superficial Aquifers and Groundwater Receptors and Features of the Environmental Statement Figures (TR010064/APP/6.2) and summarised in Table 3.8. All these abstractions are associated with industrial/commercial uses, primarily for spray irrigation (for golf courses), or food and drink processing water. Licensed groundwater abstraction information for Pilsworth Landfill/Quarry, located 800m north of the Order Limits, suggests that active dewatering is taking place at this site (Environment Agency, 2023a).

Table 3.8 Groundwater licensed abstractions within the groundwater study area

License no.	Name (and no. of abstraction points)	Distance from Order Limits	Maximum annual quantity (m^3/yr)	Aquifer	NGR	Primary use of abstraction
2569002273/R01	Borehole at Pike Fold Golf Club (1)	250m east	8,000	Coal Measures	SD8264706975	Industrial, commercial, and public services
NW/069/0002/013	Sump ‘A’ at Pilsworth Landfill Site (1)	740m north	No volumes are associated with the license (Environment Agency, 2023a)	Carboniferous Limestone Series	SD8231408875	Industrial, commercial, and public services
2569002264/R02	Borehole at Bury Golf Club (1)	1.26km west	7,000	Coal Measures	SD8096307673	Industrial, commercial, and public services
2569004042	Borehole at Premises (Stanley Road) (1)	1.18km north-west	7,000	Permo-Triassic Sandstone	SD809063	Industrial, commercial, and public services
2569004052	Borehole at Whitefield Golf Club (1)	788m north-west	8,000	Coal Measures	SD80420538	Industrial, commercial, and public services
2569004053	Borehole at Stand Golf Club (1)	1.61km north-west	9,000	Superficial Deposits	SD7975405858	Industrial, commercial, and public services

3.4.3 PWS questionnaires have been sent out to all landowners with land holdings situated within 250m of the Order Limits (excluding urban/residential areas which were assumed to be connected to a public supply). 250m was considered appropriate given the specific construction methods and excavation requirements that would be adopted for the Scheme. It is within this distance that potentially significant impacts could occur to PWS and significant impacts are not expected to exceed this distance. 10 out of 38 PWS questionnaires have been returned. Figure 13.4.1 in Annex A of this appendix shows the location of PWS along with questionnaire responses. Where returned questionnaires indicated the presence of a PWS, details are provided in Table 3.9 and shown on Figure 13.4: Superficial Aquifers and Groundwater Receptors and Features of the Environmental Statement (TR010064/APP/6.2).

Table 3.9 PWS questionnaire results within 250m of the Order Limits

PWS Name	Location	Type	Use	Sensitivity	Comments
Whitefield Golf Club	East of golf course	Borehole	Irrigation	Medium	Used only in summer for golf course
Pike Fold Golf Club	On the golf course	Well	Irrigation	Medium	Used for irrigation of golf course
Castle Road	North of Pike Fold golf course	Unknown	Unknown	Medium	Private water mains (rising)
Heaton North	South-west of M60 J18	Unknown	Unknown	Low	Inactive
Cowl Gate Farm	Located on property	Well	Unknown	Low	Inactive. Owners yet to locate supply

3.4.4 Two out of the five PWSs recorded by the questionnaire results (Whitefield Golf Club and Pike Fold Golf Club) have been identified as being located at the same land parcel as a licensed groundwater abstraction from bedrock. This suggests that they relate to the same supply.

3.4.5 Table 3.10 lists wells marked on OS maps in the groundwater study area. There are five wells shown on current OS maps within the groundwater study area (see Figure 13.4: Superficial Aquifers and Groundwater Receptors and Features of the Environmental Statement Figures (TR010064/APP/6.2)). The closest well, according to present-day OS mapping, lies 170m east of the Order Limits; located just east of Croft Avenue. None of the wells shown on current OS maps correlate with any of the licensed groundwater abstractions identified within the study area. There is potential for the Hazlitt Wood West well to relate to the Heaton North PWS, but this is not certain in the absence of specific PWS coordinates.

Table 3.10 Wells marked on OS maps in the groundwater study area

Location	NGR	Sensitivity	Distance from Order Limits
Hazlitt Wood West	SD8326805056	Medium	225m south
Woodland View	SD8061204094		800m south-west
Hollins Vale North	SD8163508390		550m north-west
Simon Lane	SD8434806825		1km east
Croft Avenue	SD8366405938		170m east

3.5 Permitted discharges

3.5.1 Discharges of liquids to ground or groundwater may be occurring within the groundwater study area. As shown on Figure 13.4: Superficial Aquifers and Groundwater Receptors and Features of the Environmental Statement Figures (TR010064/APP/6.2), three licensed groundwater discharges have been identified (Defra, 2023), the closest of which lies 110m south of the Order Limits at St George's Church (see Table 3.11).

Table 3.11 Licensed groundwater discharges in the groundwater study area

License no.	Name	Distance from Order Limits
S/151/S	St George's Church	110m south
S/280/S	Mount Pleasant Farm	280m south
S/314-03/S	Mellowdew Cottage	500m east

3.6 Groundwater dependent terrestrial ecosystems

3.6.1 At the Preliminary Environmental Information Report (PEIR) stage (the PEIR is contained in Annex L of the Consultation Report Annex (TR010064/APP/5.2)), three potential Groundwater Dependent Terrestrial Ecosystems (GWDTE) were identified within the initial 250m screening buffer, from the provisional Order Limits. These were identified through a screening assessment of locally designated ecological sites such as Local Nature Reserves (LNR) and Local Wildlife Sites (LWS) (including Sites of Biological Importance (SBI)).

3.6.2 Since PEIR stage, this list has been revisited to incorporate UK Habitat Classification (UKHab) survey data (see Appendix 8.1: UK Habitat Classification Report of the Environmental Statement Appendices (TR010064/APP/6.3) for full details), which describes a terrestrial habitat type and/or vegetation community that could be indicative of a wetland habitat. This has led to a further six sites being identified within 250m of the Scheme (with potential to be impacted by the Scheme), increasing the number of GWDTE from three to nine. Details on the GWDTE and potential impacts from the Scheme can be found in Appendix 13.5: GWDTE Assessment Report of the Environmental Statement Appendices (TR010064/APP/6.3) and the sites are shown on Figure 13.5: GWDTEs and Groundwater Dependency Classification of the Environmental Statement Figures (TR010064/APP/6.2).

3.7 Groundwater vulnerability

3.7.1 Groundwater vulnerability maps provide an assessment of the vulnerability of groundwater to a pollutant discharged at ground level based on the hydrological, geological, hydrogeological and soil properties (Defra, 2023). The groundwater vulnerability map shows that the majority of the Scheme lies on aquifers with medium-high or medium vulnerability. That is, areas where pollutants from accidental spillages, ground disturbance etc. can easily transmit to groundwater (typically characterised by high-leaching soils and an absence of low-permeability superficial deposits), but also includes areas that offer some degree of groundwater protection.

3.7.2 Small areas of low vulnerability are also present, which correlate with the mapped extent of peat deposits, and typically provide the greatest protection to groundwater from pollution due to the presence of low-leaching soils and / or low-permeability superficial deposits.

3.8 Groundwater quality

3.8.1 The baseline groundwater quality from the Made Ground and Superficial Deposits is presented in Section 9.7 of Chapter 9: Geology and Soils of the Environmental Statement (TR010064/APP/6.1).

3.8.2 From the GI it was identified that within the superficial deposits exceedances of EQS values were recorded at all groundwater quality sampling locations.

3.8.3 No information on groundwater quality in the bedrock has been gathered during the ground investigations. Groundwater quality information for the two main bedrock aquifers underlying the groundwater study area is provided in two Environment Agency reports (Griffiths *et al.*, 2003; Cheney, 2007). The key points of pertinence to this assessment are summarised below.

3.8.4 The Permo-Triassic Sandstone aquifer comprises a predominantly calcium bicarbonate type groundwater, the baseline chemistry of which is thought to be primarily influenced by the dissolution of carbonate and dolomite cements (Griffiths *et al.*, 2003). As a result, it is likely that shallower parts of the aquifer have been decalcified, i.e. the original calcite has been dissolved, reflected by low alkalinity and pH values. The presence of thick, relatively impermeable superficial deposits over much of the aquifer may also permit reducing conditions to exist, even at shallow depths, resulting in high iron and manganese concentrations, but low nitrate concentrations (due to denitrification). Saline groundwater has occurred in parts of Greater Manchester, most notably in the Trafford Park area and near Chat Moss. This has been attributed to the dissolution of halite derived from the Triassic Mercia Mudstone Group, which overlies the sandstone aquifer in the Cheshire area to the south. Given the absence of this particular geology beneath the groundwater study area, saline groundwater from this source is unlikely to be a concern for the Scheme.

3.8.5 Coal Measures groundwater is typically dominated by calcium, magnesium, and bicarbonate ions (Cheney, 2007). However, elevated concentrations of chloride and iron in groundwater from deep coal mines can also be encountered. Reducing conditions are common throughout the Coal Measures, with the evolution of methane and hydrogen sulphide often reported. Mining activities tend to lower the level of the groundwater table, allowing oxidation of certain minerals (for example pyrite) within the coal measures, and the production of iron oxide and sulphate. On the cessation of mine dewatering, groundwater levels rise, and dissolved concentrations of sulphate, arsenic, iron, and other metals increase in the groundwater. This can result in localised areas of acid groundwater conditions within mined areas. Such conditions may exist in the far west of the Scheme where the potential for underground coal mining exists. Where mine-impacted groundwater discharges (whether this be naturally or artificially), this can lead to rust-coloured watercourses due to precipitation of some or all of the dissolved iron to form the red, orange, or yellow ochreous sediments in the bottom of channels and banks.

3.9 Water Framework Directive compliance

3.9.1 There are two Water Framework Directive (WFD) groundwater bodies (Environment Agency, 2023b) within the groundwater study area. The Northern Manchester Carboniferous Aquifers (GB41202G101800) achieved poor overall status as of 2019, with good quantitative status and poor chemical status. The Manchester and East Cheshire Permo-Triassic Sandstone Aquifers (GB41201G101100) are also achieving poor overall status (2019) both with poor chemical and quantitative status.

3.9.2 Neither the Scheme nor the groundwater study area lie within a groundwater nitrate vulnerable zone.

3.9.3 Appendix 13.1: WFD Compliance Assessment Report of the Environmental Statement Appendices (TR010064/APP/6.3) reviews the potential impacts on these WFD groundwater bodies (and associated receptors such as GWDTE) from a WFD compliance perspective.

4 Construction dewatering assessment

4.1 Introduction

4.1.1 This section provides an assessment of the potential dewatering impacts on groundwater receptors (aquifers, groundwater abstractions, existing contamination, surface water features, buildings and highways infrastructure (from groundwater induced settlement)) present within the study area for the Scheme. This supports Chapter 13: Road Drainage and the Water Environment of the Environmental Statement (TR010064/APP/6.1). Dewatering impacts on GWDTE have been assessed separately in Appendix 13.5: GWDTE Assessment Report of the Environmental Statement Appendices (TR010064/APP/6.3).

4.1.2 Groundwater dewatering impacts could occur as a result of earthworks and excavations associated with features including road cuttings and widenings, ponds and associated drainage infrastructure, and site compound construction that penetrate below the water table.

4.1.3 The assessment has been carried out in two stages. The initial screening considers the potential for excavations planned as part of the Scheme to intercept groundwater and generate a dewatering effect.

4.1.4 Potential impacts on all groundwater receptors within the estimated dewatering zone of influence at excavations were then assessed. An initial review based on the potential groundwater drawdown at each receptor was followed by a further detailed assessment for all potential impacts identified as moderate significance or greater.

4.1.5 In these assessments, the magnitude of impact has been derived based on the expected degree of groundwater drawdown at the location of the receptor, assuming a degree of hydraulic conductivity exists between groundwater and the receptor.

4.1.6 The sensitivity of the receptors is as reported in Chapter 13: Road Drainage and the Water Environment of the Environmental Statement (TR010064/APP/6.1).

4.2 Initial screening

4.2.1 The initial screening identifies which excavations are likely to intercept groundwater, based on the depth of excavation and available information on groundwater levels from GI and groundwater level monitoring. Where groundwater level information is limited or not available a conservative approach has been taken, i.e., assuming levels to be high / close to the ground surface.

Road widenings and cuttings

4.2.2 For the purposes of this assessment, road 'widenings' are taken as the lateral expansion of the road surface where there are no large vertical changes in the existing and new road levels. A 'cutting' has been assumed to comprise scenarios where the ground level would be excavated significantly below the existing road surface. The latter are scenarios where, subject to the water table level, significant groundwater impacts could be expected. Widening and cuttings are a combination of both.

4.2.3 The results of the initial screening of major excavations are presented in Table 4.1 for five widenings and four cuttings and widenings combined. In total, one widening and two widening and cuttings were identified with the potential to intercept groundwater.

Table 4.1 Potential groundwater interception at excavations

Cutting/ widening ID	Location	Anticipated groundwater depth (mAOD)	Maximum excavation depth (mAOD)	Likelihood to intercept groundwater
Widening 1	Sandgate Road	96.01	98	Unlikely
Widening 2	South of M60 J18	85.46	96	Unlikely
Widening 3	M66 South of M60 J18	102.95	102	Likely
Widening 4	North-west of M60 J18	91.29	98	Unlikely
Widening 5	M66 North of M60 J18	92	93	Unlikely
Widening and cutting 1	South-west of M60 J18	103.31	100	Likely
Widening and cutting 2	Centre of M60 J18	85.26	92	Unlikely
Widening and cutting 3	North of M60 J18	89.44	98	Unlikely
Widening and cutting 4	Base of Northern Loop	97.07	97	Likely

*All cuttings and widenings are within superficial deposits.

Ponds

4.2.4 Five ponds are to be implemented as part of the road drainage system, see Appendix 13.7: Drainage Strategy Report of the Environmental Statement Appendices (TR010064/APP/6.3) for full details and Figure 2.2: Scheme Design of the Environmental Statement Figures (TR010064/APP/6.2) for their locations. The results of the initial screening are presented in Table 4.2. All ponds have the potential to intercept groundwater.

Table 4.2 Potential groundwater interception ponds

Pond ID	Location	Anticipated groundwater depth (mAOD)	Maximum excavation depth (mAOD)	Likelihood to intercept groundwater
Pond 1	North-east of M60 J18	90.50	87.98	Likely
Pond 2	East of M66	88.55	87.40	Likely
Pond 4	South-west of M60 J18	94.31	92.31	Likely
Pond 5	West of M66	96.46	92.26	Likely
Pond 7	North-west of M60 J18	94.38	91.32	Likely

Note: there are no ponds for catchments 3 and 6.

Drainage connections

4.2.5 Excavations would be required to upgrade the existing drainage network within the Order Limits and to install new drainage infrastructure. This would include trenching to install new linear drainage pipes, as well as localised excavations for manholes. The results of the initial screening are presented in Table 4.3 (see Figure 13.2: Outfall Locations of the Environmental Statement Figures (TR010064/APP/6.2) for the locations of the drainage catchments).

Table 4.3 Potential groundwater interception from drainage catchments

Drainage ID	Location	Anticipated groundwater depth (mAOD)	Maximum excavation depth (mAOD)	Likelihood to intercept groundwater
Catchment 1B (Assessment Area 1)	Northern Loop	90.63	88.48	Likely
Catchment 1B (Assessment Area 2)	Northern Loop	91.32	95.62	Unlikely
Catchment 1B (Assessment Area 3)	Northern Loop	91.21	90.45	Likely
Catchment 2	M66 north of M60 J18	91.32	91.08	Likely
Catchment 4	South-west of M60 J18	87.20	96.5	Unlikely
Catchment 5	M60 south of M60 J18	88.61	93.33	Unlikely
Catchment 6	M62 east of M60 J18	95.11	91.34	Likely
Catchment 7	North-west of M60 J18	92.66	91.74	Likely

Other excavations

4.2.6 There are no other excavations anticipated to be required as part of the Scheme. Design assumptions relating to excavation requirements are summarised in Section 2.1 of this appendix.

4.3 Dewatering impact assessment

Methodology

4.3.1 The identification of groundwater receptors which may be impacted by dewatering is based on indicative estimates of the dewatering zone of influence around each excavation which may intercept groundwater.

4.3.2 Receptors could potentially be impacted be dewatering in several ways:

- Surface water features: reduction in baseflow and / or change in water quality
- Groundwater abstractions: reduction in water availability and / or change in quality
- GWDTE: lowering of the water table, reduction in groundwater discharge, and / or change in water quality leading to alteration or loss of habitat
- Buildings and highways infrastructure: damage due to groundwater induced subsidence causing differential settlement of buildings and infrastructure.

4.3.3 The magnitude of impact is based on the estimated degree of dewatering induced groundwater drawdown at the receptor and the significance of effect was derived based on the methodology described in Chapter 13: Road Drainage and the Water Environment of the Environmental Statement (TR010064/APP/6.1), assuming that a degree of hydraulic conductivity exists between groundwater at the excavation and the receptor. The determination of the significance of effect is considered before the application of mitigation measures. Where significant effects are identified in this assessment, mitigation measures to reduce the magnitude of impact are detailed in Section 13.9 of Chapter 13: Road Drainage and the Water Environment of the Environmental Statement (TR010064/APP/6.1).

4.3.4 For those excavations where potential land contamination sources have been identified within the estimated zone of influence of groundwater drawdown, the potential for contaminated groundwater to be captured by the dewatering is considered in Tables 4.5 and 4.6.

4.3.5 The Sichardt method was used to estimate the dewatering radius of influence around each excavation expected to intercept groundwater (Preene *et al.,* 2016). This was applied using the estimated drawdown of groundwater levels to the base of the excavation. For this initial review step the maximum depth within the excavation has been applied to the whole excavation, although in most cases depth varies across the footprint of the excavation.

4.3.6 No permeability testing in standpipes were conducted during the GI. Therefore, hydraulic conductivity values used in the calculation were based on generic values from scientific literature appropriate to the materials recorded in the boreholes or mapping were applied (Domenico and Schwartz, 1990, and Preene *et al.,* 2016).

4.3.7 Where the zone of influence estimated using the Sichardt equation is small, the method is unreliable. Therefore, to ensure a suitable conservative assessment, a minimum zone of influence of 25m has been assumed.

4.3.8 The degree of induced groundwater drawdown at a given receptor was estimated based on the distance of the receptor from the excavation and associated estimated groundwater drawdown depression at that location.

Aquifers

4.3.9 Groundwater drawdown at excavations would impact aquifers due to the dewatering effect within the potential zone of influence. The excavations would affect the superficial deposits only. No dewatering impacts would be expected to the underlying bedrock aquifers, given that none of the excavations are anticipated to encounter bedrock below the Scheme.

4.3.10 Considering the scale of the superficial aquifers across and beyond the study area, the dewatering would be expected to have a minor adverse magnitude of impact, resulting in a significance of effect of:

- **Slight adverse** effect on Secondary A aquifers (Glacio-fluvial deposits and Glaciofluvial Ice contact deposits).
- **Slight adverse** effect on Secondary B and Secondary Undifferentiated aquifers (Glacial till, Hummocky Glacial deposits, and Head deposits).

4.3.11 No other superficial Secondary A or B aquifers listed in Table 3.1 are expected to be impacted by dewatering activities.

Surface water and groundwater features

4.3.12 The outcome of the assessment of surface water and groundwater features falling under the estimated zones of influence is presented in Table 4.4.

4.3.13 Sands and gravels, attributed to glaciofluvial and head deposits, underline most of the watercourses throughout the study area. The degree of connectivity between groundwater and surface water is unconfirmed and may be variable. However, this assessment assumes that the local groundwater has a degree of hydraulic linkage (either directly or indirectly) to watercourses as baseflow. The magnitude of impact was assessed based on the predicted degree of groundwater drawdown at the surface water feature and does not consider the size of the watercourse.

4.3.14 The review indicates that no surface water features lie directly within the location of the excavations requiring dewatering. The maximum drawdown at a surface water feature is estimated to be at Castle Brook Tributary because of dewatering for the construction of drainage catchment 1A. This in combination with dewatering for the construction of Pond 1 could potentially dry up the channel temporarily during construction. This is due to the shallow nature of it, resulting in a **moderate adverse** significance of effect.

4.3.15 The remaining watercourses impacted by dewatering are estimated to experience minor to negligible impacts resulting in **slight adverse** or **neutral** significance of effects on the remaining watercourses listed in Table 4.4. Unnamed ponds at Pike Fold Golf Course lie within the radius of influence for Pond 1 and drainage catchment 1A. The drawdown at these ponds could result in minor impacts to water levels within the pond if connected to groundwater.

4.3.16 One groundwater feature, an issue, lies within the dewatering zone of influence for drainage catchment 1A. Impacts are expected to be **moderate adverse** given the potential for this issue to be sourced from a spring which could be sensitive to any changes in groundwater levels. No other groundwater features are expected to be impacted by dewatering activities.

4.3.17 Where a significance of effect has been identified as slight or neutral, no further assessment is required.

4.3.18 It should be noted that there are surface water licensed abstractions present throughout the Scheme. But considering that no significant effects on any surface water bodies because of groundwater dewatering are anticipated it is considered that there would be no consequent impact on surface water abstractions.

Table 4.4 Dewatering impacts on surface water features during construction

Water feature	Feature ID	Sensitivity of receptor	Magnitude of impact	Significance of effect
Unnamed tributary of Parr Brook (Unnamed Watercourse 2)	Pond 4	Medium	Negligible	Neutral
Several unnamed ponds at Pike Fold Golf Course	Drainage catchment 1A	Low	Minor	Slight adverse
	Pond 1			
Castle Brook Tributary	Drainage catchment 1A	Medium	Moderate	**Moderate adverse**
	Pond 1			
Tributary to Castle Brook Tributary	Drainage catchment 1A	Low	Minor	Slight adverse
Blackfish	Pond 5	Low	Negligible	Neutral

Water feature	Feature ID	Sensitivity of receptor	Magnitude of impact	Significance of effect
Issue South of Pike Fold Golf Club	Drainage Catchment 1A	Moderate	Moderate	**Moderate adverse**

Water quantity impacts on groundwater abstractions

Licensed groundwater abstractions

4.3.19 There are no licensed groundwater abstractions within the dewatering zone of influence of any cutting/widening, pond, or drainage catchment. The closest licensed abstraction point to a dewatering zone of influence is Borehole at Pike Fold Golf Club, which is located 245m south of the maximum calculated zone of influence of Catchment 2. Therefore, no dewatering impact is expected on licensed abstractions.

Private water supplies and OS marked wells

4.3.20 There are no known PWS or OS marked wells within a dewatering zone of influence. This includes the PWS located at Pike Fold Golf Course, which is in proximity to the clubhouse (and used primarily for irrigation of the golf course). Therefore, no dewatering impact is associated with PWS.

Water quality impacts on groundwater abstractions

Licensed groundwater abstractions

4.3.21 All licensed groundwater abstractions are either known or assumed to be sourced from bedrock, except the borehole at Stand Golf Club (NGR 25690 04053) which is located within superficial deposits. Given the deep nature of the abstractions they would be less susceptible to surface water quality impacts during the construction phase. Therefore, the magnitude of water quality impacts to licensed groundwater abstractions that abstract groundwater from bedrock are expected to be negligible, leading to a **neutral** significance of effect.

4.3.22 The borehole at Stand Golf Club is located within glaciofluvial deposits, composed of sands and gravels. However, the abstraction point is located 1.6km north-west of the Order Limits. Therefore, the magnitude of water quality impacts to this licensed groundwater abstractions is also expected to be negligible, leading to a **neutral** significance of effect.

PWS and OS marked wells

4.3.23 All groundwater abstractions intended for human consumption or food production purposes have a default SPZ1 with a minimum radius of 50m. In some cases, depending on the volumes abstracted, a default SPZ2 with a minimum radius of 250m applies.

4.3.24 Five private water supplies have been identified, where questionnaires have been returned (see Figure 13.4.1 in Annex A) on land parcels located within 250m of the Order Limits. The PWS not in use have not been assessed. The PWS records for Whitefield and Pike Fold Golf Club, assumed to correspond to the licensed abstractions and from bedrock will not be affected by the Scheme. The Castle Road PWS, which is described by the owner as private water mains, and therefore has been conservatively assessed as a PWS. The magnitude of impact of the Scheme to this PWS has been assessed as major with a significance of effect of **large adverse**.

4.3.25 Five of the four OS marked wells are located outside 250m radius (default zone for SPZ2) and therefore not considered to be impacted by the Scheme. The only well to lie inside of this default radius is Hazlitt Wood which is located 225m from the Order Limits and to the east of Heaton Park Reservoir. Given its distance from the Order Limits, and proximity to the default SPZ, the magnitude of any impact to this receptor is likely to be negligible, leading to a **neutral** significance of effect.

Buildings and highways infrastructure

4.3.26 Groundwater dewatering has the potential to create settlement effects, and the difference in settlement from one end to of a building to the other, also called differential settlement, can cause structural risks depending on the magnitude of the differential settlement and the building itself.

4.3.27 There are three residential buildings within the dewatering zone of influence for cuttings/widenings. However, these are at the edge of the estimated Radius of Influence (ROI) and groundwater fluctuations are expected to be negligible (if any) and within the anticipated natural groundwater fluctuations. Therefore, groundwater induced settlement would be expected to be negligible and detailed settlement calculations are not required.

4.3.28 No impacts to highways infrastructure are anticipated.

GWDTEs

4.3.29 Potential impacts to GWDTE, including dewatering impacts, are assessed in Appendix 13.5: GWDTE Assessment Report of the Environmental Statement Appendices (TR010064/APP/6.3).

Groundwater quality from contaminated land

4.3.30 Historical and current potential sources of contamination are documented in Chapter 9: Geology and Soils of the Environmental Statement (TR010064/APP/6.1) where groundwater quality samples and leachability test results have been compared to relevant Environmental Quality Standards (EQS). This is so that groundwater quality, which is expected to be intercepted during earthworks and would be discharged to surface water receptors, is placed within the context of the end receptor.

4.3.31 A list of contaminants exceeding EQS at each excavation is listed in Table 4.5 and Table 4.6.

4.3.32 Groundwater quality data is available from within the zone of influence of dewatering of two of the three cuttings / widenings expected to intercept groundwater. At both locations, groundwater quality exceeds EQS standards.

4.3.33 Groundwater quality data is available from within the zone of influence of dewatering of three of the five ponds where groundwater is expected to be intercepted. At all three locations, groundwater quality exceeds EQS standards.

4.3.34 The potential impacts associated with these groundwater quality exceedances are two-fold:

- Potential water quality discharge issues during the construction phase. This could result in a moderate magnitude of impact resulting in a significance of effect from **moderate** to **large adverse** depending on the sensitivity of the receiving watercourse.
- Long term road drainage water quality issues during the operational phase. The potential impact of these groundwater seepage is expected to be minor because it would be diluted in the runoff as well as the receiving watercourses. However, it could result in a **slight** to **moderate adverse** significance of effect subject to the sensitivity of the receiving watercourse.

Table 4.5 Summary of groundwater quality characteristics at dewatering locations from road cuttings/widenings

Cutting ID	Land contamination sources	Groundwater quality exceedances against EQS	Soil leachate quality exceedances against EQS
Widening and Cutting 1	Industrial area, agricultural practices, historical mining activities.	Ammoniacal Nitrogen Cadmium Chromium, trivalent Cadmium Copper Iron Manganese Mercury Nickel Benzo Pyrene Benzo Perylene Fluoranthene Ideno Pyrene	Ammoniacal Nitrogen Aluminium Copper Lead Zinc Manganese Fluoranthene
Widening and Cutting 4	Industrial area, agricultural practices, historical mining activities.	Ammoniacal Nitrogen Cadmium Copper Iron	Ammoniacal Nitrogen Aluminium Copper Lead

Cutting ID	Land contamination sources	Groundwater quality exceedances against EQS	Soil leachate quality exceedances against EQS
		Manganese Mercury Nickel Benzo Pyrene Benzo Perylene Fluoranthene Ideno Pyrene	Fluoranthene Nickel Manganese Iron Phenol
Widening 5	No GI data		

Table 4.6 Summary of groundwater quality characteristics at dewatering locations from ponds

Pond ID	Land contamination sources	Groundwater quality exceedances against EQS	Soil leachate quality exceedances against EQS
Catchment 1	No GI data		
Catchment 2	No GI data		
Catchment 4	Industrial area, agricultural practises, historical mining activities.	Ammoniacal Nitrogen Aluminium Cadmium Copper Iron Manganese Mercury Benzo Pyrene Benzo Perylene Fluoranthene Ideno Pyrene	Aluminium Copper Lead
Catchment 5	Industrial area, agricultural practises, historical mining activities.	Ammoniacal Nitrogen Aluminium Cadmium Chromium, Trivalent Copper Manganese Mercury	Aluminium Copper Lead Zinc

Pond ID	Land contamination sources	Groundwater quality exceedances against EQS	Soil leachate quality exceedances against EQS
		Benzo Pyrene Benzo Perylene Fluoranthene Ideno Pyrene	
Catchment 7	Industrial area, agricultural practises, historical mining activities.	Ammoniacal Nitrogen Aluminium Cadmium Iron Manganese Mercury Nickel Benzo Pyrene Benzo Perylene Fluoranthene Ideno Pyrene	Aluminium Copper Lead Zinc

Acronyms and initialisms

Acronym or initialism	Term
BGS	British Geological Survey
CP	Cable percussion
CSM	Conceptual Site Model
Defra	Department for Environment, Food and Rural Affairs
EMP	Environmental Management Plan
EQS	Environment quality standards
GI	Ground Investigation
GWDTE	Groundwater dependent terrestrial ecosystem
IP	Inspection pit
LNR	Local Nature Reserve
LWS	Local Wildlife Site
mAOD	Metres Above Ordnance Datum
mbgl	Metres below ground level
NGR	National Grid Reference
NVC	National Vegetation Classification
OP	Open hole
OS	Ordnance Survey
PVD	Prefabricated Vertical Drains
PWS	Private Water Supply
RO	Rotary open hole
ROI	Radius of Influence
RC	Rotary core
SBI	Site of Biological Interest
SPZ	Source Protection Zone
SSSI	Site of Special Scientific Interest
TP	Trial pit
UKHab	UK Habitat Classification
UKTAG	UK Technical Advisory Group

Acronym or initialism	Term
WFD	Water Framework Directive
WLS	Window sample

Glossary

Term	Definition
Aquiclude	An impermeable body of rock or stratum of sediment that acts as a barrier to the flow of groundwater.
Aquitard	Poorly permeable underground layer that limits the flow of groundwater from one aquifer to another
Dewatering (groundwater)	Groundwater control which typically involves pumping groundwater from an array of wells or sumps, located in or around an excavation, to temporarily lower groundwater levels to allow excavation to be carried out in dry and stable conditions.
Interfluves	An area of higher ground between two rivers in the same drainage system
Principal Aquifer	These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale
Recharge	Recharge of an aquifer occurs water added to the aquifer through the unsaturated zone after infiltration and percolation following any storm rainfall event.
Secondary A Aquifer	Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers
Secondary B Aquifer	Predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.
Secondary Undifferentiated Aquifer	Assigned in cases where it has not been possible to attribute either category Secondary A or B aquifers to a rock type
Seep/seepages	A seep or flush is a moist or wet place where groundwater reaches the surface from an underground aquifer.
Springs	A point at which groundwater discharges onto the surface.
Strikes	The level at which water is first encountered when drilling.
Unproductive Strata	These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

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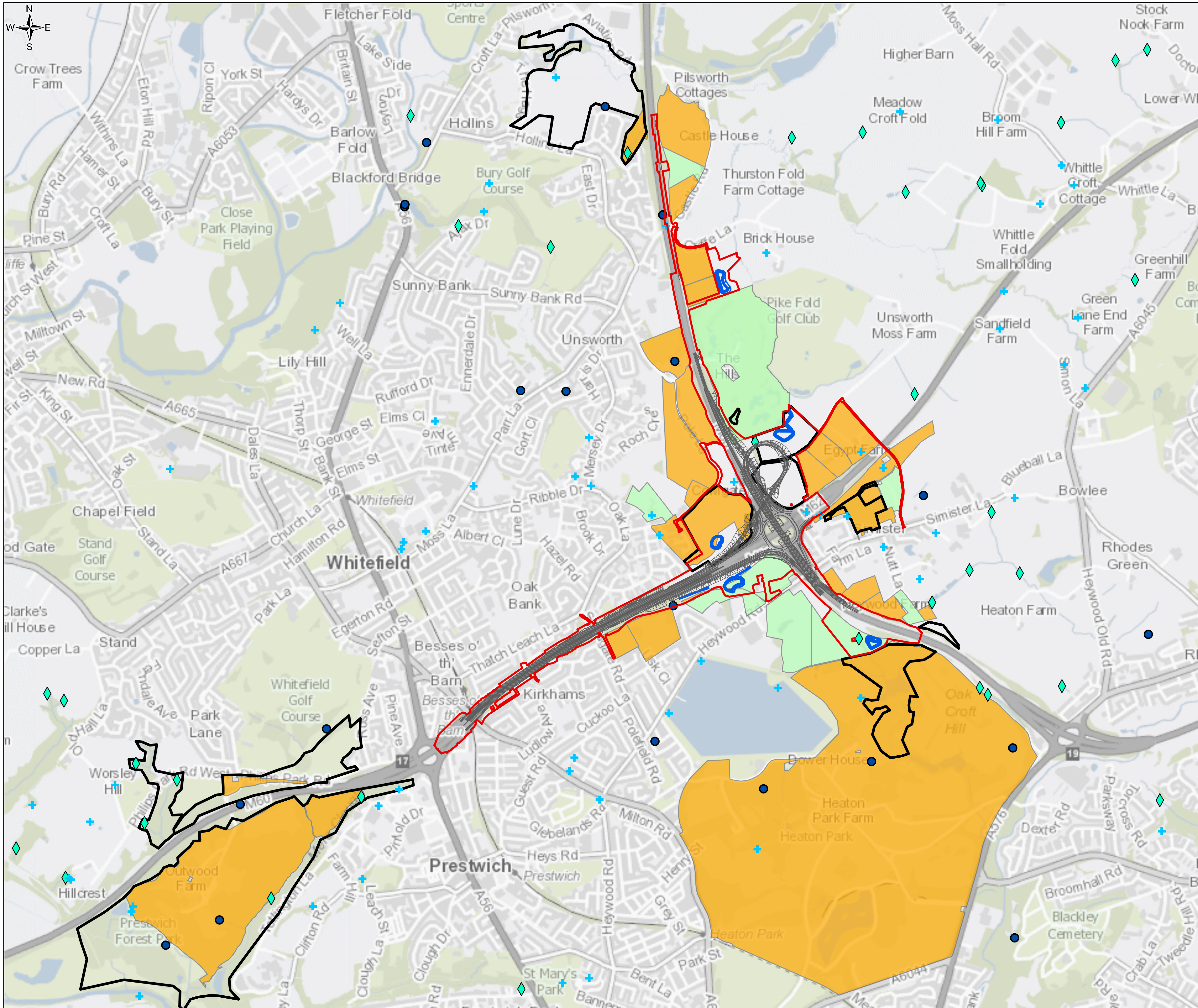
Annex A Figures

Figure 13.4.1: Response to Private Water Supply Questionnaires



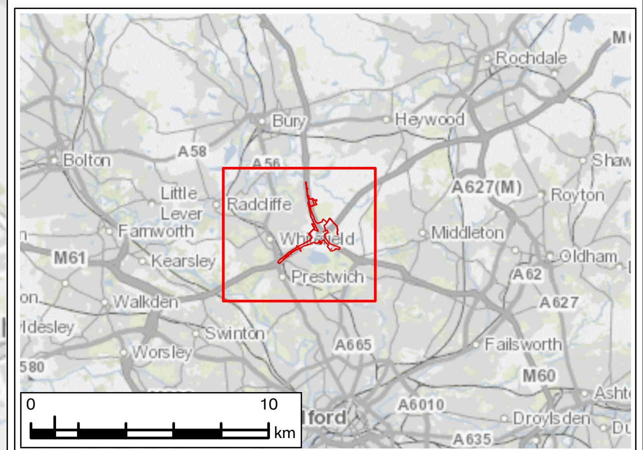
ENVIRONMENTAL STATEMENT APPENDIX 13.4 FIGURE 13.4.1

Legend

- Order Limits
- Scheme Highway Design
- Attenuation Ponds
- Spring
- Well
- Issues
- Groundwater Dependent Terrestrial Ecosystem (GWDTE) Boundary

Private Water Supply Questionnaire 2023 - Received Surveys

- Outstanding
- Yes



P01	JAN 24	For DCO application	LT	MS	JR	BB
Rev.	Rev. Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

Development Consent Order Number:	Development Consent Order Drawing Number:
TR010064	6.3

Client

national highways

Project

REGIONAL DELIVERY PARTNERSHIP
M60/M62/M66 SIMISTER ISLAND INTERCHANGE

Drawing Title

RESPONSES TO PRIVATE WATER SUPPLY QUESTIONNAIRES

Drawing Status: S4 – SUITABLE FOR STAGED APPROVAL

Scale @ A3	1:20,000	DO NOT SCALE
Jacobs No.	B36601F0	
Client No.	HE548642	Rev P01

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