highways england

A303 Amesbury to Berwick Down

TR010025

6.3 Environmental Statement Appendices

Appendix 11.4 Groundwater Risk Assessment

Volume 6

APFP Regulation 5(2)(a)

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1 Introduction

1.1 Structure of Groundwater Risk Assessment report

1.1.1 A full description of the A303 Amesbury to Berwick Down scheme is provided in the main Environmental Statement (ES). This report provides a hydrogeological risk assessment in support of the Development Consent Order (DCO) application, and is provided as an appendix to the Road Drainage and Water Environment chapter of the main ES.

1.1.2 Annex 1 contains the groundwater numerical modelling report, Annex 2 contains a summary of the water features survey undertaken in 2018, Annex 3 contains a site specific assessment of the Blick Mead Archaeological Area, Annex 4 contains the groundwater quality data collected in 2018, and Annex 5 contains the qualitative risk assessment undertaken.

1.1.3 Section 2 of this report provides discussion of the data sources used, and stakeholder engagements, Section 3 details the groundwater baseline, while Section 4 presents conceptual site models. Section 5 presents the risk assessment methodology, with Section 6 providing further discussion of the quantitative assessment of risks. Section 7 provides recommendations for monitoring and mitigation measures.

1.2 Scope of assessment

1.2.1 The spatial scope of the assessment covers the Water Framework Directive (WFD) surface water body catchments of the River Till and River Avon (upstream and downstream of the Nine Mile River). These surface water bodies are part of the Chalk WFD groundwater body (Upper Hampshire Avon).

1.2.2 The assessment considers the construction and operation of the scheme within the study area (as described in Chapter 2 of the Environmental Statement), which includes the construction of:

a) The Winterbourne Stoke Bypass, which includes the River Till Viaduct

b) The Longbarrow Junction, with associated cuttings and bridges

c) The Cutting approach to the western portal

d) The Twin-bore tunnel (to be constructed using a Tunnel Boring Machine (TBM), and associated cross-passages

e) The Amesbury Cutting and approach to the eastern portal

f) The Countess Junction including flyover

g) Rollestone Corner road improvements

h) Habitat creation at East Parsonage Down

1.2.3 During construction abstraction of groundwater may be used as a water supply if alternative sources are not available. This abstraction will require an abstraction licence that would need to be agreed with the Environment Agency.

The impact of abstraction will be assessed for the abstraction licence, rather than within this assessment.

1.2.4 The assessment considers the construction and operation of the scheme within the study area on groundwater and surface water, which includes the potential impacts of the Scheme on existing groundwater resources, including consideration of:

a) Abstractions (licensed and unlicensed)

b) Springs

c) Surface water

d) Groundwater dependent ecosystems

e) Archaeological deposits that are dependent on saturated conditions

1.2.5 The WFD assessment (provided as a separate appendix to the ES) provides a comprehensive review of the potential impacts of the scheme on the designated groundwater body and the dependent surface water bodies.

1.2.6 The assessment also considers the pollution risks to groundwater associated with routine discharges of runoff from the scheme within the study area during the operational phase of the scheme. This is further discussed in the Road Drainage and Water Environment chapter including a HEWRAT assessment using the Highways England Water Risk Assessment Tool (HEWRAT), as presented in Design Manual for Roads and Bridges (DMRB) (Ref 1.1). The Method C assessment has been carried out for the proposed infiltration basins and drainage soakaways.

1.3 Study area description and key features

1.3.1 The study area lies within the South West River Basin District and Avon Hampshire management catchment, as set out within the River Basin Management Plan (RBMP). It is predominantly a rural area with a number of villages, and the town of Amesbury located within it.

1.3.2 The main environmental features of relevance to groundwater include:

a) The Chalk Principal aquifer;

b) Permeable superficial deposits Secondary A aquifers;

c) Spring features at West Amesbury, Amesbury Abbey, Durrington, Spring Bottom Farm and Lake.

d) The surface water bodies of the River Avon and River Till and the associated ecological designated Special Area of Conservation (SAC) and Sites of Special Scientific Interest (SSSI);

e) Licensed public groundwater abstractions with published Source Protection Zones (SPZ);

f) Licensed private groundwater abstractions, with default 50m SPZ1;

g) Unlicensed groundwater abstractions; and

h) Archaeological deposits at Blick Mead close to the River Avon.

1.3.3 Several communities in the study area have had historical records of possible groundwater flooding:

a) within the River Till Catchment: the Till Valley, Tilshead, Orcheston, Shrewton, Salisbury Plain Military Camps, Winterbourne Stoke, Berwick St James and Stapleford.

b) within the River Avon catchment: Enford, Haxton, Netheravon, Durrington, Wilsford-Cum-Lake, Woodford (both Upper and Lower).

2 Data sources and stakeholder engagement

2.1 Data sources

2.1.1 An understanding of the existing baseline groundwater environment has been developed from publically available data; the work undertaken for the 2003 Environmental Statement; historical investigations carried out between 2001 and 2006; site investigations undertaken in 2017; groundwater monitoring undertaken in 2017 and 2018; and, information provided by consultees. Further site investigation is underway in 2018 that will provide additional information to reduce elements of risk identified at the detailed design stage.

2.2 Stakeholder engagement

2.2.1 Discussions have been held with the following stakeholders to inform the groundwater risk assessment:

a) Environment Agency (EA)

b) Wiltshire Council (WC)

c) Wessex Water

d) English Heritage

e) Amesbury Abbey and Archaeologists involved with the Blick Mead site

f) Ministry of Defence (MoD)

2.2.2 Site surveys of springs and groundwater abstractors in the study area have been undertaken in November 2017 and between February and April 2018, when access arrangements have been agreed.

3 Baseline

3.1 Climate and topography

3.1.1 Rainfall data from the Meteorological Office for 1981 to 2000 show that the study area receives an annual average rainfall total of between 748mm (Boscombe Down) and 770mm (Larkhill).

3.1.2 The Environment Agency has provided daily rainfall data in the vicinity to the Scheme from two sites at Boscombe Down (3.2km southeast of the Scheme), and Larkhill (2.6km north of the Scheme and within the groundwater study area). These locations are shown on Figure 3.1.

3.1.3 Table 3.1 provides the monthly average rainfall for these stations and the annual average, as well as those presented by the Meteorological Office for the 1981 to 2000 period. This shows that the highest rainfall generally occurs between October and January.

Table 3.1: Average rainfall (mm)

Average	Larkhill		Boscombe Down	
	EA data (1921-2017)	Met. Office (1981-2000)	EA data (2010 – 2017)	Met. Office (1981-2000)
January	82.8	80.3	102.2	74.5
February	57.1	53.9	60.2	52
March	52.2	58.5	46.8	57.2
April	46.5	51.4	45.6	51.4
May	55.5	52.8	50.6	54.4
June	51.0	50.3	55.6	51
July	55.0	51.4	62.6	48.9
August	54.6	53.7	68.1	51.5
September	60.0	62.7	46.5	59.4
October	80.2	85.6	72.9	82.6
November	83.8	83.7	77.0	84
December	80.2	86	73.0	81.7
Annual Average	753.1	770.4	760.9	748.6

3.1.4 The topography of the study area consists of low relief, gently sloping Chalk downland. The ground levels vary from around 180m above Ordnance Datum (AOD) on the Salisbury Plains in the north to 54m AOD at the River Avon, and also reflect the presence of a number of valleys within the area.

3.1.5 Dry valleys are a feature typical of the Chalk landscape of southern Britain. Their characteristics derive from periglacial conditions in this area during the last ice age. The most prominent dry valley crossed by the route is that at Stonehenge Bottom, shown on Figure 3.2. This has an elevation of around 80m AOD at the current A303 road, an elevation of 70m AOD close to Spring Bottom Farm, and ends at Lake at an elevation of 62m AOD. Other dry valleys are crossed north of Winterbourne Stoke, east of Winterbourne Stoke, at Wilsford

Down, west of Vespasian's Camp, and north of the Blick Mead archaeological site.

3.2 Surface water features

3.2.1 Two main surface water bodies are present in the study area and these are the River Avon and the River Till. These are part of the South West River Basin District and Avon Hampshire management catchment, as set out within the River Basin Management Plan (RBMP) (Ref 3.1).

3.2.2 The River Avon is designated as a Main River and a WFD water body (GB108043022351, and GB108043022352). It flows in a southerly direction in the eastern part of the study area. Its catchment is predominantly from the Chalk, with small inliers of Upper Greensand and Gault in the northern area of the catchment.

3.2.3 The River Avon accretes steadily through the study area from Milston to Upper Woodford as measured by EA spot flows (2005). However there are very few readings taken on a given date to ascertain where specifically the flow accretes.

3.2.4 The EA has a river level and flow gauge station located at Amesbury, shown on Figure 3.1. The flows recorded between 1965 and 2016 range between $1.13m^3/s$ (at the Q95 for low flows), and $25.75m^3/s$ (at the maximum gauged flow).

3.2.5 There are also a number of small channels, ponds and ditches located within the River Avon floodplain. These include the Amesbury Abbey Pond and Blick Mead drain located in the Amesbury Abbey estate, as well as a seasonal pond within the Blick Mead archaeological site that can contain water in winter months (Figure 3.2).

3.2.6 The River Avon Nutrient Management Plan (Ref 3.2) was implemented by WC, Natural England and the EA in 2015 to help manage phosphorous levels in the River Avon and to avoid the deterioration of ecologically designated sites as a result of water quality changes. Phosphorous poses the most significant threat to the River Avon and its ecologically important features.

3.2.7 The River Till is also designated as a Main River and a WFD water body (GB108043022570) and flows southwards in the west of the study area. The River Till is groundwater fed and in its upper reaches north of Berwick St James it flows as a winterbourne on an intermittent basis.

3.2.8 The headwaters of the River Till are typically at Shrewton in winter as measured by EA spot flows (1992-2001) However in dry years (e.g. 1992) there is no flow above Bell Inn, approximately 3.3km upstream of Berwick St James and 4.2km downstream of Shrewton. In each accretion profile presented by the EA, flow accretes steadily rather than large inflows at discrete locations. In wet years (e.g. 2014) the headwaters of the river can reach Tilshead.

3.2.9 There are no flow monitoring locations on the River Till, with the nearest gauging station located at South Newton on the River Wylye.

3.3 Environmental designations and archaeological areas

3.3.1 The River Avon is recognised as a site of ecological importance and is a designated SAC, which forms part of the European network of protected sites commonly referred to as Natura 2000. It is also a designated SSSI. The River Avon supports populations of Desmoulin's whorl snail (*Vertigo moulinsiana*), sea lamprey (*Petromyzon marinus*), brook lamprey (*Lampetra planeri*), Atlantic salmon (*Salmo salar*) and bullhead (*Cottus gobio*).

3.3.2 The Desmoulin's whorl snail lives in permanently wet, usually calcareous, swamps, fens and marshes, bordering rivers, lakes and ponds, or in river floodplains (Ref 3.3). The distribution of the snail is influenced by the presence of high groundwater levels, with a low population where groundwater levels are deeper than 0.5 m below ground level in summer.

3.3.3 The River Till is a designated SAC and SSSI and has been recognised for its ecological importance. The site is an example of a winterbourne Chalk stream containing the "*floating vegetation of water crowfoot* Ranunculus *of plain and submountainous rivers*". Associated areas of the reed canary grass (*Phalaris arundinacea)* swamp are also present. These habitats support internationally important fish and other wildlife.

3.3.4 The Blick Mead Archaeological site (a non-designated Historic Environment Record) is located east of the Vespasian's Camp Iron Age Hillfort in the grounds of the Amesbury Abbey estate. Archaeological excavations carried out since 2005 at the site have located Mesolithic deposits in association with what is reported as a springhead depression (Ref 3.4). The date of the Mesolithic deposits at Blick Mead reflects the earliest known human activity in the World Heritage Site (WHS). The Archaeologist who led the excavations (D Jacques) has suggested in consultation discussions that changes to the water environment could affect the conditions of archaeological preservation at the site. Further details of the Blick Mead site are provided at Appendix 11.4: Annex 3.

3.4 Land use and soils

3.4.1 The study area is characterised by rural land use, with a number of villages, and the town of Amesbury located within it.

3.4.2 The majority of the land within the study area is in arable use, though some alongside the River Till and around the major archaeological monuments is permanent grassland.

3.4.3 Cattle and sheep are the main livestock kept in the study area but there is also a large outdoor pig enterprise and free-range poultry. Farms are generally large but smaller holdings are found around Winterbourne Stoke where a more diversified land use includes campsites and paddocks for horses, ponies, goats and alpacas.

3.4.4 Small areas of woodland are scattered throughout the landscape, some of which contain stands of coniferous trees indicating commercial management (although this may be historic). Management of game for commercial shoots, principally pheasants, is an important activity and the survival of small woodlands on the otherwise open downland is linked to this.

3.4.5 Information presented on the Cranfield Soil and Agrifood Institute Soilscapes map (Ref 3.5) shows that the majority of the study area is underlain by shallow lime-rich loamy soils, which are freely draining. The 1:250,000 soil map of South East England (Ref 3.6) published in 1983 shows the soils to be mainly shallow, calcareous soils over Chalk, these include the Andover 1 association of calcareous silty soils, and the Icknield association distinguished from the Andover by their blackish humose topsoils. On steeper slopes there is the Upton 1 association of shallow, well drained, silty soils and in the valley at Winterbourne Stoke is the Coombe 1 association of deep calcareous silty soils in colluvium (soil material deposited by hillwash and soil creep).

3.4.6 There are several sites that could contain contaminants within the study area, associated with historical and current land uses, which could affect baseline water quality conditions. Contaminants within the soils could become mobilised by construction activities which could lead to an adverse effect on the water quality of surface water and groundwater bodies. The location of the potentially contaminated sites (as identified for the Geology and Soils chapter of the ES) is shown on Figure 3.3.

3.5 Geological setting

3.5.1 Figure 3.2 shows the superficial and bedrock geology within the study area, taken from British Geological Survey (BGS) mapping.

Bedrock geology

3.5.2 The bedrock underlying the study area comprises the White Chalk; an Upper Cretaceous succession of the Chalk group, including the Newhaven and Seaford Chalk Formations, with deposits of Phosphatic Chalk (Ref 3.7). The majority of the Chalk outcrop is the Seaford Chalk, with a north-east south-west trending outcrop of Newhaven Chalk present in the area between the Avenue and Normanton Down, and an outcrop on Coneybury Hill.

3.5.3 The Seaford Chalk Formation is described by the BGS as a ‘firm white chalk with conspicuous semi-continuous nodular and tabular flint seams’. The Seaford Chalk Formation is up to approximately 60m thick in the study area. The Newhaven Chalk is described by the BGS as a soft to medium hard, smooth white chalk with numerous marl seams and flint bands, and is approximately 10m thick.

3.5.4 The Lewes Chalk is the oldest formation and comprises hard nodular chalks and hardgrounds interbedded with softer grainy chalks and marls, and widespread sheet flints. This unit outcrops at Berwick St James in the Till Valley around 2km south of Winterbourne Stoke (Ref 3.8).

3.5.5 A number of key lithological marker beds exist in the Chalk bedrock, which along with nannofossil biostratigraphy have been used to determine the broad geological structure of the area (Ref 3.9). These include the Stockbridge Rock Member in the Seaford Chalk, and the Chalk Rock hardground identified as the base of the Lewes Chalk.

3.5.6 Investigation in the study area has also identified distinct deposits of Phosphatic Chalk within the Seaford and Newhaven Chalk Formations of a limited lateral extent.

3.5.7 The Phosphatic Chalk is believed to have been deposited in scoured marine channels (known as cuvettes) in an organic rich environment. The Stonehenge Phosphatic Chalks are largely pelletal, detrital material including shelly fragments of fossils, phosphatized fossil pellets and reworked phosphatized sponges (Ref 3.7).

3.5.8 The Phosphatic Chalk is described as a variably, and often weakly, cemented brown sandy Chalk with pelletal phosphatic grains. It contains up to about 50% of fine to medium sand size particles and may thus be described as a calcarenite (Ref 3.8). Phosphate nodules were proven in the Chalk at depths between 4.3m and 22.45m bgl in exploratory holes located on the western side of the Stonehenge Bottom dry valley. Monitoring boreholes R503B, PX505A and PX506 shown on Figure 3.2 are located in this area.

3.5.9 The study area is located within the wider Wessex Basin, which comprises a series of broadly east-west trending anticlines and synclines plunging toward the east. Due to this the Chalk strata are folded and dip to the north east or south or south east.

Superficial geology

3.5.10 The superficial deposits within the study area typically comprise alluvium, sands and gravels, localised river terrace deposits, and head deposits, which are largely remobilised weathered Chalk material deposited as a result of periglacial processes.

3.5.11 The dry valleys contain head deposits, comprising clay, silt, sand and gravel, overlying the Chalk. Where proved in site investigations, the head deposits were recorded at depths no greater than 1m to 2m below ground level (bgl) in the base of dry valleys. Borehole RX513A installed in Stonehenge Bottom valley proved a thickness of 0.66m of sandy slightly gravelly Silt deposits.

3.5.12 The active river valleys of the Avon and Till contain alluvial and terrace gravel deposits, as well as head deposits of gravel. The head deposits are present at the lower levels of some of the dry valleys that join the River Avon.

3.5.13 Historical ground investigations in and around the study area of the proposed Scheme have shown alluvium to be present in the Till Valley to depths of between 3m and 5m bgl and in the Avon Valley to depths of up to 7.5m bgl. The alluvium associated with the River Till was recorded to comprise flint gravel with Chalk clasts, and lenses and layers of sand, silt and clay. Alluvium associated with the River Avon consists of three distinct units of cohesive alluvium, peat and granular alluvium.

3.5.14 Additional superficial Head deposits of clay with flints are indicated on the BGS geological mapping to be located on a number of the hill tops.

Karstic features

3.5.15 The Defra Natural and Artificial Cavities Database, indicates that there are no recorded, significant, subterranean cavities in the area.

3.5.16 Historical investigations in the study areas have proved dissolution at shallow depths. Geophysical surveys carried out for the proposed Visitors Centre north of Countess Roundabout by John Grimes Partnership were interpreted to indicate the presence of dolines, where solution weathering or karstification has occurred along discontinuities to depths of up to about 5m. Trial pitting, completed as part of the Phase 1A investigations, identified dissolution features which appeared to cut through the surrounding, flint-rich periglacial deposits (Ref 3.10).

3.5.17 The historic investigations within the Phosphatic Chalk, identified open voids. The voids appeared to be restricted to the zone of seasonal groundwater fluctuation (Ref 3.10).

3.6 Hydrogeological setting

3.6.1 The White Chalk bedrock (including the Seaford, Newhaven and Lewes Nodular Chalk Formations) in the study area is classified by the EA as a principal aquifer, and is within the WFD Upper Hampshire Avon groundwater body (GB40801G806900). As a principal aquifer the Chalk provides water supply on a strategic scale and significant river baseflow, and forms an aquifer is of regional importance.

3.6.2 The Chalk is a dual porosity medium with groundwater flow principally through fractures and fissures. The majority of aquifer storage is derived from secondary porosity within these fractures. A strong topographical control on transmissivity is also evident with high transmissivity values occurring within valleys and decreasing towards the interfluves.

3.6.3 There are three types of superficial aquifers classified by the EA within the study area:

a) Alluvium, river terrace gravel deposits, and head deposits (where they consist of gravel) are classified as Secondary A aquifers. These are permeable layers with a moderate to high primary permeability and which are capable of supporting water supplies at a local rather than strategic scale, and in some cases form an important source of baseflow to rivers. The deposits provide groundwater that flows to the River Avon and River Till.

b) Clay and sand deposits located on interfluves towards the River Avon are classified as Secondary B aquifers, and

c) Head deposits (comprising clay, silt, sand and gravel) located in dry valleys and the River Till and River Avon valleys are classified as Secondary (undifferentiated) aquifers. These aquifers are defined where it has not been possible to define an A or B category.

3.6.4 Peat is noted as being present in the vicinity of the Blick Mead archaeological site. This is classified by the EA as Unproductive Strata.

Groundwater level fluctuations

3.6.5 The Chalk in the study area generally is of an unconfined nature, being at outcrop and with limited cover from secondary aquifers that are not considered to be confining. There are no observation boreholes installed in different Chalk layers or superficial deposits to measure whether there are any discrete confining layers. Some confinement of Chalk groundwater is anticipated in the Avon valley where there are extensive alluvial deposits.

3.6.6 Ten current EA groundwater level monitoring observation boreholes are located in the study area as shown on Figure 3.2. Most of these monitor the Chalk, with the Amesbury Shallow borehole installed in both the Chalk and superficial gravel deposits. Groundwater levels recorded in these boreholes range between 78.7m AOD and 99.9m AOD in the northwest of the study area at Tilshead, and between 61.3m AOD and 79.4m AOD in the south of the study area at Stoford Cross.

3.6.7 The monitoring data has been used by the EA to inform their groundwater model of the Wessex Basin (Ref 11.4.12). This model is further discussed in the Numerical Modelling report provided in Annex 1. Figure 3.4 presents the time-series of available groundwater level monitoring data between January 2002 and April 2018 for the EA monitoring boreholes.

3.6.8 Monitoring data shows that groundwater levels in the Chalk aquifer respond rapidly to recharge events at the surface due to a low storage capacity, and significant changes in groundwater level can occur over short periods of time. Annual fluctuations shown in the EA borehole at Berwick Down are between approximately 6m and 25m, with rapid rises in excess of 10m occurring over approximately one month. Data for the Berwick Down observation borehole (located with handheld GPS at 405302, 140492) collected between 2001 and 2018 is presented on Figure 3.5 with the rainfall data collected from the EA rain gauge at Larkhill, and shows extreme high groundwater levels occurring in the winter of 2002/03 and 2013/14.

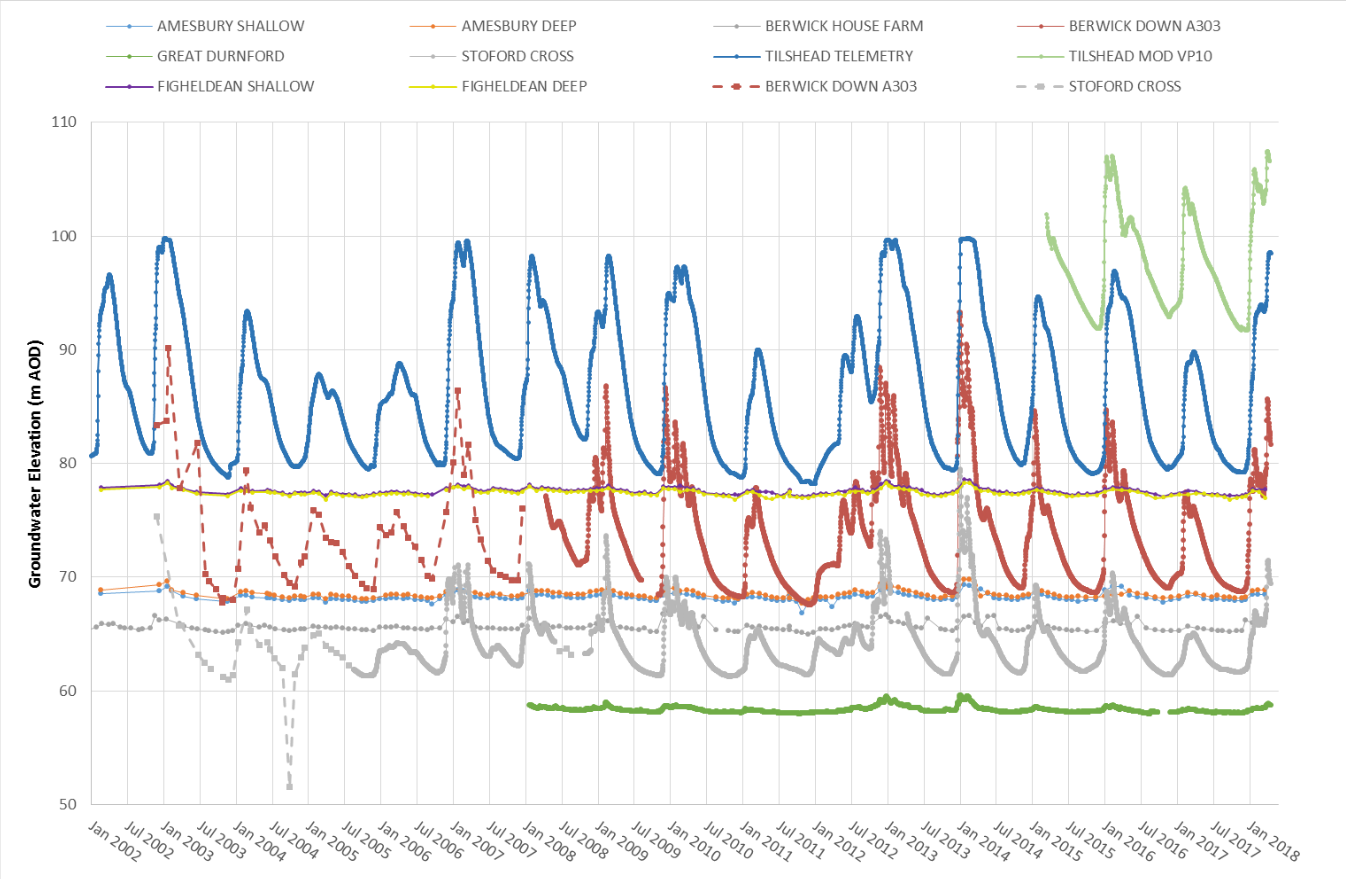


Figure 3.4: EA Groundwater Level Monitoring (January 2002 to April 2018)

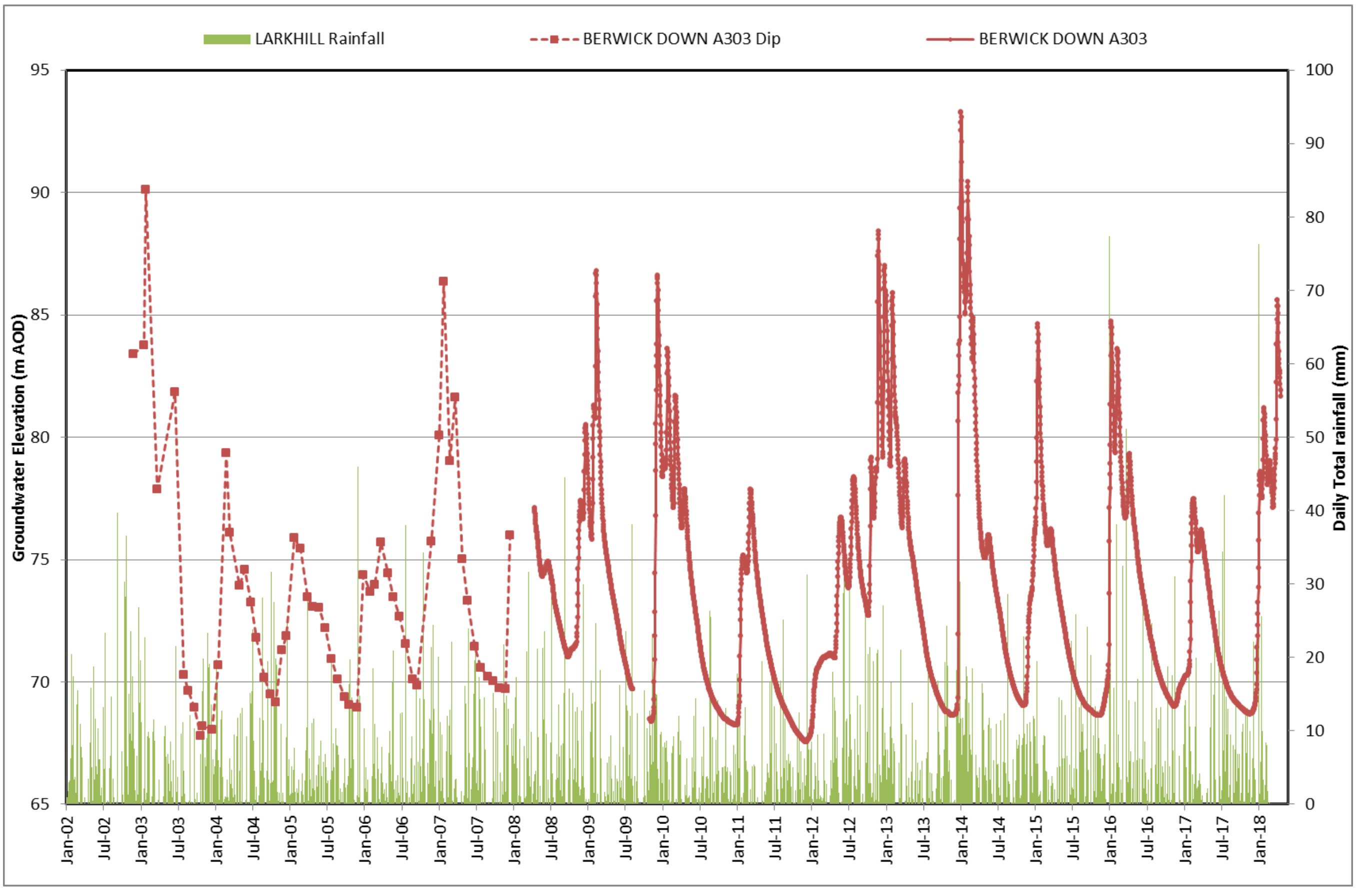


Figure 3.5: EA Berwick Down observation borehole

3.6.9 Groundwater monitoring data from ground investigation boreholes installed in 2001 near the proposed tunnel alignment covered the 2001-2006 period. All but one of these investigation boreholes (R158) has since been lost. Additional groundwater level monitoring boreholes were installed in 2017, with telemetry monitoring commencing in April 2017. A replacement monitoring system has been installed in 2018 to provide more reliable data collection. The locations of the current monitoring boreholes as well as the historic investigation boreholes are shown on Figure 3.2. The groundwater level monitoring data collected in 2017 and 2018 is presented in Figure 3.6.

3.6.10 Groundwater levels in the Chalk are controlled by recharge from rainfall infiltration and by natural discharge to the rivers Avon and Till, as well as groundwater abstractions. The seasonal fluctuations in the groundwater level tend to be less in the dry valleys (between 8m and 10m) (borehole P2 for example), than below topographic divides (about 15m) (Berwick Down A303 borehole for example) as the storage capacity is usually greater beneath dry valley systems, than in the interfluve areas. Boreholes located close to the active rivers in the groundwater discharge regions show a limited seasonal fluctuation (about 2m) (Amesbury borehole for example).

3.6.11 Groundwater is abstracted from the Chalk in the area (abstraction locations are discussed in Section 3.8). Three of the boreholes installed in 2017 have recorded groundwater levels that indicate they are within the radius of influence of a groundwater abstraction, boreholes RX506, RX507A and RX514A. The water level in these boreholes shows rapid reductions in groundwater level compared to the other monitoring boreholes.

3.6.12 Groundwater is known to rise to the surface in otherwise dry valleys during periods of high rainfall, including in Stonehenge Bottom (80m AOD near piezometer P2 shown on Figure 3.2) and the River Till north of Berwick St James.

3.6.13 Groundwater levels measured in boreholes in the vicinity of the Scheme alignment are shown in Figure 3.7. Simulated groundwater levels from the EA Wessex Basin model for typical groundwater low and high periods are given in Figure 3.8, and recent groundwater levels from April 2018 are shown in Figure 3.9.

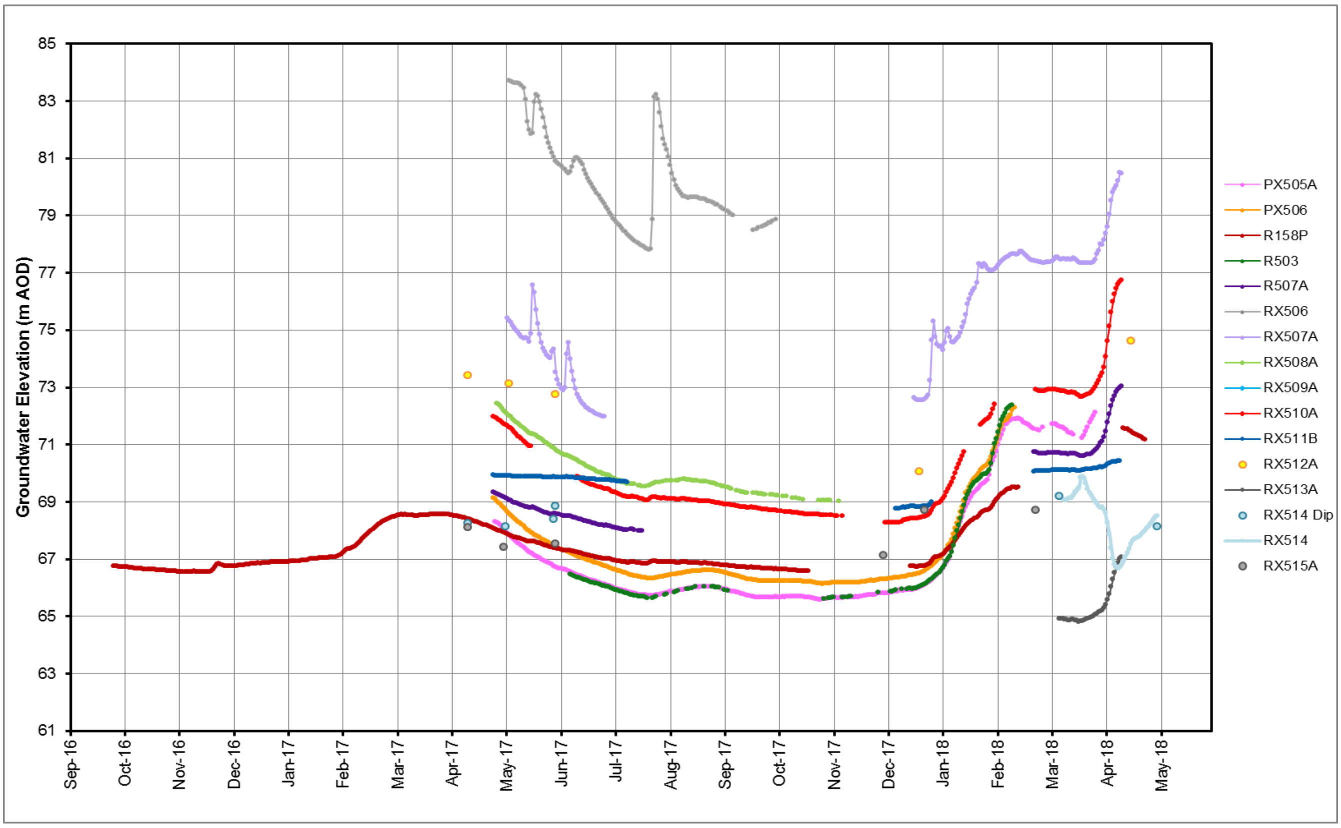


Figure 3.6: Highways England Groundwater Level Monitoring (2016 to Apr 2018)

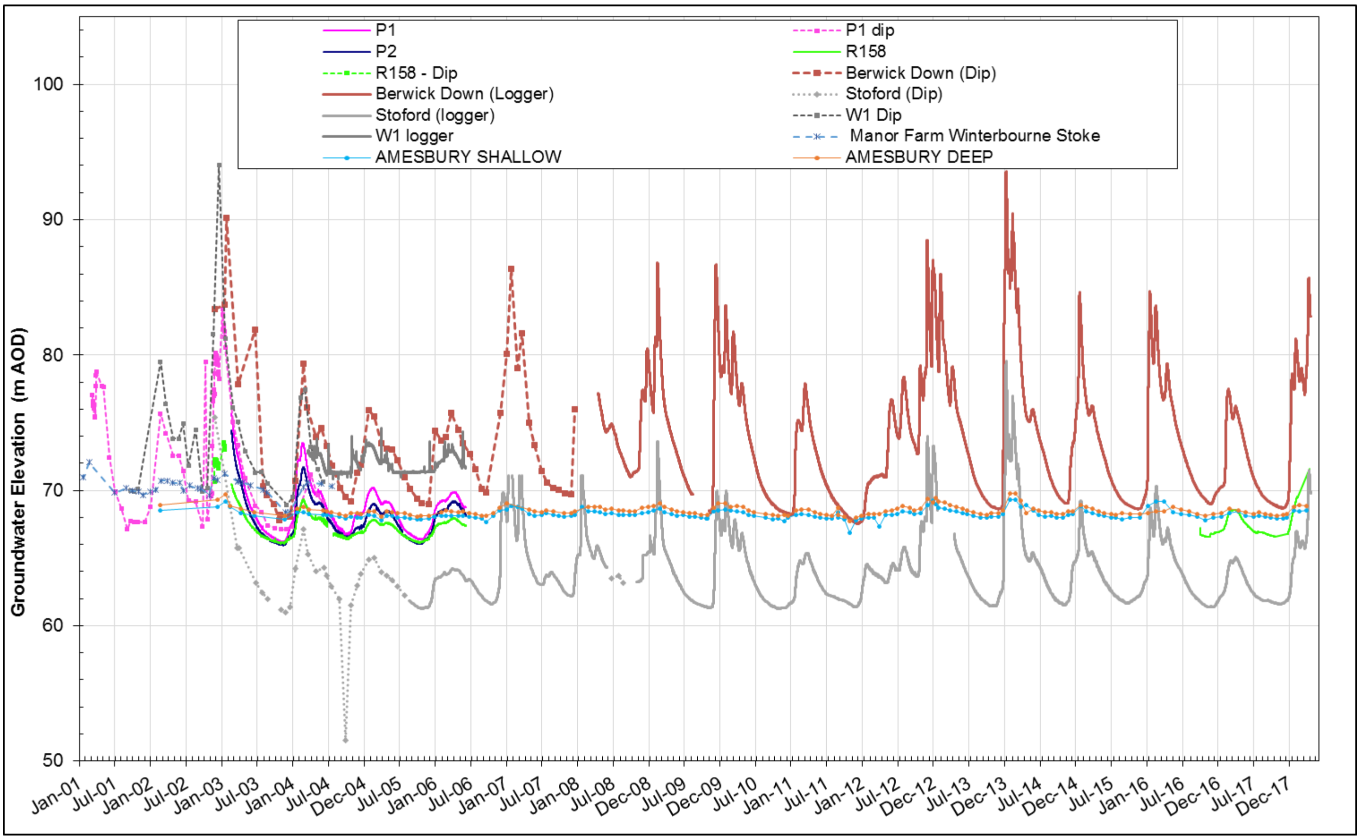


Figure 3.7: Groundwater Level Monitoring along the Scheme alignment

3.6.14 Drought conditions were observed in the area in 1976 and these groundwater levels have been used to assess impacts from the scheme during drought conditions in the numerical modelling presented in Annex 1.

3.6.15 The highest groundwater levels within the EA Wessex Basin model are those recorded in February 2014, presented on Figure 3.10. These groundwater levels have been used to assess impacts from the scheme during peak groundwater conditions in the numerical modelling presented in Annex 1.

3.6.16 The groundwater levels recorded within the boreholes monitored in 2017 and 2018 have been compared to the drought and peak groundwater levels predicted at these locations by using the Wessex Basin groundwater model. The comparison is shown in Table 3.2, and shows that all the water levels lie within the predicted ranges (with the exception of the lowest groundwater elevation recorded in R158 (in 2003) dropping 10cm below the modelled minimum) illustrating that the model provides a good representation of the groundwater levels in the local study area.

Table 3.2: Comparison of modelled and recorded groundwater levels

Borehole ID	Recorded Minimum Groundwater Elevation (m AOD)	Modelled Minimum Groundwater Elevation – Drought 1976 (m AOD)	Recorded Maximum Groundwater Elevation (to 2 May 2018) (m AOD)	Modelled Maximum Groundwater Elevation – Peak 2014 (m AOD)	Range of Modelled Groundwater Elevations (m)
PX505A	65.59	59.91	76.12	82.26	22.35
PX506	66.13	58.80	76.60	81.99	23.19
R503B	65.61	61.11	76.22	82.04	20.93
R507A	67.97	60.58	73.09	74.62	14.04
RX506	77.78	70.76	86.24	97.89	27.13
RX507A	71.98	67.21	80.80	90.51	23.30
RX508	69.04	62.39	79.66	90.22	27.83
RX509	68.47	63.48	83.05	89.89	26.41
RX510A	68.27	59.94	77.17	83.42	23.48
RX511B	68.75	67.92	70.46	72.38	4.46
RX512A	70.08	68.63	74.62	77.95	9.32
RX513A	62.49	59.68	67.11	69.78	10.10
RX514A	68.13	60.48	68.15	69.68	9.20
RX515A	67.13	64.36	68.71	73.14	8.78
R158	66.07	66.17	73.56	76.42	10.25

Groundwater movement

3.6.17 The EA Wessex Basin model utilises the groundwater level data collected in the area and groundwater elevation contours have been produced to indicate the regional groundwater flow (Ref 3.11).

3.6.18 The groundwater elevation contours (Figure 3.8) indicate that regionally groundwater in the Chalk aquifer flows in a generally southerly direction with flow at high groundwater levels converging towards the River Till in the west of the study area and towards the River Avon in the east of the study area, creating a groundwater divide between the two rivers. The groundwater discharges naturally as baseflow to the Rivers Avon and Till. The discharge to the River Avon is perennial whereas the River Till is a winterbourne (dry through periods of low groundwater levels) north of Berwick St James. The hydraulic gradient is generally around 0.002 in typical low groundwater level conditions, and around 0.0036 in typical high groundwater level conditions.

3.6.19 At low groundwater levels, the groundwater elevation contours indicate that the upper River Avon northeast of Larkhill may lose flow to the Chalk aquifer with groundwater flow occurring in a south-westerly direction towards the Stonehenge Bottom dry valley catchment.

3.6.20 At low groundwater levels, the groundwater elevation contours indicate that the River Till loses flow to the aquifer in its central reaches flowing over the higher transmissivity Chalk units in the syncline (e.g. the Chalk Rock at the base of the Lewes Chalk), with groundwater flow across catchment towards the River Avon i.e. the groundwater catchment divide is not present in low groundwater level conditions.

3.6.21 In the south of the study area groundwater flow in the Stonehenge Bottom valley flows in a south-easterly direction to discharge into the River Avon at Lake. The River Avon accretes flow significantly below Amesbury reflecting the discharge from the Stonehenge Bottom catchment.

3.6.22 Groundwater elevation contours are produced from groundwater levels recorded in April 2018 at the EA groundwater monitoring boreholes and current groundwater monitoring boreholes in the vicinity of the scheme. These contours for the typical high groundwater levels during the period of monitoring are presented on Figure 3.8 and show a similar pattern to those produced by the EA using the Wessex Basin model for average high groundwater level conditions. Locally the hydraulic gradient ranges between 0.0026 and 0.0073 to the south and south east.

3.6.23 Localised ephemeral flow occurs within the dry valleys in the Chalk landscape, where preferential pathways are formed by more permeable zones during periods of high groundwater level. The dry valleys are corridors where the majority of the flow occurs beneath the surface and occasionally partially above surface when groundwater levels are particularly high. This is the case in the Stonehenge Bottom area and in the upper reaches of the River Till.

3.6.24 There are also north-south trending dry valleys to the east of Coneybury Hill and above the existing A303 to the north of the Blick Mead area. There is no evidence that there is flow in these dry valleys. The geological map shown in Figure 3.2 indicates that these dry valleys contain valley infill material of head deposits.

Aquifer properties and preferential flow horizons

3.6.25 Pumping tests were carried out (in the Chalk) close to the route alignment in 2002 (winter) and 2004 (summer), at two locations close to Stonehenge Bottom (W148 in the dry valley, W137 in the interfluve area) (Refs 3.12 and 3.13, and shown on Figure 3.9). Transmissivity values of 1,430 - 2,650m^2/d for the dry valley, and 400 – 850m^2/d in the interfluve are quoted, with the lower values reported in the summer. In both tests the transmissivity at W148 was about three times that measured in W137. This supports the concept that transmissivity is typically greater beneath the dry valleys compared to interfluve areas, where preferential groundwater flow zones beneath dry valleys result in the enhanced development of fissuring within the Chalk.

3.6.26 Packer testing undertaken in borehole RX502A during the 2017 site investigations in the Coneybury Hill area showed slightly lower hydraulic conductivities than elsewhere, indicating this interfluve could be limiting flow from the upper reaches of Stonehenge Bottom eastwards towards the River Avon. A pumping test within this area to the northeast of Spring Bottom Farm, is scheduled to provide additional hydrogeological information for the detailed design stage.

3.6.27 Geological information has been reviewed in order to evaluate whether preferential flow horizons exist in the Chalk aquifer. Information reviewed from all previous site investigation reports consisted of lithological changes, geotechnical log CIRIA grading (reflecting fracture frequency and openness), geophysical tests identifying flow horizons, and packer tests calculating hydraulic conductivity in discrete vertical bands.

3.6.28 Packer testing involves isolating intervals of a borehole and pumping water into the aquifer and enables a calculation of the permeability in that horizon only. The packer test data presented in the site investigations carried out show no clear pattern with higher and lower permeability zones interspersed vertically and not repeated laterally.

3.6.29 The main change in the vertical profile noted is the presence of Phosphatic Chalk. In terms of permeability, the description of this unit includes that it may have conduits for enhanced flows in ‘voidage’ areas but that these may be infilled by low permeability silt. The gravelly material itself is noted as poorly sorted indicating that a lower permeability may be present compared to a well sorted deposit. Therefore there is no strong evidence that the Phosphatic Chalk forms a preferential flow pathway; voids may enhance flow while silty infill and poorly sorted gravelly material may reduce the permeability. While previous investigations (Ref 3.10) describe voids being observed, the geological description indicates that open voids are unlikely to be laterally extensive and connected for forming a significant flow horizon. A pumping test specific to the Phosphatic Chalk has yet to be undertaken, but is scheduled to be undertaken in the area close to the historical pumping test location of W137 to provide additional information for the detailed design stage.

3.6.30 CIRIA grading does not follow a pattern with depth or spatially along the alignment. The gradings are mostly B or C meaning fractures greater than 3mm aperture or less than 3mm aperture respectively, and 2 or 3 (e.g B2 to C3); meaning fractures are at close or medium spacing, 60-200mm and 200-600mm. There are some intervals of A grading, meaning closed or tight fractures that may indicate lower permeability, but these are not persistent between boreholes. Overall the rock mass down to approximately 50m AOD appears relatively uniform, with no clear stratification of fracture spacing or aperture. Therefore there is no evidence for laterally extensive high permeability horizons from CIRIA grading in the area of the tunnel profile (approximately 45-90 m AOD).

3.6.31 Geophysical tests are available for several boreholes extending to the proposed elevation of the tunnel including caliper, flow velocity, gamma, electrical conductivity and temperature logs. In the Stonehenge Bottom area pumped flow velocity tests in the pumping test boreholes W137 and W148 recorded a significant increase in flow between 69m and 73m AOD. The most marked change is in Stonehenge Bottom, with a more gradual increase on the interfluve test. This horizon correlates with the main zone of water table fluctuation, and it is within the average low and high water levels. This indicates that there may be preferential flow in this zone reflecting a zone of fracturing in the dry valley.

3.6.32 A borehole investigation carried out at the Stonehenge Visitors Centre (Ref 3.14) provides data for the Chalk below 50m AOD. The borehole was drilled to approximately 0m AOD and found a very uniform rock profile with several discrete flow horizons. The most significant fracture zone was at 102-104m bgl (~0m AOD), with another major flow horizon at 65.5 – 66.5m bgl (~35m AOD), and a minor flow horizon at 78.2m bgl (~22m AOD).

3.7 Springs

3.7.1 In general, groundwater baseflow enters the rivers as seepages rather than at discrete springs. Within the study area springs have been identified at:

a) A seasonal spring at Spring Bottom Farm (present at extreme high seasonal Chalk groundwater levels only);

b) A seasonal groundwater-fed lake near the village of Lake, just to the west of the River Avon (groundwater was present during the high groundwater levels in March and April 2018);

c) A seasonal spring at Durrington;

d) A spring system at West Amesbury and Gallows Hill; and

e) Amesbury Abbey springs (referred to as Blick Mead spring in the Preliminary Environmental Information Report) in the grounds of Amesbury Abbey and adjacent to the Blick Mead archaeological site.

3.7.2 The locations of these springs, shown on Figure 3.2, were visited as part of the water features survey between November 2017 and March 2018. The results of these surveys are provided in Annex 2.

3.7.3 Previous investigations identified the West Amesbury Spring as a water feature in the area. Groundwater level monitoring is not at a sufficient density to delineate the catchment of the springs. The catchment to this spring is likely to be largely along the north-south orientated dry valley to the north with the spring representing an outflow point. Based on spring flow and recharge the catchment area was estimated in previous investigations to be approximately 0.235km^2, which is a small proportion of the dry valley topographic catchment (1.7km^2). Therefore it was concluded that the spring flows are derived from a very local catchment recharge area unrelated to the Stonehenge Bottom catchment.

3.7.4 Spring flows from the West Amesbury Spring system were monitored between 2003 and 2005. The maximum flow over the monitoring period was approximately 800m^3/d during the very high groundwater levels in January 2003. The following winters had more typical winter peaks with maximum spring flows of 340m^3/d in 2003-4 and 200m^3/d in 2004-5. Spring flows were 10m^3/d to 30m^3/d when groundwater levels were at their lowest during the monitoring period. When the springs were visited as part of the recent water features survey in November 2017, little flow was observed.

3.7.5 The Amesbury Abbey springs have been visited as part of the water features survey, and these visits and the study undertaken on the hydrogeology of the Blick Mead site are detailed in Annex 3. This has identified that the low permeability superficial deposits (peat, alluvial silts and clays, and head deposits) locally confine the underlying Chalk and the superficial deposits sands and gravels aquifer at the site, such that groundwater springs (e.g. Amesbury Abbey springs) emerge at the margins of the superficial deposits.

3.7.6 The springs at Durrington, West Amesbury and Gallows Hill are located in areas indicated as being underlain by low permeability superficial deposits (alluvial silts and clays). These deposits may therefore also locally be confining the underlying groundwater in these areas, with the springs emerging at the margins.

3.8 Groundwater abstractions

3.8.1 Source protection zones (SPZ) are areas designated by the EA in order to protect significant potable water groundwater abstractions. The zones identify areas within which activities may result in contamination of the groundwater source. They are classified into three zones depending on travel time of pollutants and therefore potential risk to the source: the inner zone (or zone 1), the outer zone (or zone 2) and the total catchment (or zone 3). The zones have been determined to represent a 50 day travel time, a 400 day travel time, and the whole groundwater catchment for public water supply and other sensitive groundwater sources.

3.8.2 There are five published SPZs for public drinking water supply abstractions within 5km of the Scheme in the study area:

a) One located north of Amesbury at Durrington;

b) Two located north of Amesbury at Bulford;

c) One located at Shrewton, north of Winterbourne Stoke; and

d) One located south of Amesbury, near Little Durnford.

3.8.3 Twenty eight (28) active EA licensed groundwater abstractions are located within the study area, which are all understood to be sourced from the Chalk. Eight are licensed for drinking water supply, one is licensed for the production of energy, two are licensed for industrial, commercial and public services, fourteen are licensed for agricultural purposes and three are licensed for agriculture and drinking water supply. Where not covered by a published SPZ, each abstraction is defined a nominal SPZ1 of 50m, and SPZ2 of 250m by the EA. The details of the licensed groundwater abstractions are given in Table 3.3 and shown on Figure 3.11.

3.8.4 Through the water features survey undertaken in 2018 an additional expired licence has been identified at Manor Farm in Winterbourne Stoke. This licence, which covers four boreholes for agricultural (general and domestic) purposes, lapsed in March 2017 and was reapplied for in February 2018, and therefore was included in the water features survey. We understand it has now been re-licensed.

3.8.5 The Wiltshire Council register of Private Water Supplies for potable use listed 21 private groundwater supplies within the wider search area, twelve of which were licensed by the EA (abstracting $20m^3/d$ or higher volumes), mainly for agricultural purposes. A water features survey has been undertaken to confirm this information and gain more information on these water supplies. Through the water feature survey it has become apparent that some of the WC provided coordinates are likely to be the tap sampling points rather than the locations of the boreholes/wells.

3.8.6 A summary of the private water supplies located within the study area in addition to those licensed by the Environment Agency is given in Table 3.4, with the full results of the water features survey provided in Annex 2. Locations also are shown on Figure 3.11.

3.8.7 The study area lies within the Hampshire Avon catchment and the abstraction licensing strategy for the area (Ref 3.15) shows that groundwater is available for abstraction at Q30 and Q50 (high and average conditions), restricted at the Q70 conditions and not available for licensing at Q95 (low conditions). Licensed abstractions (more than $20m^3/d$) are managed by the EA to protect the environment (river flows) and other water users.

3.8.8 There are licensed discharges to ground held by the EA within the study area; licensed discharges to ground or surface water are shown on Figure 3.1.

Table 3.3: Environment Agency licensed groundwater abstractions

Name	Abstraction Point	EA Use Description	Licence Number	Easting	Northing	Annual Licensed Quantity (m^3/yr)	Wiltshire Council Reference	Additional Information from EA or Water Features Survey
Biddesden House Farm Partnership	Druids Lodge Borehole #1	Agriculture	13/43/021/G/251	409968	139122	37,360	PW/000000937	Borehole depth 125m
	Oatlands Hill Borehole #1	Agriculture	13/43/023/G/245	408700	140600	29,700	PW/000000933	
	Oatlands Hill, Winterbourne Stoke Well Point B	Agriculture	13/43/023/G/065	408700	140600	24,094.2	PW/000000933	
	Stapleford Well Point A			407500	137200			
Chemring Countermeasures Limited	High Post, Durnford Borehole #1	Industrial, Commercial And Public Services	13/43/021/G/232	414200	136900	20,000		
	High Post, Durnford Borehole #2			414100	136900			
Crook	Amesbury Down Well #1	Agriculture	13/43/021/G/067	414800	139900	7274		
English Heritage	Borehole at Point 'A' Airman's Corner	Production of Energy	SW/043/0021/003	410101	142843	107,676	PW439	
	Borehole at Point 'B' Airman's Corner	Water Supply		409898	142916			
Mr W & Mrs S Grant	Wisma Farm Borehole Point A	Agriculture	13/43/023/G/246	407400	140400	1700		Potentially no longer in use
Great Durnford Estate	Great Durnford Well Point 1	Agriculture	13/43/021/G/069	413900	138300	6364		
	Great Durnford Well Point 2			414900	138900			
M & R Hosier	Wilsford-Cum-Lake, Borehole #A	Agriculture	13/43/021/G/236	411400	139100	10,000	PW/000000934	Supplies farm and 2 cottages and fills reservoir to 12 m

Name	Abstraction Point	EA Use Description	Licence Number	Easting	Northing	Annual Licensed Quantity (m^3/yr)	Wiltshire Council Reference	Additional Information from EA or Water Features Survey
								Owner believes approximately 95 m deep but not confirmed Environment Agency state 80m
	Wilsford-Cum-Lake, Borehole #B			412000	138300		PW/000000934	Fills reservoir Approximately 40-50 m deep, not confirmed
Langdon	Salterton Farm Borehole #1	Agriculture	13/43/021/G/226	413000	135800	14,104		
Little Durnford Farms	Laverstock Borehole #1	Agriculture and Water Supply	13/43/021/G/228	412970	132960	8286		
Sir Simon Rasch's Childrens Accumulation & Maintenance Trust	Woodford Mill Borehole #1	Agriculture	13/43/021/G/024	412000	135900	8464		
Smith	Eston Hill Farm Borehole #1	Agriculture	13/43/023/G/209	406800	145700	9092	PW/000000912	Depth 91.4 m
G E Street & Son	Berwick St James Borehole #1	Agriculture	13/43/023/G/083	407100	139200	15,929	PW/000000929	Depth 12.13 m Used by Environment Agency as monitoring borehole
Trustees of Lake Settlement Estate	Wilsford-Cum-Lake, Borehole A	Agriculture & Water Supply	13/43/021/G/212	413359	139143	27,276	PW/000000917	Used for cottages near the estate
	Wilsford-Cum-Lake, Borehole B			412378	139945			Source not in use, depth on licence is 2.4m
Wessex Water	Durrington A	Water Supply	13/43/021/G/152	415300	143700	1,800,000		

Name	Abstraction Point	EA Use Description	Licence Number	Easting	Northing	Annual Licensed Quantity (m^3/yr)	Wiltshire Council Reference	Additional Information from EA or Water Features Survey
Services Ltd	Durrington B			415300	143700			
	Durrington C			415300	143700			
	Shrewton Borehole No.1	Water Supply	13/43/023/G/101	406100	143500	831,932		
	Shrewton Borehole No.2			406200	143500			
	Dean's Farm Borehole A and B	Water Supply	13/43/021/G/208	413500	133400	4,300,000		
	Dean's Farm Borehole C			413500	133500			
Licence expired and being reapplied for								
Robert Lionell Turner	Manor Farm, Well 1	Agriculture (General and Domestic)	13/43/023/G/074	409780	143812	5973		
	Manor Farm, Well 2			408221	142074	3982		
	Manor Farm, Well 3			409214	141548	4977		
	Manor Farm, Well 4			407728	141190	4977		

Table 3.4: Private water supplies

Name	Figure 3.11 ID Number	Wiltshire Council Ref No	Main Activity	Accessed during Water Features Survey	Additional Information
Sceptre Lodge, Elston Lane, Shrewton, Salisbury	9	PW/000000911	Domestic	Yes	Borehole Open hole, water is UV treated. Borehole supplies the house and Manor House which is now a school
Scotland Lodge, Winterbourne Stoke, Salisbury	11	PW/000000932	Domestic	Yes	
Wiltshire Grain Ltd, Rollestone Silo	14	PW/000001137	Commercial	Yes	Supplies small office (toilets and kitchen tap) Pump suction at 61m bgl
Heale House, Middle Woodford	18	PW/000000903	Domestic	Yes	The coordinate provided by the council for Heal Stables was incorrect Depth 27.9m bgl
Shrewton Farm	21	Not on council list	Agricultural	Yes	Well used for dairy farm Owner also has a well at Rockery Farm which was not visited.
Shrewton Lodge Stud	22	Not on council list	Agricultural and Domestic	Yes	Well for agriculture including sheep and horses. House well for main house, water treated with UV sediment filter and softener.

3.9 Groundwater flooding

3.9.1 Groundwater flooding occurs when receptors are affected by water emerging from the ground rather than by direct rainfall or surface water runoff. The River Avon and River Till are Chalk rivers both fed by groundwater and also from overland sources during periods of heavy or prolonged rainfall.

3.9.2 There are four groundwater flooding mechanisms that may exist in the study area:

a) *Water table elevation in the chalk aquifer rising to above the ground surface:* groundwater flooding during periods of elevated groundwater levels results in the water table rising above the ground surface, via springs and seepages: such that the flooded area is a representation of the groundwater table. This occurs in locations such as at Stonehenge Bottom, Spring Bottom Farm and Lake.

b) *Water table in the Chalk aquifer induced groundwater floods by increasing baseflow:* water table rises in the Chalk aquifer in the catchments of the River Avon and its tributaries can result in the flowing of ephemeral springs and streams, some of which rarely flow, resulting in greater river flows downstream.

c) *Superficial aquifers along the River Avon and its tributaries:* flooding may be associated with alluvium and the river terrace deposits where they are in hydraulic continuity with surface watercourses. Stream levels may rise following high rainfall events but still remain “in-bank”, and this can trigger a rise in groundwater levels in the adjacent superficial deposits. The properties at risk from this type of groundwater flooding are probably limited to those in the vicinity of the watercourses, with basements / cellars, which have been constructed within the superficial deposits.

d) *Superficial aquifers in various locations:* a second mechanism for groundwater flooding associated with superficial deposits occurs when they are not connected to surface watercourses. Perched groundwater tables can exist within these deposits (river terrace deposits and head (gravel deposits), developed through a combination of natural rainfall recharge and artificial recharge e.g. leaking water mains. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars; and in close proximity to the course of the River Avon and its tributaries.

3.9.3 It is also important to consider the secondary impacts of higher groundwater levels on other types of flooding, for example high groundwater levels within the Chalk mean there is less floodwater storage and therefore there is a higher risk of pluvial and fluvial flooding. High groundwater levels can also flood storm sewers making them ineffective.

3.9.4 There is groundwater flooding susceptibility where peak groundwater levels are close to or above ground level. The highest recorded groundwater levels were in 2014 (note groundwater monitoring in the area does not include the 2000-1 event), and the numerical groundwater modelling undertaken uses this event as the peak groundwater level conditions. The groundwater elevation contours for this event are presented on Figure 3.10. The Wessex Basin model predicts in a number of areas, along the rivers and in dry valleys such as Stonehenge Bottom, where peak groundwater levels can rise above the ground level and therefore groundwater flooding is likely to occur.

3.9.5 Reports of historical flooding events in the study area have been collected from the EA and WC. **Error! Reference source not found.** shows a summary of the years in which these flood events have been reported as having a potential groundwater component. Figure 3.10 highlights the area where historic groundwater flooding has been reported. Some of these reports will relate to exceptional Chalk groundwater levels where groundwater emerges at surface in otherwise dry locations; while others will be a combination of other sources of flooding, such as surface water flow in intense rainfall events, leaking pipes, and high river levels leading to higher groundwater levels in the superficial gravel aquifers in the river valleys.

3.9.6 *Within The River Till catchment* likely groundwater flooding events were noted in: The Till Valley, Tilshead, Orcheston, Shrewton, Salisbury Plain Military Camp, Winterbourne Stoke, Berwick St James and Stapleford.

3.9.7 *Within The River Avon catchment* there were likely groundwater flooding events in these communities; Enford, Haxton, Netheravon, Durrington, Wilsford-Cum-Lake, Woodford (including both Upper and Lower).

Table 3.5: Summary of historical reporting of flooding

Location/Community	Years in which flooding occurred
River Till	
Berwick St James	2014
Orcheston	1990, 1992, 1993, 1995, 1996, 1998, 1999, 2000, 2003, 2013, 2014
Salisbury Plain military camp	1912
Shrewton	1841, 1915, 1960, 1990, 1993, 1995, 2000, 2001, 2003, 2014,
Stapleford	2003
Till Valley	1986, 1990, 1995, 2003
Tilshead	1951, 1977, 1992, 1993, 1995, 1999, 2000, 2001, 2003, 2014
Winterbourne Stoke	1990, 1995, 1998, 2004
River Avon	
Durrington	2008
Enford	1994, 1995, 2000, 2001, 2002, 2003, 2004, 2005, 2014
Haxton	2006
Netheravon	Prior to 2001
Wilsford-Cum-Lake	2003
Woodford (Flooding also noted in Lower and Upper Woodford without a date)	2014

3.9.8 Information provided by Wessex Water states that groundwater flooding of their sewer network has occurred in Tilshead, Orcheston, Shrewton and Berwick St

James. In these locations an Infiltration Reduction Plan, and an Operational Management Action Plan, are in place that are actioned when there is a risk of flooding.

3.9.9 The areas reporting likely historical groundwater flooding are consistent with the locations where the peak modelled groundwater levels are predicted to be above ground level. Figure 3.10 shows the peak modelled groundwater levels relative to the ground level based on the latest LIDAR data.

3.9.10 The EA has a groundwater flood warning system in place in the study area:

a) The flood alert system for the wider Salisbury Plain area (Ref 3.16) includes the communities of Orcheston, Shrewton, Tilshead, Winterbourne Stoke and Woodford in the study area. This alert is issued when groundwater levels are high enough that they may start affecting roads and ponding is seen in fields. The last alert was issued on 10 April 2018.

b) The flood warning system (Ref 3.17) is used to alert vulnerable communities to the onset of groundwater flooding, in some cases a week in advance. The flood warnings cover a smaller area than the flood alert system, and are based on communities and catchments. A flood warning is issued when there is a potential for properties to be flooded, and the Till flood warning system covers Tilshead, Orcheston, Shrewton, Winterbourne Stoke, Berwick St James and Stapleford. These warnings allow residents to prepare for groundwater flooding, by turning on pumps and activating resilience measures.

3.10 Groundwater quality

3.10.1 The groundwater signature using the major ions is one of a calcium bicarbonate ($Ca\text{-}HCO_3$) type. A piper diagram (Figure 3.12) has been produced from the analytical results of groundwater samples collected in April 2018. The diagram shows there is little variation in the groundwater chemistry across the study area. The pH recorded in 2018 ranged between 7.15 and 8.08 pH units, temperature ranged between 9.3 and 15.09°C, and electrical conductivity ranged between 460µS/cm and 619µS/cm.

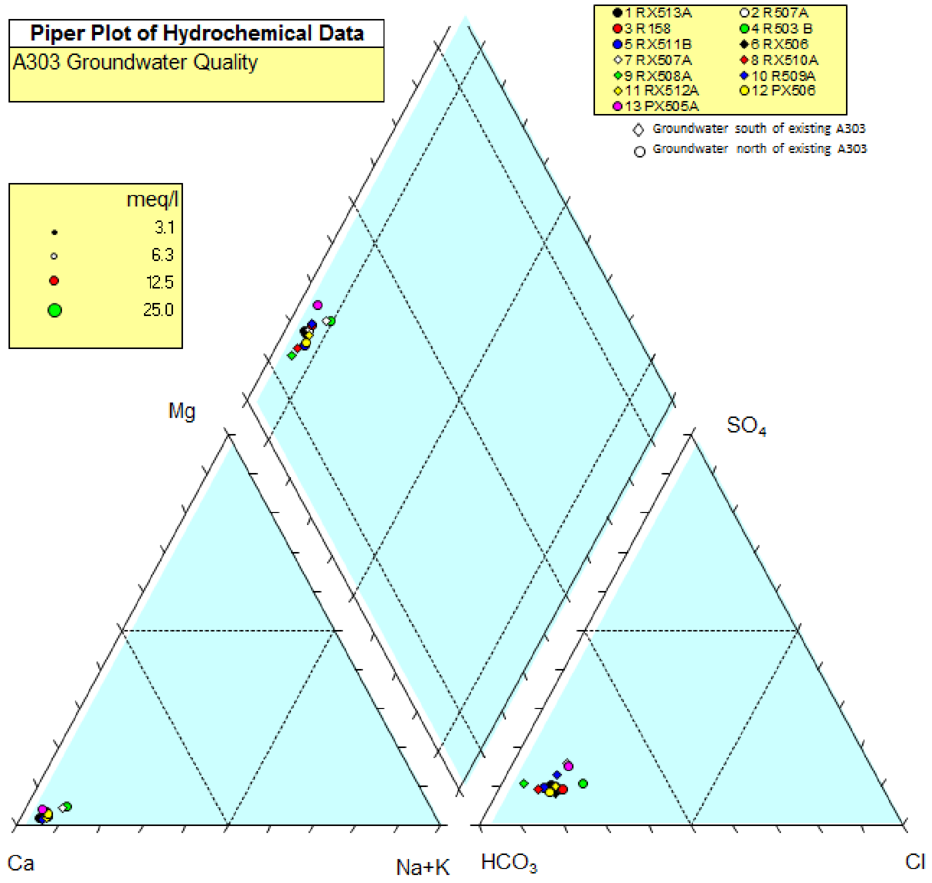


Figure 3.12: Groundwater Piper Diagram April 2018

3.10.2 The baseline groundwater chemistry has been informed by data from water quality samples collected from the study area historically and in 2018 from the current groundwater monitoring boreholes and from nearby EA boreholes shown on Figure 3.2. The groundwater quality data is compared to the UK Drinking Water Standards (DWS), the UKTAG Groundwater hazardous substances standards (Table 3.6) and the baseline quality for the Chalk in Hampshire as determined by the BGS (Ref 3.18) (Table 3.7).

Table 3.6: Summary of samples exceeding the Drinking Water Standards and the UKTAG hazardous substances guidance concentrations

Determinand	Borehole Name	Source	Date	Drinking Water Standard	UKTAG Hazardous substances	Measured concentration
Arsenic (µg/l)	DURRINGTON BH 1	EA monitoring boreholes	02/10/2006	10	5	5.6
Cyanide Total (mg/l)	R13	2003 ES	23/06/2003	0.05	-	0.6
Nitrate (as NO3-) (mg/l)	R13	2003 ES	21/01/2003	50	-	72.2
	R158	2018 Monitoring	22/02/2018			51.5
	RX514A	2018 Monitoring	08/03/2018			50.1
	RX513A	2018 Monitoring	08/03/2018			75.1
	R503-D	2018 Monitoring	11/04/2018			63.2
	R503B	2018 Monitoring	11/04/2018			61.9
	R158	2018 Monitoring	11/04/2018			57
	RX513A	2018 Monitoring	12/04/2018			59.1
	RX506	2018 Monitoring	13/04/2018			119.1
	RX512A	2018 Monitoring	17/04/2018			52.4
	RX509	2018 Monitoring	17/04/2018			68
	PX505A	2018 Monitoring	18/04/2018			63.8
	CP4	2003 ES	26/09/2002			265
Sodium (mg/l)	RX506	2018 Monitoring	13/04/2018	200	-	16800
Turbidity (NTU)	RX509	2018 Monitoring	17/04/2018	4	-	11120
	PX505A	2018 Monitoring	18/04/2018			10060
	RX508A	2018 Monitoring	17/04/2018			8860
	RX510A	2018 Monitoring	13/04/2018			4740
	RX507A	2018 Monitoring	13/04/2018			4720
	RX514A	2018 Monitoring	08/03/2018			4230
	PX506	2018 Monitoring	18/04/2018			2980
	RX513A	2018 Monitoring	12/04/2018			2372
	RX512A	2018 Monitoring	17/04/2018			1484
	R158	2018 Monitoring	11/04/2018			925
	R503-D	2018 Monitoring	11/04/2018			884
	RX513A	2018 Monitoring	08/03/2018			814
	RX510A	2018 Monitoring	23/02/2018			565
	RX507A	2018 Monitoring	23/02/2018			481
	R503B	2018 Monitoring	11/04/2018			433
	R507A	2018 Monitoring	22/02/2018			92.1
	R158	2018 Monitoring	22/02/2018			51.1
	R507A	2018 Monitoring	12/04/2018			42.1
	RX511B	2018 Monitoring	11/04/2018			18.9
	RX511B	2018 Monitoring	22/02/2018			6.5

Table 3.7: Summary of determinands exceeding the mean and maximum concentrations of the BGS regional baseline

Determinand	No. of exceedances (mean)	No. of exceedances (mean and max)	Total No of samples measured	Percentage of samples exceeding mean
Nitrate (as NO3-)	29	24	181	16.0%
Sulphate	27	11	181	14.9%
Phosphorus	18	10	63	28.6%
Ammoniacal Nitrogen as N	12	8	178	6.7%
pH (Lab)	13	7	238	5.5%
Chloride	23	6	180	12.8%
Antimony	5	5	136	3.7%
Arsenic	4	4	90	4.4%
Sodium	14	4	194	7.2%
Magnesium	12	2	194	6.2%
Aluminium	1	1	115	0.9%
Dissolved Organic Carbon	3	1	121	2.5%
Electrical conductivity *(lab)	4	1	173	2.3%
Lead	3	0	174	1.7%
Nitrite (as NO2-)	2	1	161	1.2%
Potassium	3	1	194	1.5%
Cadmium	2	0	209	1.0%
Calcium	11	0	194	5.7%
Copper	4	0	209	1.9%
Nickel	2	0	174	1.1%
Zinc	1	0	223	0.4%

3.10.3 Historical data has shown concentrations of cyanide, nitrate and sodium exceeding the relevant DWS in one or two samples. The arsenic UKTAG standard (5µg/l) was exceeded in a sample from the EA Durrington BH1 monitoring point in 2006. Only nitrate, sodium and turbidity exceeded the DWS in groundwater samples collected and analysed in 2018.

3.10.4 Overall the concentrations of the parameters recorded in the study area are consistent with the BGS baseline data for Chalk groundwater. However ammoniacal nitrogen, chloride, magnesium, nitrate, phosphorus, sodium and sulphate exceeded the mean BGS baseline in over 6% of the samples taken. Table 3.8 provides details of the determinands which exceeded the BGS mean and maximum baseline concentrations, which borehole the results are associated with and the origin of the data. The results highlighted in red exceeded the regional maximum concentrations, while those in black only exceeded the regional mean. It should be noted that the average only considers the measurements that were above the detection limit.

Table 3.8: Details of determinands exceeding the mean and maximum concentrations of the BGS regional baseline

Determinand	Borehole Name	Source	BGS Mean	BGS Max	Avge > BGS mean	Avge > BGS max	No. of Samples
Aluminium (Filtered)	DRUIDS LODGE BH	EA monitoring boreholes	0.416	3.67	13.43	13.43	50
Ammoniacal Nitrogen as N	RX508A	2018 Monitoring	0.009	0.066	0.07	0.07	1
	RX514A	2018 Monitoring	0.009	0.066	0.04	0.00	1
	RX513A	2018 Monitoring	0.009	0.066	0.03	0.00	2
	P2	2003 ES	0.009	0.066	0.20	0.20	5
	CP2	2003 ES	0.009	0.066	0.20	0.20	3
	P1	2003 ES	0.009	0.066	0.20	0.20	5
	R13	2003 ES	0.009	0.066	0.15	0.15	5
	PX505A	2017 GIR	0.009	0.066	0.10	0.10	1
	R16	2003 ES	0.009	0.066	0.10	0.10	1
	R503B	2017 GIR	0.009	0.066	0.07	0.07	1
	R507A	2017 GIR	0.009	0.066	0.05	0.00	1
	SHREWTON BH 1	EA monitoring boreholes	0.009	0.066	0.01	0.00	27
Antimony (Filtered)	RX512A	2018 Monitoring	0.042	0.073	5.00	5.00	1
	RX507A	2018 Monitoring	0.042	0.073	4.00	4.00	2
	R503B	2018 Monitoring	0.042	0.073	2.00	2.00	1
	R507A	2018 Monitoring	0.042	0.073	2.00	2.00	2
	RX511B	2018 Monitoring	0.042	0.073	2.00	2.00	2
Arsenic (Filtered)	RX507A	2018 Monitoring	0.302	0.757	2.60	2.60	2
	DURRINGTON BH 1	EA monitoring boreholes	0.302	0.757	5.60	5.60	24
	DRUIDS LODGE BH	EA monitoring boreholes	0.302	0.757	1.00	1.00	19
	SHREWTON BH 1	EA monitoring boreholes	0.302	0.757	1.00	1.00	14
Cadmium (Filtered)	SHREWTON BH 1	EA monitoring boreholes	0.089	2.44	0.20	0.00	6
	DRUIDS LODGE BH	EA monitoring boreholes	0.089	2.44	0.10	0.00	15
Calcium	RX506	2018 Monitoring	109	144	118.90	0.00	1
	RX510A	2018 Monitoring	109	144	117.45	0.00	2
	PX505A	2018 Monitoring	109	144	114.20	0.00	1
	RX512A	2018 Monitoring	109	144	112.70	0.00	1
	R509A	2018 Monitoring	109	144	111.40	0.00	1
	RX508A	2018 Monitoring	109	144	109.30	0.00	1
	W1	2003 ES	109	144	124.20	0.00	1
	R16	2003 ES	109	144	122.00	0.00	1
	DURRINGTON BH 2	EA monitoring boreholes	109	144	110.31	0.00	13
	DURRINGTON BH 1	EA monitoring boreholes	109	144	109.52	0.00	29

Determinand	Borehole Name	Source	BGS Mean	BGS Max	Avge > BGS mean	Avge > BGS max	No. of Samples
	CP2	2003 ES	109	144	109.10	0.00	2
Chloride	R503-D	2018 Monitoring	17.7	26.3	32.60	32.60	1
	R503B	2018 Monitoring	17.7	26.3	32.10	32.10	1
	RX506	2018 Monitoring	17.7	26.3	23.40	0.00	1
	R158	2018 Monitoring	17.7	26.3	22.25	0.00	2
	PX505A	2018 Monitoring	17.7	26.3	21.60	0.00	1
	RX507A	2018 Monitoring	17.7	26.3	21.05	0.00	2
	RX512A	2018 Monitoring	17.7	26.3	20.60	0.00	1
	RX513A	2018 Monitoring	17.7	26.3	20.00	0.00	2
	RX514A	2018 Monitoring	17.7	26.3	19.60	0.00	1
	R509A	2018 Monitoring	17.7	26.3	18.40	0.00	1
	PX506	2018 Monitoring	17.7	26.3	17.90	0.00	1
	W1	2003 ES	17.7	26.3	159.00	159.00	1
	CP4	2003 ES	17.7	26.3	74.00	74.00	2
	R503B	2017 GIR	17.7	26.3	35.00	35.00	1
	W137	Factual Report	17.7	26.3	34.33	34.33	3
	W148	Factual Report	17.7	26.3	22.33	0.00	3
	PX505A	2017 GIR	17.7	26.3	22.00	0.00	1
	CP2	2003 ES	17.7	26.3	21.00	0.00	2
	R13	2003 ES	17.7	26.3	20.75	0.00	4
	P1	2003 ES	17.7	26.3	19.50	0.00	4
	P2	2003 ES	17.7	26.3	19.50	0.00	4
	DURRINGTON BH 2	EA monitoring boreholes	17.7	26.3	18.38	0.00	13
	DURRINGTON BH 1	EA monitoring boreholes	17.7	26.3	17.81	0.00	35
Copper (Filtered)	R16	2003 ES	6.68	31.8	16.00	0.00	1
	P2	2003 ES	6.68	31.8	13.00	0.00	4
	P1	2003 ES	6.68	31.8	8.50	0.00	4
	R507A	2017 GIR	6.68	31.8	10.00	0.00	1
Dissolved Organic Carbon	R503B	2017 GIR	0.813	1.24	1.40	1.40	1
	R507A	2017 GIR	0.813	1.24	1.00	0.00	1
	SHREWTON BH 1	EA monitoring boreholes	0.813	1.24	0.82	0.00	16
Electrical conductivity *(lab)	W1	2003 ES	563	715	925.00	925.00	1
	W148	Factual Report	563	715	583.33	0.00	3
	DURRINGTON BH 2	EA monitoring boreholes	563	715	576.92	0.00	13
	DURRINGTON BH 1	EA monitoring boreholes	563	715	572.65	0.00	34
Lead (Filtered)	SHREWTON BH 1	EA monitoring boreholes	0.447	1.35	1.07	0.00	6
	DRUIDS LODGE BH	EA monitoring boreholes	0.447	1.35	0.93	0.00	15
	DURRINGTON BH 1	EA monitoring boreholes	0.447	1.35	0.56	0.00	11
Magnesium (Filtered)	R503-D	2018 Monitoring	2.1	4.81	3.80	0.00	1
	R503B	2018 Monitoring	2.1	4.81	3.80	0.00	1

Determinand	Borehole Name	Source	BGS Mean	BGS Max	Avge > BGS mean	Avge > BGS max	No. of Samples
	PX505A	2018 Monitoring	2.1	4.81	3.00	0.00	1
	RX506	2018 Monitoring	2.1	4.81	3.00	0.00	1
	RX508A	2018 Monitoring	2.1	4.81	2.70	0.00	1
	RX507A	2018 Monitoring	2.1	4.81	2.65	0.00	2
	R158	2018 Monitoring	2.1	4.81	2.35	0.00	2
	R503B	2017 GIR	2.1	4.81	7.00	7.00	1
	CP4	2003 ES	2.1	4.81	6.25	6.25	2
	PX505A	2017 GIR	2.1	4.81	4.00	0.00	1
	CP2	2003 ES	2.1	4.81	2.17	0.00	2
	W148	Factual Report	2.1	4.81	2.17	0.00	3
Nickel (Filtered)	P1	2003 ES	3.04	10.9	4.00	0.00	1
	SHREWTON BH 1	EA monitoring boreholes	3.04	10.9	3.18	0.00	6
Nitrate (as NO3-)	RX506	2018 Monitoring	6.58	12.6	119.10	119.10	1
	R509A	2018 Monitoring	6.58	12.6	68.00	68.00	1
	RX513A	2018 Monitoring	6.58	12.6	67.10	67.10	2
	PX505A	2018 Monitoring	6.58	12.6	63.80	63.80	1
	R503-D	2018 Monitoring	6.58	12.6	63.20	63.20	1
	R503B	2018 Monitoring	6.58	12.6	61.90	61.90	1
	R158	2018 Monitoring	6.58	12.6	54.25	54.25	2
	RX512A	2018 Monitoring	6.58	12.6	52.40	52.40	1
	RX514A	2018 Monitoring	6.58	12.6	50.10	50.10	1
	RX510A	2018 Monitoring	6.58	12.6	38.80	38.80	2
	PX506	2018 Monitoring	6.58	12.6	38.20	38.20	1
	R507A	2018 Monitoring	6.58	12.6	27.65	27.65	2
	RX511B	2018 Monitoring	6.58	12.6	24.30	24.30	2
	RX508A	2018 Monitoring	6.58	12.6	22.10	22.10	1
	RX507A	2018 Monitoring	6.58	12.6	18.15	18.15	2
	PX505A	2017 GIR	6.58	12.6	85.13	85.13	1
	W1	2003 ES	6.58	12.6	40.20	40.20	1
	R13	2003 ES	6.58	12.6	36.80	36.80	4
	R503B	2017 GIR	6.58	12.6	33.19	33.19	1
	P2	2003 ES	6.58	12.6	28.93	28.93	4
	CP2	2003 ES	6.58	12.6	20.20	20.20	2
	P1	2003 ES	6.58	12.6	17.05	17.05	4
	W148	Factual Report	6.58	12.6	15.33	15.33	3
	CP4	2003 ES	6.58	12.6	13.00	13.00	2
	W137	Factual Report	6.58	12.6	10.20	0.00	3
	DRUIDS LODGE BH	EA monitoring boreholes	6.58	12.6	9.79	0.00	58
	R507A	2017 GIR	6.58	12.6	9.77	0.00	1
	DURRINGTON BH 2	EA monitoring boreholes	6.58	12.6	7.53	0.00	13
	DURRINGTON BH 1	EA monitoring boreholes	6.58	12.6	7.17	0.00	35
Nitrite (as NO2-)	DURRINGTON BH 1	EA monitoring boreholes	0.002	0.01	0.03	0.03	35

Determinand	Borehole Name	Source	BGS Mean	BGS Max	Avge > BGS mean	Avge > BGS max	No. of Samples
	SHREWTON BH 1	EA monitoring boreholes	0.002	0.01	0.01	0.00	27
pH (Lab)	P2	2003 ES	7.14	7.55	8.00	8.00	1
	P1	2003 ES	7.14	7.55	7.90	7.90	1
	R13	2003 ES	7.14	7.55	7.70	7.70	1
	R16	2003 ES	7.14	7.55	7.70	7.70	1
	R507A	2017 GIR	7.14	7.55	7.69	7.69	1
	R503B	2017 GIR	7.14	7.55	7.62	7.62	1
	PX505A	2017 GIR	7.14	7.55	7.56	7.56	1
	W148	Factual Report	7.14	7.55	7.53	0.00	3
	DRUIDS LODGE BH	EA monitoring boreholes	7.14	7.55	7.33	0.00	99
	SHREWTON BH 1	EA monitoring boreholes	7.14	7.55	7.32	0.00	35
	DURRINGTON BH 1	EA monitoring boreholes	7.14	7.55	7.29	0.00	50
	DURRINGTON BH 2	EA monitoring boreholes	7.14	7.55	7.25	0.00	20
	W137	Factual Report	7.14	7.55	7.20	0.00	3
Phosphorus (Total)	PX505A	2018 Monitoring	40	308	3925.00	3925.00	1
	RX506	2018 Monitoring	40	308	2274.00	2274.00	1
	R509A	2018 Monitoring	40	308	1949.00	1949.00	1
	RX508A	2018 Monitoring	40	308	1607.00	1607.00	1
	PX506	2018 Monitoring	40	308	1287.00	1287.00	1
	RX507A	2018 Monitoring	40	308	1286.50	1286.50	2
	RX514A	2018 Monitoring	40	308	909.00	909.00	1
	RX510A	2018 Monitoring	40	308	755.00	755.00	2
	RX512A	2018 Monitoring	40	308	342.00	342.00	1
	R503-D	2018 Monitoring	40	308	318.00	318.00	1
	RX513A	2018 Monitoring	40	308	304.50	0.00	2
	R503B	2018 Monitoring	40	308	266.00	0.00	1
	R507A	2018 Monitoring	40	308	146.00	0.00	2
	R158	2018 Monitoring	40	308	111.00	0.00	2
	R13	2003 ES	40	308	150.00	0.00	4
	CP2	2003 ES	40	308	130.00	0.00	2
	P2	2003 ES	40	308	130.00	0.00	4
	P1	2003 ES	40	308	100.00	0.00	4
Potassium	CP4	2003 ES	1.47	3.53	3.70	3.70	2
	DURRINGTON BH 1	EA monitoring boreholes	1.47	3.53	2.17	0.00	11
	W148	Factual Report	1.47	3.53	1.63	0.00	3
Sodium	R503-D	2018 Monitoring	8.88	14.4	13.70	0.00	1
	R503B	2018 Monitoring	8.88	14.4	13.70	0.00	1
	RX507A	2018 Monitoring	8.88	14.4	9.90	0.00	2
	CP4	2003 ES	8.88	14.4	141.05	141.05	2
	W1	2003 ES	8.88	14.4	133.50	133.50	1
	CP2	2003 ES	8.88	14.4	29.25	29.25	2

Determinand	Borehole Name	Source	BGS Mean	BGS Max	Avge > BGS mean	Avge > BGS max	No. of Samples
	R503B	2017 GIR	8.88	14.4	15.00	15.00	1
	W148	Factual Report	8.88	14.4	14.00	0.00	3
	R13	2003 ES	8.88	14.4	13.28	0.00	4
	P2	2003 ES	8.88	14.4	13.08	0.00	4
	P1	2003 ES	8.88	14.4	12.57	0.00	4
	DURRINGTON BH 1	EA monitoring boreholes	8.88	14.4	9.99	0.00	11
	PX505A	2017 GIR	8.88	14.4	9.00	0.00	1
	W137	Factual Report	8.88	14.4	9.00	0.00	3
Sulphate	RX507A	2018 Monitoring	12.9	22.8	36.45	36.45	2
	PX505A	2018 Monitoring	12.9	22.8	32.50	32.50	1
	R509A	2018 Monitoring	12.9	22.8	28.40	28.40	1
	R503B	2018 Monitoring	12.9	22.8	24.70	24.70	1
	RX510A	2018 Monitoring	12.9	22.8	24.35	24.35	2
	RX508A	2018 Monitoring	12.9	22.8	23.80	23.80	1
	RX513A	2018 Monitoring	12.9	22.8	23.55	23.55	2
	R503-D	2018 Monitoring	12.9	22.8	22.60	0.00	1
	RX512A	2018 Monitoring	12.9	22.8	22.30	0.00	1
	RX514A	2018 Monitoring	12.9	22.8	22.00	0.00	1
	RX511B	2018 Monitoring	12.9	22.8	20.90	0.00	2
	RX506	2018 Monitoring	12.9	22.8	19.60	0.00	1
	R158	2018 Monitoring	12.9	22.8	19.35	0.00	2
	R507A	2018 Monitoring	12.9	22.8	19.20	0.00	2
	PX506	2018 Monitoring	12.9	22.8	16.20	0.00	1
	CP4	2003 ES	12.9	22.8	52.00	52.00	2
	W1	2003 ES	12.9	22.8	27.00	27.00	1
	DURRINGTON BH 2	EA monitoring boreholes	12.9	22.8	24.16	24.16	13
	W148	Factual Report	12.9	22.8	23.00	23.00	3
	DURRINGTON BH 1	EA monitoring boreholes	12.9	22.8	22.24	0.00	29
	SHREWTON BH 1	EA monitoring boreholes	12.9	22.8	21.33	0.00	25
	DURRINGTON BH 1	EA monitoring boreholes	12.9	22.8	20.64	0.00	8
	SHREWTON BH 1	EA monitoring boreholes	12.9	22.8	19.77	0.00	3
	CP2	2003 ES	12.9	22.8	19.50	0.00	2
	R507A	2017 GIR	12.9	22.8	16.00	0.00	1
	W137	Factual Report	12.9	22.8	15.33	0.00	3
	DRUIDS LODGE BH	EA monitoring boreholes	12.9	22.8	13.66	0.00	49
Zinc (Filtered)	R13	2003 ES	21.8	253	65.50	0.00	4

3.10.5 Sulphate exceeded the BGS mean in the majority of locations, enhanced concentrations could be due to agricultural activities or reactions with oxidised pyrite, which are known to be present in hardgrounds in the Chalk (Ref 3.18).

The concentrations of nitrate and ammoniacal nitrogen are higher than the BGS regional maximum at several boreholes, with nitrates being above the maximum in all locations but W137, Durrington BH1 and BH2, R507A and Druids Lodge. These determinands are indicators of pollution (fertilisers, slurry or domestic waste) and the high observed concentrations are attributed to land-use.

3.10.6 Concentrations of chloride and sodium were much higher than the regional maximum at the historical locations W1 and CP4, with average concentrations of 159mg/l and 74mg/l respectively for chloride. Average sodium concentrations were 133.5 and 141.1 mg/l respectively. Boreholes R503B and W137 had an average concentration of chloride that was also higher than the regional maximum, while CP2 had higher concentrations of sodium, although the magnitude of this is less than W1 and CP4. Road salt can be a source of elevated concentrations of chloride and sodium.

3.10.7 The average concentrations of arsenic (Durrington BH1, Druids Lodge, Shrewton BH 1 and RX507A), lead (P1) and aluminium (Druids Lodge) exceeded the maximum BGS baseline concentrations at some sites across the area. Arsenic is present in oxides and clays within the Chalk and natural desorption from the mineral structure is the likely source.

Phosphate in groundwater

3.10.8 An elevated level of dissolved phosphorus in the Chalk groundwater is a key reason for the surface water bodies of the River Avon and River Till failing to achieve “good status” classification under the WFD. The main sources of phosphorus include farming as well as point sources such as wastewater treatment works discharges (phosphorus) and natural phosphatic minerals in the Upper Greensand and Chalk aquifers (Ref 3.19). The presence of phosphate nodules in the Phosphatic Chalk present in the vicinity of Stonehenge Bottom has been previously noted as a possible natural source of higher phosphorus in groundwater.

3.10.9 There is no DWS for phosphorus, however the receiving River Avon SAC surface water bodies are subject to the WFD class boundary standards (43 µg/l for the “High/Good” class boundary) and the SAC standards for phosphorus (soluble reactive phosphorus measured as orthophosphate) of 50 µg/l.

3.10.10 The groundwater samples taken in 2018 have been analysed for dissolved phosphorus, as well as for total phosphorus which was the only concentration recorded historically. The concentration of dissolved phosphorus in the Chalk groundwater in the study area (ranging from <5µg/l to 11µg/l) is lower than the mean BGS regional concentration (40µg/l) at all locations monitored, with only three locations (PX505A, RX508A and R511B) recording concentrations slightly above the BGS minimum (9µg/l).

3.10.11 Dissolved phosphorus concentrations in groundwater can be derived from both natural and anthropogenic sources (e.g. inorganic and organic fertilisers, effluent from water treatment and farmyard slurry). No organophosphorus pesticides have been recorded in the groundwater and there is no apparent relationship between phosphorus and other potential indicators of anthropogenic sources such as nitrates. While a natural source of dissolved phosphorus may be present it should be noted that the samples from the boreholes closest to the Phosphatic Chalk (boreholes PX505A, R503B and PX506) did not show notably different (e.g. not higher) concentrations than samples from boreholes further away from the Phosphatic Chalk.

3.10.12 Orthophosphate (soluble reactive phosphorus) for which there is an SAC standard has also been analysed for the 2018 samples. The concentrations recorded (using the phosphomolybdenum blue colorimetric method) were less than the detection limit of 0.03 mg/l in all samples except from borehole RX514A, situated approximately 3km south west of the scheme alignment, which recorded a concentration of 0.56 mg/l.

3.10.13 It is likely that the dominant calcium carbonate chemistry of the Chalk generates a precipitated form of phosphorus rather than a soluble form. Dissolution of calcite carbonate minerals at lower pH can result in the release of phosphorus contained within the Chalk. However the pH range measured across all the samples is relatively small (6.7 – 8) with near-neutral values, which are consistent with groundwater being well-buffered by carbonate equilibrium reactions.

3.10.14 The general low concentration of orthophosphate measured in the groundwater is in contrast to higher concentrations measured in the River Avon. This suggests that the origin of the natural phosphorus in the surface water is from the Upper Greensand rather than the Chalk. Leachate tests were undertaken on Phosphatic Chalk samples to determine the likelihood of phosphorus being released from the strata. The leachate tests (reported in the Geology and Soils chapter of the ES) all reported concentrations of orthophosphate below the laboratory detection limit, and it is therefore considered unlikely that the Phosphatic Chalk yields large concentrations of dissolved phosphorus.

Evidence of contaminated groundwater

3.10.15 The groundwater quality data available historically and from monitoring undertaken in 2018 have not shown any evidence of groundwater contamination from the potentially contaminated land identified in the Geology and Soils chapter of the ES is shown on Figure 3.3. However no samples were collected in the vicinity of the Countess Roundabout where more potential sources of contamination are located. The groundwater quality data represents the available baseline conditions and does not represent groundwater quality at local potentially contaminated sites.

4 Hydrogeological Conceptual Model

4.1.1 The review of the baseline environment presented in Section 3 indicates the following conceptual model for the study area:

a) Groundwater flow in the Chalk aquifer in the study area is generally from north to south with flow at high groundwater levels converging towards the River Till in the west of the study area and towards the River Avon in the east of the study area. The groundwater discharges naturally as baseflow to the Rivers Avon and Till. The discharge to the River Avon is perennial via springs along the margins of overlying superficial deposits and upward flow via superficial deposits, whereas the River Till is a winterbourne (dry through periods of low groundwater levels) north of Berwick St James.

b) Groundwater levels range between 78.2m AOD and 99.9m AOD in the northwest of the study area at Tilshead, and between 61.3m AOD and 79.4m AOD in the south of the study area at Stoford Cross.

c) The seasonal fluctuations in the groundwater level tend to be less in the dry valleys (between 8m and 10m) than below topographic divides (about 15m) as the storage capacity is usually greater beneath dry valley systems, than in the interfluve areas. Boreholes located close to the active rivers in the groundwater discharge regions show a limited seasonal fluctuation (about 2m).

d) Groundwater levels in the Chalk aquifer respond rapidly to recharge events at the surface due to a low storage capacity, and significant changes in groundwater level can occur over short periods of time. Rapid rises in excess of 10m occur over approximately one month in the EA borehole at Berwick Down.

e) Groundwater is known to rise to the surface in otherwise dry valleys during periods of extreme peak groundwater levels, including in Stonehenge Bottom, and at Lake, and the River Till north of Berwick St James. A spring at Spring Bottom Farm is present at extreme peak groundwater levels. A section along the tunnel profile with high and low groundwater levels is given in Annex 1 Figure 3.9.

f) Chalk transmissivity is typically greater beneath the dry valleys compared to the interfluve zones. Preferential groundwater flow zones beneath dry valleys result in the enhanced development of fissuring within the Chalk. Flow velocity tests run in the 2003/2004 pumping test boreholes W137 and W148 recorded a significant increase in flow between 69m and 73m AOD. This horizon correlates with the zone of water table fluctuation, and is within the average low and high water levels. This indicates that there may be preferential flow in this zone reflecting a zone of fracturing in the Stonehenge Bottom dry valley.

g) Secondary A aquifers of alluvium, river terrace gravels and head superficial deposits are present in the River Avon and Till valleys. Head deposits (comprising clay, silt, sand and gravel) located in the dry valleys are classified as Secondary (undifferentiated) aquifers.

h) Groundwater baseflow enters the rivers as seepages rather than at discrete springs. A number of springs have been identified in the study area associated with the margins of the superficial deposits in the River Avon valley at Durrington, West Amesbury, Gallows Hill and Amesbury.

i) Groundwater is abstracted from the Chalk in the study area for public drinking water supply, private drinking water supply, energy production, industrial and commercial services and agriculture. There are five published SPZs are presented within 5km of the Scheme in the study area. Twenty eight active licensed abstractions are located in the study area, with an additional expired licence that has been reapplied for in February 2018. The EA define a nominal SPZ1 of 50m, and SPZ2 of 250m to these abstractions. A number of private unlicensed water supplies (abstracting less than 20m^3/d) are also in the study area. Abstraction affects groundwater levels observed locally in the Chalk aquifer, such as in monitoring boreholes RX506, RX507A and RX514A.

j) Drought conditions within the Chalk were reported in 1976, with modelled extreme low groundwater elevations between 81.2m AOD at Tilshead in the northwest and 60.3m AOD in the south at Stoford Cross. Low groundwater levels reduce the availability of groundwater for abstraction and the supply of baseflow to the River Till and River Avon surface water bodies.

k) There is groundwater flooding susceptibility where peak groundwater levels are close to or above ground level. The Wessex Basin model predicts a number of areas, along the rivers and in dry valleys such as Stonehenge Bottom, where peak groundwater levels can rise above the ground level and therefore groundwater flooding is likely to occur.

l) In the study area historical reports of likely groundwater flooding, corresponding to extreme high groundwater levels in 2003 and 2014, have been noted in the Till catchment at Tilshead, Orcheston, Shrewton, Berwick St James and Stapleford; and in the Avon catchment at Enford, Wilsford-Cum-Lake and Woodford.

m) The Chalk groundwater is of a calcium bicarbonate type, with chemistry generally consistent with the BGS baseline data. There is little variation in the groundwater quality across the study area. Only nitrate and turbidity concentrations exceeded the DWS in groundwater samples collected in 2018.

n) Natural sources are postulated for elevated sulphate, dissolved phosphate and arsenic concentrations compared to the BGS baseline, with elevated nitrate and ammoniacal nitrogen likely to be related to the general agricultural land use in the study area. Elevated concentrations of chloride and sodium reported for historic data could be due to road salt.

o) Elevated dissolved phosphorus is a key reason for the surface water bodies of the River Avon and River Till failing to achieve “good status” classification under WFD, being above 43 µg/l. Dissolved phosphorus concentrations measured in groundwater in 2018 were at or below 11µg/l in all locations. There are no apparent anthropogenic sources of dissolved phosphorus. However it should be noted that the monitoring boreholes closest to the Phosphatic Chalk did not show notably different concentrations to other sites. Leachate tests on Phosphatic Chalk samples all reported concentrations of orthophosphate below the detection limit. It is therefore considered unlikely that the Phosphatic chalk is the source of elevated concentrations of dissolved phosphorus in the rivers.

p) The dominant calcium carbonate chemistry of the Chalk is likely to generate a precipitated form of phosphorus rather than a soluble form. The general low concentration of orthophosphate measured in the groundwater is in contrast to higher concentrations measured in the River Avon. This suggests that the origin of the phosphorus in the surface water is natural discharges from the Upper Greensand rather than the Chalk upstream of the study area.

q) There is no evidence of groundwater contamination from potentially contaminated land identified in the study area.

4.1.2 Historic England has produced guidance on preserving archaeological remains, including water environment assessment techniques (Ref 4.1). A conceptual model has been developed for the Blick Mead Archaeological site, located close to the River Avon. The archaeological site is underlain by alluvial deposits comprising sand, peat and clay, underlain by a sand and gravel aquifer considered to be in hydraulic continuity with the Chalk aquifer at depth. This is presented in the tiered assessment following the Historic England guidance in Annex 3.

4.1.3 Annex 3 concludes that Mesolithic deposits of interest are likely to remain wetted by the underlying Chalk and sands and gravel aquifer under normal conditions. Groundwater levels in the underlying aquifer are generally above 68m aOD, although could potentially drop below the upper level of the Mesolithic deposits layer towards 67.5m aOD for a number of months in a natural drought. Despite this, the draining of the Mesolithic deposits layer will not occur immediately following a drop in groundwater level owing to their lower permeability, relative to the underlying aquifer.

4.1.4 The existing A303 road drainage may be contributing some overland flow to Blick Mead at times of heavy rainfall.

4.1.5 Groundwater and surface water monitoring at Blick Mead is the subject of ongoing discussion with Historic England.

5 Groundwater Risk Assessment Methodology

5.1 Methodology approach

5.1.1 The method adopted for undertaking this Assessment is based on the requirements of The Town and Country Planning (Environmental Impact Assessment) Regulations 2011, the Design Manual for Roads and Bridges (DMRB), and guidance from the Environment Agency (Ref 5.1)

5.1.2 A technical framework for risk assessment is set out on the Environment Agency webpage Groundwater risk assessment for your environmental permit (Ref 5.2), which is based on the Government's Guidelines for Environmental Risk Assessment and Management (Ref 5.3) and includes:

a) A conceptual model (as set out in Section 4 of this Groundwater risk assessment (GRA));

b) The source-pathway-receptor approach, (as set out in Section 5.2 of this GRA);

c) A tiered approach from qualitative risk screening to detailed quantitative risk assessment;

d) Identifying sources or potential hazards and impacts , examining consequences and evaluating the significance of any risk;

e) Dealing with uncertainties and sensitivity analysis; and

f) Risk management.

5.2 Source-Pathway-Receptor

5.2.1 The GRA identifies the potential sources or 'causes' of effect; the 'receptors' (water bodies) that could potentially be affected; and, the 'pathways' via which the source can have an effect on the receptors..

5.2.2 The first stage in utilising the Source-Pathway-Receptor model is to identify the sources of potential impact. This was undertaken in the context of local conditions relative to the relevant water bodies, such as geology, climatic conditions and potential sources of contamination. The sources were identified through a review of the details of the Scheme. The Scheme includes mitigation measures being incorporated into the design and construction.

5.2.3 The next stage is to undertake a review of the potential receptors, that is, the water bodies themselves that have the potential to be affected. The identification of potential water resource receptors was undertaken through a review of literature and the baseline data available for the site, as detailed in Section 3.

5.2.4 The final stage is to determine if there is an exposure pathway or a 'mechanism' allowing an effect to potentially occur at the receptor. All three elements must be present before a potential impact (linkage) can be realised. The assessment covers both the construction and operational phases of the Scheme.

5.3 Sources of potential impact

5.3.1 The potential sources of temporary impact to groundwater from the construction of the Scheme are identified as:

a) contamination risk to the underlying Chalk aquifer; through:

   i. excavation, and the subsequent deposition of soils, sediments, or other construction materials causing pollution;

   ii. spillage of fuels or other contaminating liquids causing pollution;

   iii. mobilisation of contaminants following disturbance and exposure of contaminated ground or groundwater, or through uncontrolled site runoff.

   iv. release or leaching of substances (e.g. cement or grout) used in the tunnelling process, which may negatively impact groundwater quality.

b) temporary dewatering or abstraction, if required, diverting water away from groundwater-dependent receptors, or bypassing part of the system, leading to reduced groundwater level and flow.

5.3.2 The potential sources of permanent impact to groundwater from construction of the scheme are identified as:

a) the presence of underground structures (piers or foundations) that could cause interference to groundwater flow;

b) the presence of part of the tunnel below the groundwater level in the Chalk interfering with groundwater flow. This could lead to increased groundwater levels up hydraulic gradient of the tunnel, and decreased groundwater levels down hydraulic gradient.

5.3.3 The potential sources of impact to groundwater from the operation of the scheme are identified as:

a) impacts arising from pollutants, e.g. oils from fuel combustion/accidental spillages and salts or herbicides from road maintenance due to any increase in discharges to ground;

b) impacts arising from pollutants from incident response in the tunnel and adjacent roads, e.g. oil and fuel spills from car accidents, fire-fighting foam.

5.4 Pathways

5.4.1 The pathways present or potentially created by the scheme are identified as:

a) Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits;

b) Flow of groundwater through the Chalk aquifer, and superficial deposit aquifers;

c) Change in groundwater flow direction within the aquifers due to abstraction or dewatering activities; and

d) Preferential flow pathways created by the construction of foundations for structures or the blockage of groundwater flow by scheme elements.

5.5 Receptors

5.5.1 The sensitivity or importance of a water resource receptor needs to be taken into account in order to assess the significance of potential consequences of a hazard or impact occurring. Definitions of the level of sensitivity of potential receptors are based on their considered value and are presented in Table 5.1.

Table 5.1: Sensitivity/Importance of water receptors

Sensitivity/ Importance	Criteria	Examples
Very High	Water resource with a nationally significant importance with limited potential for substitution	- Principal aquifer providing a regionally important resource and/or supporting a site protected under EC and UK habitat legislation - Groundwater supports a sensitive water dependent terrestrial ecosystem - SPZ1 for an abstraction for public water supply
High	Water resource with a locally significant attribute of high importance and limited potential for substitution	- Principal aquifer providing locally important resource or supporting a river ecosystem - Groundwater locally supports a water dependent terrestrial ecosystem - SPZ2 for an abstraction for public water supply
Medium	Water resource with a high quality and rarity at a local scale; or Water resource with a medium quality and rarity at a regional or national scale	- Secondary aquifer providing potable water to a small population - An aquifer providing abstraction water for agricultural and industrial use with limited connection to surface water - SPZ3 for an abstraction for public water supply
Low	Water resource with a low quality and rarity at a local scale	- Unproductive strata - poor quality groundwater

5.5.2 The receptors of concern identified by their sensitivity/importance are given in Table 5.2.

Table 5.2: Identified receptors of concern

Sensitivity/ Importance	Receptor	Reason for Sensitivity/Importance
Very High	Chalk Aquifer	- The water resource is used for public water supply in the study area and supports flow in the Rivers Avon and Till, which are part of the designated River Avon SAC. - The groundwater input to the River Avon also supports the water dependent terrestrial ecosystem required by the Desmoulin's whorl snail.
	Licensed Public Drinking Water Abstractions with	- abstractions are used for public supply in the area and are therefore nationally significant. The published SPZ1 for the

Sensitivity/ Importance	Receptor	Reason for Sensitivity/Importance
	published SPZ.	five abstractions within 5km of the scheme extend beyond the nominal 50m applied for other licensed abstractions.
	River Avon	- The River Avon receives baseflow from the Chalk aquifer, and is a SSSI. - The groundwater input to the River Avon is supports the water dependent terrestrial ecosystem required by the Desmoulin's whorl snail.
	River Till	- The River Till is a winterbourne fed by groundwater from the Chalk. It is part of the designated River Avon SAC, and a SSSI. It is also a source of groundwater flooding to communities in the vicinity of the River.
Very High	Communities that have reported historical groundwater flooding	- Communities that have reported historical groundwater flooding
	Blick Mead Archaeological Site	- The archaeological site at Blick Mead has been noted for its preservation of Mesolithic remains due to saturated conditions. As it is a nationally significant archaeological site of high importance (it is a non-designated Historic Environment Record) it is assessed as a very high value receptor under the water environment.
High	Licensed and Unlicensed Private Drinking Water abstractions	- These abstractions provide potable drinking water and are therefore locally significant with limited potential for substitution.
	Springs near River Avon	- The spring systems noted in the area near the River Avon (West Amesbury, Gallows Hill, and Amesbury Abbey) are identified as emerging from the Chalk aquifer at the margins of the superficial deposits, and support flow in the River Avon.
Medium	Secondary A aquifers of alluvium, river terrace gravels and gravel head superficial deposits	- These superficial deposits do not support potable water supplies in the study area, but they do contribute groundwater flow to the River Avon and River Till.
	Secondary undifferentiated aquifers of head deposits	- These superficial deposits do not support potable water supplies in the study area, but they do provide a pathway for flow that contributes to baseflow to the River Avon and River Till.
	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	- These licensed abstractions are used for reasons other than drinking water and do have the potential to be substituted. - The pending licence for the Manor Farm wells is applied as a licensed abstraction as it is for agricultural use.
	Unlicensed abstractions for domestic and other uses	- These abstractions provide water to a small population at a rate of less than 20 m^3/d with potential for substitution.
	Seasonal Springs	- The seasonal spring locations at Spring Bottom Farm and at the seasonal lake at Lake are surface expressions of high groundwater levels. As such they provide a rare water resource.
	Environment Agency Monitoring boreholes	- The EA groundwater level monitoring boreholes are utilised for the groundwater flood warning system. As such they are a locally important receptor.

5.6 Qualitative assessment of risks

5.6.1 The risk screening records an assessment of all the source-pathway-receptor linkages that may occur as a result of the Scheme.

5.6.2 The magnitude of a potential impact is established based on the nature and extent of the proposed development and the likely degree of impact to the receptor. It is independent of the sensitivity of the receptor, i.e. the water resource in this risk assessment. Magnitudes of impact are defined in

5.6.3 Detailed discussion of the magnitude of impacts assessed and the uncertainties associated with these is given in Section 6. In particular this includes where a quantitative assessment has been undertaken, and sensitivity analysis of these. The calculation of magnitude includes consideration of embedded mitigation measures within the Scheme. Where additional mitigation measures are required, these are discussed in the GRA.

5.6.4 The likelihood that a pathway/mechanism takes place has been assessed based upon the Scheme, judgement and experience. The product of the likelihood and the magnitude of the impact provides the calculation of risk:

Risk = Likelihood that harm will occur x the magnitude of impact if it does occur.

5.6.5 Once the magnitude of impact (which can be beneficial or adverse) and the receptor sensitivity have been defined, the significance of the potential effect can be derived by combining the assessments of both the importance of the water resource and the magnitude of the impact in a simple matrix as shown in Table 5.4. Effects that are assessed to be large or very large are considered to be significant.

5.6.6 The scoring of the likelihood and risk is described in Table 5.5 and Table 5.6.

5.7 Embedded mitigation

5.7.1 Influencing the Scheme’s design has been a key consideration to maximise the opportunities for delivering mitigation of impacts by avoidance of sensitive receptors wherever reasonably practicable, or minimising impacts.

5.7.2 The Outline Environment Management Plan (OEMP) (provided with the ES) includes requirements to protect the surface water and groundwater bodies and their associated water resources from the potential impacts of pollution, and to mitigate the temporary and permanent effects on groundwater flows and water quality during excavation and construction of foundations, the tunnels and cuttings as far as is reasonably practicable.

Table 5.3: Magnitude of impact

Magnitude of Impact	Criteria	Examples	Risk Score
Major Adverse	Results in impact on integrity of attribute or loss of part of attribute	a) Loss of, or extensive change to, an aquifer b) Loss of regionally important water supply c) Potential high risk of pollution to groundwater from routine runoff - risk score >250 d) Calculated risk of pollution from spillages ≥2% annually e) Loss of, or extensive change to, groundwater supported designated wetlands or baseflow contribution to protected surface water bodies f) Reduction in water body WFD classification	4
Moderate Adverse	Results in effect on integrity of attribute, or loss of part of attribute	a) Partial loss or change to an aquifer. b) Degradation of regionally important public water supply or loss of significant commercial/ industrial/ agricultural supplies c) Potential medium risk of pollution to groundwater from routine runoff - risk score 150-250 d) Calculated risk of pollution from spillages ≥1% annually and <2% annually e) Partial loss of the integrity of groundwater supported terrestrial ecosystem (wetland) f) Contribution to reduction in water body WFD classification	3
Minor Adverse	Results in some measurable change in attributes, quality or vulnerability	a) Potential low risk of pollution to groundwater from routine runoff - risk score <150 b) Calculated risk of pollution from spillages ≥0.5% annually and <1% annually c) Minor effects on an aquifer, groundwater supported wetlands, abstractions and structures	2
Negligible	Results in an impact on attribute but of insignificant magnitude to affect the use / integrity	a) No measurable impact on an aquifer (quantity or quality) and/or groundwater receptors	1
Minor Beneficial	Results in some beneficial effect on attribute or a reduced risk of negative effect occurring	a) Calculated reduction in existing spillage risk by 50% or more to an aquifer (when existing spillage risk <1% annually) b) Reduction of groundwater hazards to existing structures c) Minor improvement in groundwater quality d) Reductions in waterlogging and groundwater flooding	NA
Moderate Beneficial	Results in moderate improvement of attribute quality	a) Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is >1% annually) b) Contribution to improvement in water body WFD classification c) Remediation of contaminated groundwater leading to an improvement in groundwater quality d) Improvement in water body CAMS classification e) Support to significant improvements in damaged GWDTE	NA
Major Beneficial	Results in major improvement of attribute quality	f) Removal of existing polluting discharge to an aquifer or removing the likelihood of polluting discharges occurring g) Recharge of an aquifer h) Improvement in water body WFD classification	NA

NA – risk score is not applicable for beneficial magnitude

Table 5.4: Significance of effect

Receptor Sensitivity	Magnitude of Impact			
	Negligible	Minor	Moderate	Major
Very High	Neutral	Moderate/Large	Large/Very Large	Very Large
High	Neutral	Slight/Moderate	Moderate/Large	Large/Very Large
Medium	Neutral	Slight	Moderate	Large
Low	Neutral	Neutral	Slight	Slight/Moderate

Table 5.5: Likelihood of a S-P-R mechanism occurring

Score	Likelihood	Description	Example
1	Very unlikely	Very unlikely to occur	Extreme set of circumstances required
2	Remote	Unlikely to occur	Site underlain by low permeability strata
3	Moderately Likely	Equally likely or unlikely to occur	Controllable activity
4	Likely	More likely to occur than not	Failure of equipment is likely to lead to a release of pollutants
5	Almost Certain	Highly likely to occur	Uncontrolled activity

Table 5.6: Risk rating table

X		Magnitude			
		1	2	3	4
Likelihood	1	1	2	3	4
	2	2	4	6	8
	3	3	6	9	12
	4	4	8	12	16
	5	5	10	15	20

Score	Risk Rating
1-2	Very Low
3-5	Low
6-12	Medium
15-20	High

5.8 Source-Pathway-Receptor linkages

5.8.1 The Scheme has been reviewed with respect to the hydrogeological conceptual model, and the source-pathway-receptor linkages identified are detailed below split into four areas of the Scheme.

Winterbourne Stoke Bypass

5.8.2 The Scheme elements that will provide sources of potential impact as described in Section 5.3 in the proposed Winterbourne Stoke Bypass section are:

a) Winterbourne Stoke cutting west;

b) Green bridge one at Parsonage Down; B3083 underbridge;

c) East Parsonage Down habitat creation;

d) River Till cutting west;

e) Construction compound and spill storage area off realigned B3083;

f) River Till viaduct and associated embankments;

g) Road drainage system (drainage areas 1, 2, and 3);

h) Green bridge two, PROW bridge; and

i) Green bridge two cutting.

5.8.3 All pathways described in Section 5.4 will be or potentially be present in the Winterbourne Stoke Bypass section.

5.8.4 The receptors that could potentially be affected by the scheme in the Winterbourne Stoke Bypass section are:

a) Principal Chalk aquifer;

b) Licensed Public Drinking Water abstractions with published SPZ;

c) River Till;

d) Communities that have reported historical groundwater flooding;

e) Secondary A aquifers of alluvium, river terrace gravels and gravel head superficial deposits in Till valley;

f) Secondary undifferentiated aquifers of head superficial deposits in dry valleys;

g) Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements;

h) Unlicensed abstractions for domestic and other uses; and

i) Environment Agency monitoring boreholes.

5.8.5 A conceptual illustration of the source-pathway-receptor linkages identified is presented in Figure 5.1. The summary of the risk assessment is provided in Table E.1 in Annex 5. No significant effects are noted following the implementation of embedded mitigation and hence no additional mitigation measures are required. The only medium risk relates to the spillage of fuels or other contaminating liquids during the adjustment of the road to the north of the Environment Agency borehole at Berwick Down.

Longbarrow Junction

5.8.6 The scheme elements that will provide sources of potential impact in the proposed Longbarrow Junction section are:

a) Longbarrow cutting west;

b) Construction compounds and spoil storage areas;

c) Road drainage system (drainage area 4, A360 and link to Winterbourne Stoke);

d) Longbarrow cutting central

e) Green Bridge three at Longbarrow junction;

f) New Longbarrow Junction western and eastern merge and diverge cuttings; Longbarrow Side Road cuttings;

g) Longbarrow cutting east; and

h) Rollestone Corner improvement works.

5.8.7 All pathways described in Section 5.4 will be or potentially be present in the Longbarrow Junction section. No temporary dewatering is required in the section, but abstraction may be required for water supply for construction. The impact of abstraction for water supply would be assessed in the application for an abstraction licence that would need to be agreed with the Environment Agency. As such this pathway is not assessed for this section.

5.8.8 The receptors that could potentially be affected by the scheme in the Longbarrow Junction section are:

a) Principal Chalk aquifer;

b) River Till;

c) Licensed Private Drinking Water abstractions;

d) Secondary A aquifers of alluvium, river terrace gravels and gravel head superficial deposits in Till valley;

e) Secondary undifferentiated aquifers of head superficial deposits in dry valleys;

f) Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements; and

g) Unlicensed abstractions for domestic and other uses.

5.8.9 A conceptual illustration of the source-pathway-receptor linkages identified is presented in Figure 5.2. The summary of the risk assessment is provided in Table E.2 in Annex 5. No significant effects are noted following the implementation of embedded mitigation and hence no additional mitigation measures are required. The only medium risk relates to the spillage of fuels or other contaminating liquids during the construction relating to a licensed groundwater abstraction for agricultural requirements close to the construction compound.

Approaches to Portals and Twin-bore Tunnel

5.8.10 The scheme elements that will provide sources of potential impact in the proposed approaches to portals and tunnel section are:

a) Green Bridge four at WHS;

b) Cutting approach to western portal;

c) Drainage system (infiltration crates);

d) Western portal;

e) Tunnel (and cross-passages);

f) Eastern portal;

g) Cutting approach to eastern portal; and

h) Amesbury cutting.

5.8.11 All pathways described in Section 5.4 will be or potentially be present in the approaches to portals and tunnel section. With the use of the OEMP in relation to the management and discharge of any water from dewatering, the change in groundwater flow direction with relation to groundwater quality issues is not likely to affect any receptors and as such is not included.

5.8.12 The receptors that are present that could potentially be affected by the scheme in the approaches to portals and tunnel section are:

a) Principal Chalk aquifer;

b) Licensed Public Drinking Water abstractions with published SPZ;

c) River Avon and groundwater dependent terrestrial ecosystem element of SAC.

d) River Till;

e) Communities that have reported historical groundwater flooding;

f) Blick Mead Archaeological site;

g) Licensed Private Drinking Water abstractions;

h) Springs near River Avon;

i) Secondary A aquifers of alluvium, river terrace gravels and gravel head superficial deposits in Avon and Till valleys;

j) Secondary undifferentiated aquifers of head superficial deposits in dry valleys

k) Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements;

l) Unlicensed abstractions for domestic and other uses; and

m) Seasonal springs.

5.8.13 A conceptual illustration of the source-pathway-receptor linkages identified is presented in Figure 5.3. The summary of the risk assessment is provided in

Table E.3 in Annex 5. No significant effects are noted following the implementation of embedded mitigation and hence no additional mitigation measures are required.

Countess Junction

5.8.14 The scheme elements that will provide sources of potential impact in the proposed Countess Junction section are:

a) Countess reinforced embankments;

b) Countess flyover;

c) Drainage system (ponds);

d) Construction compounds and spoil storage areas;

e) Utility connection;

f) Countess eastern diverge cutting; and

g) Improvement works at existing River Avon bridge.

5.8.15 All pathways described in Section 5.4 will be or potentially be present in the Countess Junction section, except that of change of groundwater flow direction due to the absence of abstraction or dewatering activities for this section of the Scheme.

5.8.16 The receptors that are present that could potentially be affected by the scheme in the Countess Junction section are:

a) Principal Chalk aquifer;

b) Licensed Public Drinking Water abstractions with published SPZ;

c) River Avon and groundwater dependent terrestrial ecosystem element of SAC.

d) Blick Mead Archaeological site;

e) Springs near River Avon;

f) Secondary A aquifers of alluvium, river terrace gravels and gravel head superficial deposits in Avon valley; and

g) Secondary undifferentiated aquifers of head superficial deposits in dry valleys.

5.8.17 A conceptual illustration of the source-pathway-receptor linkages identified is presented in Figure 5.4. The summary of the risk assessment is provided in Table E.4 in Annex 5.

5.8.18 The design includes piling and this was reviewed for its potential impact on groundwater flows.

5.8.19 The embankments will be founded on controlled modulus columns which are 0.4m diameter, installed to 5m depth, at 1.2m spacing. The piles may be up to 2m below the water table, within alluvium or made ground.

5.8.20 The design is not considered to cause a change to the groundwater flow regime in the area because of the limited vertical profile depth of potential groundwater flow impedance, and that there is not a lateral impedance to groundwater flow as the columns are spaced apart and not in a continuous length.

5.8.21 No significant effects are noted following the implementation of embedded mitigation and hence no additional mitigation measures are required. Risks are all low or very low, and there is potential for minor beneficial effects from the upgrade to the road drainage system, resulting in an improvement in the quality of the discharge of runoff from the new road.

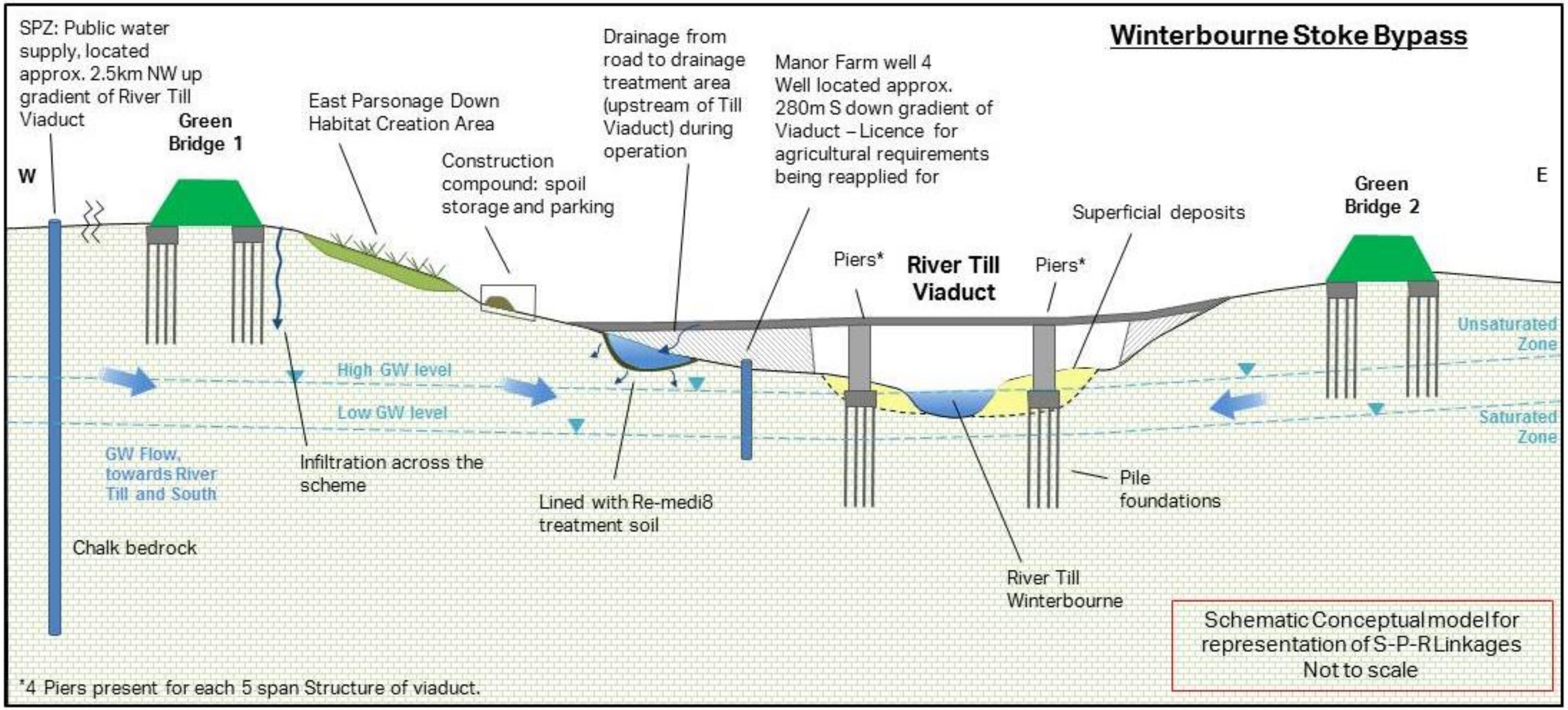


Figure 5.1: Proposed Winterbourne Stoke Bypass – Conceptual Illustration

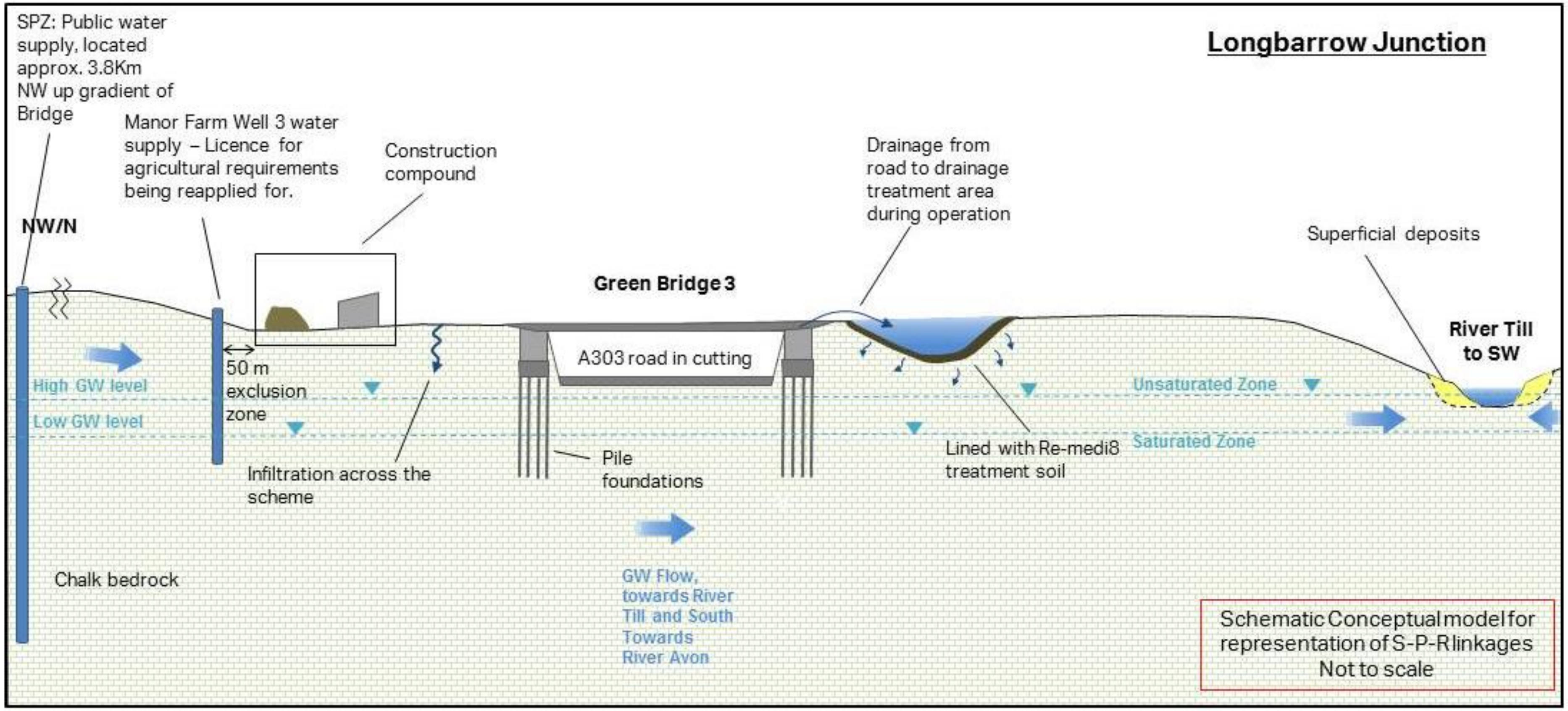


Figure 5.2: Proposed Longbarrow Junction – Conceptual Illustration

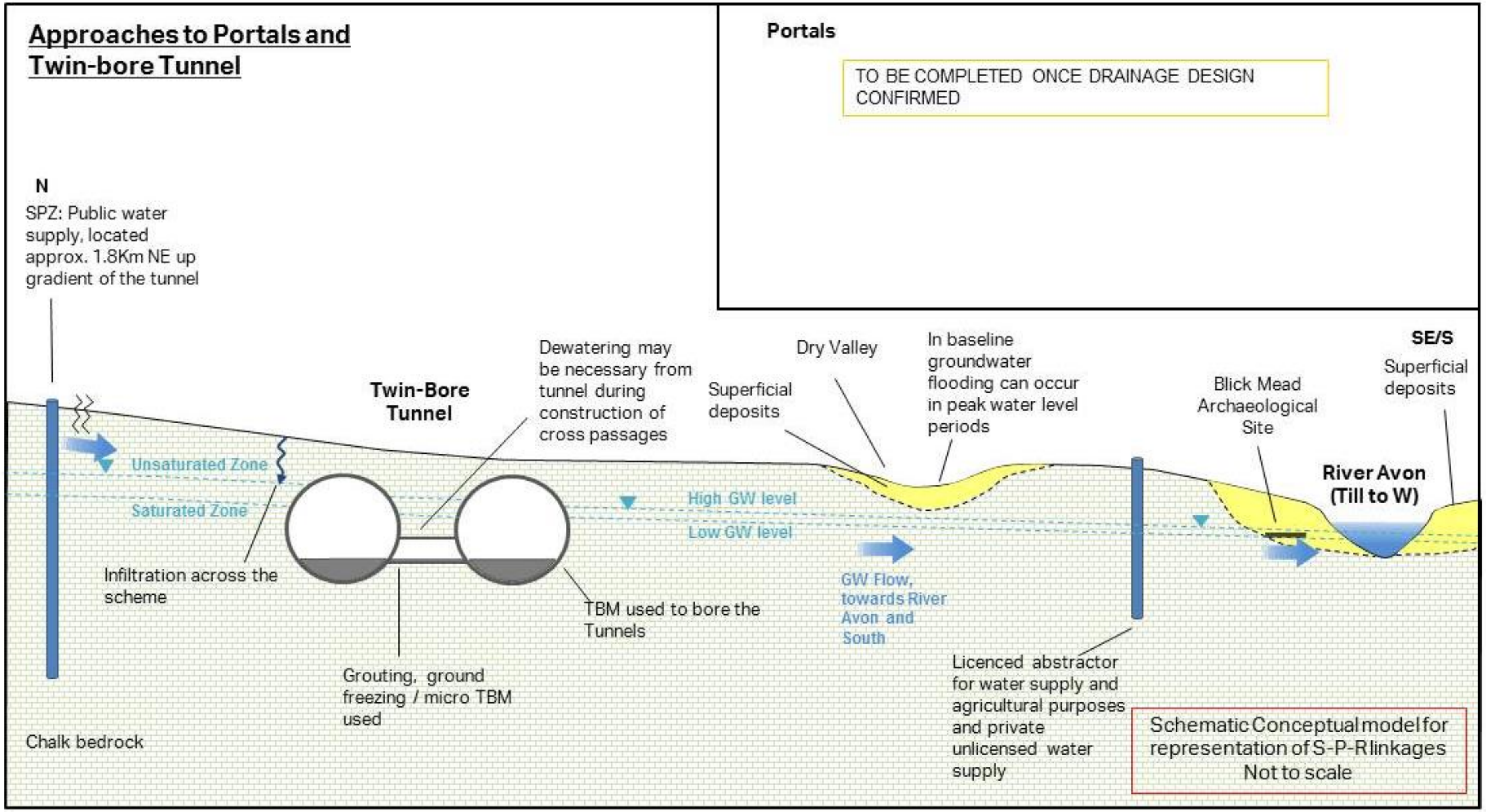


Figure 5.3: Proposed approaches to Portals and Twin-bore Tunnel – Conceptual Illustration

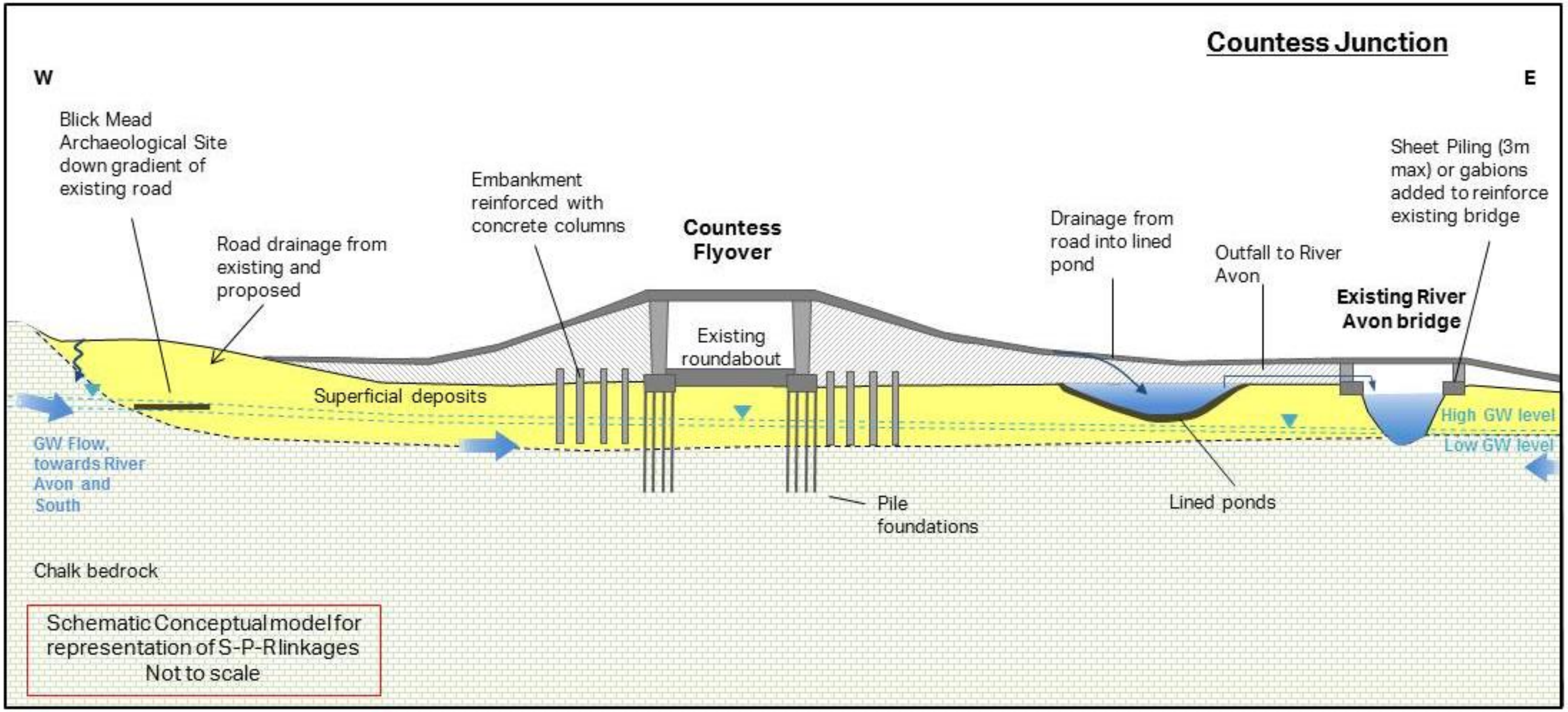


Figure 5.4: Proposed Countess Junction - Conceptual Illustration

6 Assessment of Groundwater Issues

6.1 Summary of issues

6.1.1 This section of the Groundwater Risk Assessment provides further detail and a quantitative assessment undertaken for the following potential impacts:

a) The construction and presence of cuttings, including the tunnel portals;

b) The construction of the foundations for road and Public Right of Way (PROW) bridges;

c) The construction of the River Till Viaduct piers;

d) The construction of the twin bored tunnel and associated cross passages; and,

e) Road drainage during the operation of the Scheme.

6.2 Cuttings

6.2.1 A number of cuttings are proposed for the scheme to allow the construction of the highway and the tunnel. In order to assess the risk of changes in groundwater flow paths and groundwater flooding, the full range of expected groundwater levels in the location of the cuttings needs to be considered. Table 6.1 presents the elevation of the deepest point of each cutting against the extreme peak groundwater levels and average high groundwater levels predicted by the Wessex Basin model utilised in the numerical model baseline (Annex 1).

Table 6.1: Scheme cuttings assessment

Cutting Name	Elevation of maximum depth of cutting (m AOD)	Extreme Peak Groundwater Elevation (m AOD)	Average High Groundwater Elevation (m AOD)	Likelihood of Groundwater Impact
Winterbourne Stoke cutting west	98	89.08	81.42	No impact anticipated as groundwater is below cutting
River Till cutting west	80	74.3	73.25	No impact anticipated as groundwater is below cutting
Green Bridge No 2 cutting	86.7	73.87	72.71	No impact anticipated as groundwater is below cutting
Longbarrow cutting west	94	74.23	72.85	No impact anticipated as groundwater is below cutting
Longbarrow cutting central	97.3	77.29	74.1	No impact anticipated as groundwater is below cutting
Longbarrow cutting east	100	80.13	75.22	No impact anticipated as groundwater is below cutting
Cutting approach to western portal	87.2	84.31	75.96	No impact anticipated as groundwater is below cutting
Western portal retaining wall	Tunnel base 81.00 Retaining walls - 64.4	84.47	76.86	There is a risk that the groundwater level could rise above the base of the cutting under extreme peak conditions. The impact of any

Cutting Name	Elevation of maximum depth of cutting (m AOD)	Extreme Peak Groundwater Elevation (m AOD)	Average High Groundwater Elevation (m AOD)	Likelihood of Groundwater Impact
				dewatering necessary will be localised.
Eastern portal retaining wall	Tunnel base 73.5 Retaining walls - 64.3	76.88	71.86	There is a risk that groundwater could rise above the base of the cutting under extreme peak conditions. The impact of any dewatering necessary will be localised.
Cutting approach to eastern portal	78.5	75.15	70.91	No impact anticipated as groundwater is below cutting
Amesbury cutting	76	71.70	69.07	No impact anticipated as groundwater is below cutting
Access Roads off Main Chainage				
New Longbarrow Junction Western diverge	100.7	81.17	75.62	No impact anticipated as groundwater is below cutting
New Longbarrow Junction Western merge	97.7	77.54	74.1	No impact anticipated as groundwater is below cutting
New Longbarrow Junction eastern diverge	96.4	78.86	74.7	No impact anticipated as groundwater is below cutting
New Longbarrow Junction eastern merge	100.7	81.17	75.63	No impact anticipated as groundwater is below cutting
Link to Winterbourne Stoke Cutting	103.9	78.73	74.14	No impact anticipated as groundwater is below cutting
Realigned A360 north	100.1	84.92	78.33	No impact anticipated as groundwater is below cutting
Realigned A360 south	111.5	79.77	74.56	No impact anticipated as groundwater is below cutting
Countess eastern diverge	71.1	68.83	67.71	No impact anticipated as groundwater is below cutting

6.2.2 The results of the analysis in Table 6.1 show that only the cuttings in the vicinity of the tunnel portals have the potential to intercept groundwater at extreme seasonal high levels and as such have a risk of changing flow paths or leading to groundwater flooding. The construction method used for the retaining walls will limit dewatering requirements. The retaining walls and the proposed drainage system will prevent groundwater flooding on the road with a drainage system used to pump any water collecting in the cutting and returning it to groundwater down hydraulic gradient of the tunnel to prevent any significant change in groundwater flow.

6.2.3 The presence of the retaining walls below the groundwater level has been incorporated into the numerical modelling presented in Annex 1.

6.3 Bridge and embankment foundations

6.3.1 A number of bridges are proposed to allow roads or PROWs to pass over or under the new highway. In order to assess if there is a risk of creating new groundwater flow paths or changes to existing flow paths, the full range of expected groundwater levels in the location of each of the bridges needs to be considered. Table 6.2 presents the elevation of the foundation depth, and the elevation of the base of any piling proposed against the extreme peak groundwater levels and average high groundwater levels predicted by the Wessex Basin model utilised in the numerical model baseline.

Table 6.2: Scheme bridge foundations assessment

Bridge Name	Elevation of maximum Foundation depth (m AOD)	Elevation of maximum pile depth (m AOD)	Extreme Peak Groundwater Elevation (m AOD)	Average High Groundwater Elevation (m AOD)	Likelihood of Groundwater Impact
Green Bridge One	101.0	81.0	78.78	74.59	No impact anticipated as groundwater is below structure
B3083 Underbridge	78.5	No piles proposed	75.07	73.78	No impact anticipated as groundwater is below structure
Green Bridge Two	84.6	64.6	73.87	72.71	Proposed piles extend below average high groundwater level
Green Bridge Three - Longbarrow Junction	98.7	67.1	78.86	74.7	Proposed piles extend below average high groundwater level
Green Bridge Four	95.9	75.9	81.17	75.63	Proposed piles extend below average high groundwater level
Countess Reinforced Embankment west	Modified Concrete Columns (MCC) 65.4	No piles proposed	68.47	67.83	Proposed MCC extend below average high groundwater level
Countess Flyovers 1 and 2	67.0	47.0	61.18	67.71	Proposed piles extend below peak groundwater level
Countess Reinforced Embankment east	MCC 64.5	No piles proposed	68.19	67.68	Proposed MCC extend below peak groundwater level
Existing River Avon Bridge	NA	Potential Sheet piling (to 3m max bgl) – 72.6	68.2	67.71	No impact anticipated as groundwater is below structure

6.3.2 The results of the analysis in Table 6.2 show that there are no bridge structures that will require dewatering for their foundation construction. Piles for Green bridges 2 to 4, and those for the Countess Flyovers will extend below the groundwater level. To reduce the risk of creating preferential pathways from the surface to the underlying Chalk groundwater body non-displacement construction methods, for example the continuous flight auger method (CFA) method of pile construction, will be used.

6.4 Till viaduct piers

6.4.1 The River Till is to be crossed by the Scheme via a twin deck, 5 span viaduct. Eight piers (4 per deck) are proposed to be constructed with a pile cap of 2m thickness approximately 1.3m below ground level. Piles will be constructed from these caps using non-displacement construction methods (for example CFA) to a depth of approximately 25m.

6.4.2 The construction of the pile cap may require dewatering if construction occurs when groundwater levels are high in the valley. The method of groundwater control employed will depend on the level of the water table. Battered excavations or piled cofferdams are possible methods proposed.

6.4.3 The construction methods used will also be low noise and vibration in the vicinity of the River Till and use a non-displacement construction method to reduce the risk of creating preferential pathways from the surface to the underlying Chalk groundwater body.

6.4.4 The presence of the underground piles for the piers will cause interference with groundwater flow, but this will be localised with groundwater moving around the low permeability material, and will not affect the overall groundwater flow to the River Till.

6.5 Tunnel

6.5.1 The twin-bore tunnel is to be constructed, which partially will be below the groundwater level in the Chalk. A Tunnel Boring Machine (TBM) is to be used to minimise the need to undertake dewatering during construction. The presence of the tunnel below the groundwater level will lead to interference to the groundwater flow in the Chalk aquifer. Numerical modelling (adapting the Wessex Basin model for the study area) has been undertaken to assess this risk and the magnitude of its impact on receptors. The explanation of the modelling undertaken and the presentation of the results are in Annex 1.

Extreme high groundwater level flood conditions

6.5.2 The presence of the tunnel leads to the prediction of increases in groundwater level up hydraulic gradient of the tunnel due to the baseline groundwater flow to the south being impeded. Under the extreme peak groundwater levels that are representative of the conditions when groundwater flooding occurs in the area an increase in groundwater levels of the order of 0.5 to 1.0m occurs within a distance of approximately 500m from the tunnel. This increase in groundwater levels leads to an increase in vulnerability to groundwater flooding (when levels are either above ground level or within 2m of the ground) only in small parts of the Stonehenge Bottom valley area north of the tunnel. There are no receptors susceptible to flooding in this area except the existing A303 road.

6.5.3 Table 6.3 shows the predicted increase in water levels at the abstraction receptors and monitoring boreholes up hydraulic gradient of the tunnel under the extreme peak groundwater level conditions, and under average groundwater conditions. The levels predicted are considered to be of negligible magnitude of impact on the abstraction receptors as they would not affect the use/integrity of these. Accordingly, the significance of the effects is neutral.

Table 6.3: Predicted groundwater level increase up hydraulic gradient

Abstraction/Borehole	Increase at Extreme Peak Groundwater Conditions (m)	Increase at Average Groundwater Conditions (m)
Wiltshire Grain Ltd	0.05	0.02
Shrewton Lodge Stud	0.01	0.01
Wessex Water Services Ltd Durrington A-C	0.02	0.01
English Heritage Borehole at Point 'A' Airman's Corner	0.13	0.03
English Heritage Borehole at Point 'B' Airman's Corner	0.11	0.03
Manor Farm Well 1	0.08	0.02
Manor Farm Well 2	0.00	0.00
Manor Farm Well 3	0.02	0.01
RX512A	0.02	0.01
RX509	0.32	0.08
RX508A	0.24	0.08
RX506	0.07	0.03
RX507A	0.09	0.03
RX510A	0.17	0.04

6.5.4 The model predicts negligible changes in flow to the rivers. In the River Avon flow changes average approximately 200m^3/d compared to flows in excess of 1,000,000m^3/d, a predicted change of less than 0.1%. Flows are around 100m^3/d higher in the River Till compared to approximately 300,000 m^3/d, a predicted change of less than 0.1%. As such the impact of these changes is not considered significant.

Low groundwater level conditions

6.5.5 The presence of the tunnel leads to the prediction of decreases in the groundwater level down hydraulic gradient due to the groundwater flow to the south locally being impeded. Under the extreme low groundwater levels that are representative of the drought conditions that were present in 1976, there is limited change to groundwater levels (0.05m up hydraulic gradient, 0.02m down hydraulic gradient) as the tunnel creates less impedance to flow when groundwater levels are lower.

6.5.6 Under the average groundwater conditions, the model predicts a decrease in groundwater levels of the order of 0.025m to 0.05m locally down hydraulic gradient to the tunnel, with an increase of 0.02m to 0.2m occurring locally up hydraulic gradient (Figure 4.6 in Annex 1).

6.5.7 Table 6.4 shows the predicted fall in water levels (where these are above zero) at the abstraction receptors, monitoring boreholes and springs down hydraulic gradient of the tunnel under the drought (extreme low) groundwater level conditions, and under average groundwater conditions. The levels of impact predicted are considered to be of negligible magnitude on the abstraction receptors as they would not affect the use/integrity of these. Accordingly the significance of the effect is neutral.

Table 6.4: Predicted groundwater level decrease down hydraulic gradient

Abstraction/Spring/Borehole	Decrease at Extreme Drought Groundwater Conditions (m)	Decrease at Average Groundwater Conditions (m)
Trustees of Lake Settlement Estate Wilsford-Cum-Lake Borehole B (This is the closest licensed abstraction but does not appear to be in use)	0.01	0.03
Amesbury Abbey Spring (located close to Blick Mead Archaeological site)	0.00	0.00
West Amesbury 1	0.01	0.02
West Amesbury 2	0.02	0.04
Spring Bottom Farm	0.01	0.03
Lake Winterbourne	0.00	0.00
Gallows Hill Springs	0.01	0.01
R503B	0.00	0.00
PX506	0.02	0.10
R158	0.01	0.02
RX513A	0.01	0.02

6.5.8 There are no changes in groundwater levels predicted in the area of the River Avon floodplain which supports a groundwater dependent ecosystem for the Desmoulin's whorl snail that is part of the SAC designation. As such no impacts are expected on this receptor.

6.5.9 Under the drought conditions model, it is predicted that groundwater levels would rise slightly up hydraulic gradient of the tunnel, but the increased levels predicted at each of the abstractor locations (up to a maximum of 0.011m at the English Heritage Borehole at Point 'A' Airman's Corner) are negligible and therefore not considered a significant benefit.

6.5.10 The model predicts negligible changes in flow in any reach of the River Avon or the River Till at low flows in an average year. In the River Avon flow changes average approximately 20m^3/d compared to flows in excess of 100,000m^3/d, a predicted change of less than 0.1%. Flows are up to 25m^3/d higher in the River Till from approximately 15,000m^3/d flow, an increase of approximately 0.2%. The impact of these changes is considered to be not significant. Accordingly the significance of the effect is neutral.

6.5.11 Under the drought conditions the model predicts negligible changes in flow in both rivers. Flow changes in the River Avon average approximately 20m^3/d compared to flows averaging approximately 70,000m^3/d, a predicted change of less than 0.1%. No flow changes are predicted in the River Till, as during drought conditions there is very little flow in this river.

Cross-passage tunnels

6.5.12 The two tunnel bores would be connected underground by a series of cross passages at regular intervals to allow for the safe evacuation of road users in the event of an incident in one of the tunnels.

6.5.13 Construction techniques will be used which minimise the need for dewatering. Such techniques could include micro tunnel boring machines, ground freezing and grouting. If localised dewatering is necessary, this will be undertaken from within the tunnel and the pumped water will be removed via tanker or other approved route. The impacts of dewatering will be minimal, such that effects are negligible.

6.6 Operational phase

6.6.1 During the operational phase of the Scheme, impacts on groundwater largely are related to water quality due to an improved road drainage system. Under normal conditions, there will be no significant impact on groundwater levels, flow and quantity.

6.6.2 Currently road drainage from the existing A303 drains to the side of the road and infiltrates to ground with any land drainage (surface water runoff) from road ditches without any treatment. For the Scheme land drainage will be kept separate from road drainage and returned to the aquifer through land drainage ditches. This will be of a positive benefit to groundwater quality in the area.

6.6.3 Road drainage is to be captured by a new drainage scheme and directed to grassed infiltration basins to the west of the tunnel or infiltration crate systems in the vicinity of the tunnel portals. Carrier pipes will be used to ensure that any spillages are contained within the drainage system and do not infiltrate to ground prior to reaching the infiltration basins. Tunnel drainage is to be captured in a separate system with all contaminated runoff collecting in an impounding sump and removed by tanker. Further detail of the drainage system is given in the Environmental Statement.

6.6.4 The drainage ditches to the north of the Blick Mead archaeological area, are to be maintained to ensure that there is no change in drainage infiltration in the area that could be supporting the saturated conditions reserving the Mesolithic remains. The remaining drainage system in the Countess Roundabout area is to be upgraded to lined ponds that will allow the passive treatment of drainage prior to release to the River Avon at the existing outfall(s).

6.6.5 All the discharge features are to be designed to release water at greenfield runoff rates ensuring there is no change in groundwater flow. All the mainline drainage features (excluding the lined ponds at the Countess Junction) are to include a filtration treatment system. This treatment system will be maintained by Highways England. The drainage systems on the A360 and new side road to Winterbourne Stoke will be the responsibility of Wiltshire Council following their adoption into the local road scheme. The proposed system here is designed to replicate the existing regime.

6.6.6 HEWRAT assessments have been completed for the proposed drainage system provided within another appendix to the road drainage and water environment chapter of the ES. For the drainage systems involving discharge to ground, and therefore the groundwater environment, a slight improvement on the spillage risk is estimated, but this is not enough to reach the 50% improvement threshold for a minor benefit.

7 Risk Management and Monitoring

7.1 Risk management

7.1.1 The predicted impact on groundwater levels from the presence of the tunnel has been developed for the vertical alignment presented within the numerical model report. Deviation from the modelled alignment would need to ensure that the impacts on receptors remain negligible. The limits of deviation will be influenced by the area where the design intersects the identified preferential flow zone between 69m and 73m AOD.

7.1.2 The risk of encountering preferential flow zones will be managed by further ground investigation to inform the detailed design. Packer tests and geophysical investigations are to be carried out along with pumping tests in the Phosphatic Chalk and in the Coneybury Hill area. Further site specific ground investigation will be needed at the location of the cross-passages to inform the construction method.

7.1.3 Further assessment of the groundwater levels and groundwater quality likely to be present in the vicinity of the tunnel portals, and for the construction of the cross-passages will be made through groundwater level monitoring and the collection and analysis of water samples from monitoring boreholes and pumping tests.

7.2 Groundwater monitoring strategy

7.2.1 The numerical modelling undertaken to inform the assessment of the impact of the presence of the tunnel requires monitoring to validate the predicted impacts. These monitoring requirements will be delivered as part of the OEMP and DCO requirements.

7.2.2 The following groundwater monitoring strategy for the tunnel impacts will be supplemented with local site specific monitoring plans as required for any construction dewatering. These site specific plans will be agreed with the EA and WC.

7.2.3 The following groundwater monitoring strategy has been discussed with the EA and WC. If agreed the EA may adopt some of the groundwater monitoring boreholes as part of their groundwater flood warning system after the agreed period of post construction monitoring.

7.2.4 Monitoring at Amesbury Abbey and around Blick Mead is detailed in Annex 3.

Objectives

7.2.5 The objective of the groundwater monitoring strategy is to validate the predicted groundwater level change both north and south of the tunnel section of the Scheme. This will provide groundwater level and groundwater quality information. Trigger levels for notification of changes beyond those predicted will be developed towards the end of the baseline monitoring period and prior to the commencement of construction.

7.2.6 The groundwater level monitoring system is to be maintained on a telemetry system so that the EA and WC can also view the observed water levels.

Groundwater quality monitoring will be reported to the EA in the programme outlined below.

Programme

7.2.7 The monitoring will be undertaken during a baseline period, construction, and a minimum 5 year period post construction (as required by WC). Table 7.1 provides the schedule for monitoring in these periods.

Table 7.1: Groundwater monitoring scheme

Monitoring Measurements	Frequency of Monitoring		
	Baseline	Construction	Post-Construction (5 years minimum)
Groundwater Level – by level logger	Hourly readings to be taken	Hourly readings to be taken	Hourly readings to be taken
Groundwater Level – validation data	Quarterly	Monthly	Quarterly – every six months
Groundwater Quality	Quarterly	Quarterly	Quarterly – every six months

7.2.8 Groundwater quality monitoring will be undertaken for a range of parameters during the baseline period, as detailed in Table 7.2. Further parameters will be added as required once tunnel construction fluids are confirmed. Following the baseline period, the suite of parameters to be monitored may be refined to highlight those relevant to those sourced from construction and operation only.

Table 7.2: Groundwater quality baseline parameters

Determinands	Details of measured determinands	Method of Analysis	Limit of Detection
pH		Determination of pH (Metrohm)	0.01pH units
Dissolved Oxygen		Oxygen Meter	1mg/l
Alkalinity	Total Alkalinity as $CaCO_3$	Metrohm	1mg/l
	Bicarbonate Alkalinity	Metrohm	1mg/l
	Carbonate Alkalinity as $CaCO_3$	Metrohm	1mg/l
	Dissolved Alkalinity	Metrohm	1mg/l
Total Dissolved Solids		Gravimetric - BSEN15216	35mg/l
Electrical Conductivity		Metrohm	2µS/cm
Inorganic Elements	Ammoniacal Nitrogen as N	Kone analyser	0.03mg/l
	Chloride	Kone analyser	0.3mg/l
	Nitrate as NO_3	Kone analyser	0.2mg/l
	Nitrite as NO_2	Kone analyser	0.02mg/l
	Sulphate	Kone analyser	0.5mg/l
	Fluoride	ISE (Ion Selective Electrode) using modified ISE method 340.2	0.3mg/l

Determinands	Details of measured determinands	Method of Analysis	Limit of Detection
Phosphate	SRP Ortho-Phosphate as PO_4	Kone analyser	0.03mg/l
	MRP Ortho-Phosphate as P	Kone analyser	0.06mg/l
Cyanide	Free cyanide	Flow injection	0.01mg/l
	Total cyanide	Flow injection	0.01mg/l
Dissolved Organic Carbon		Infra Red	2mg/l
Metals Dissolved	Arsenic(2.5), Cadmium(0.5), Chromium(1.5), Copper(7), Lead(5), Mercury(1), Iron(20), Nickel(2), Selenium(3), Zinc(3), Boron(12), Molybdenum(2), Manganese(2), Phosphorus(5), Antimony(2), Beryllium(0.5)	ICP-OES (Dissolved unless requested otherwise) low level available	As indicated in brackets (µg/l)
Metals Total	**TOTAL** Cadmium(0.5), Copper(7), Zinc(3), Iron(20), Phosphorus(5)	ICP-OES (Dissolved unless requested otherwise)	As indicated (µg/l)
Earth Metals	Calcium(0.2), Manganese(0.1), Potassium(0.1), Sodium(0.1)	ICP-OES	As indicated (mg/l)
Chromium	Hexavalent Chromium	Kone analyser	0.006mg/l
	Trivalent Chromium	Calculation from Total and Hex Cr	0.006mg/l
Turb	Turbidity	Meter	0.1 NTU
Phenol	Total monohydric phenols - HPLC	HPLC	0.1mg/l
Polyaromatic Hydrocarbons (PAH) 16	PAH 16 by GC-MS	Polynuclear Aromatic Hydrocarbons by GC-MS. Extraction using solvent. In house method modified USEPA 8270.	0.1-0.018µg/l
Total Petroleum Hydrocarbons (TPH)	(Aliphatics C5-6,>6-8,>8-10,>10-12,>12-16,>16-21,>21-35) (Aromatics >C5-7,>7-8,>8-10,>10-12,>12-16,>16-21,>21-35) inc Benzene, toluene, ethylbenzene and xylene (BTEX) and MTBE	C5-10 fractions by Headspace GC-FID (036W). C10-35 fraction extracted with hexane, aliphatic/aromatic splits run by GC-FID (005W).	10µg/l (BTEX/ MTBE 5µg/l)
Polychlorinated biphenyl (PCB)	PCB 7 congeners	7 congeners (101,118,138,153,180,28,52) by GC-MS	0.1µg/l
Organophophorus Pesticides	21 compounds	GC-MS	0.01µg/l

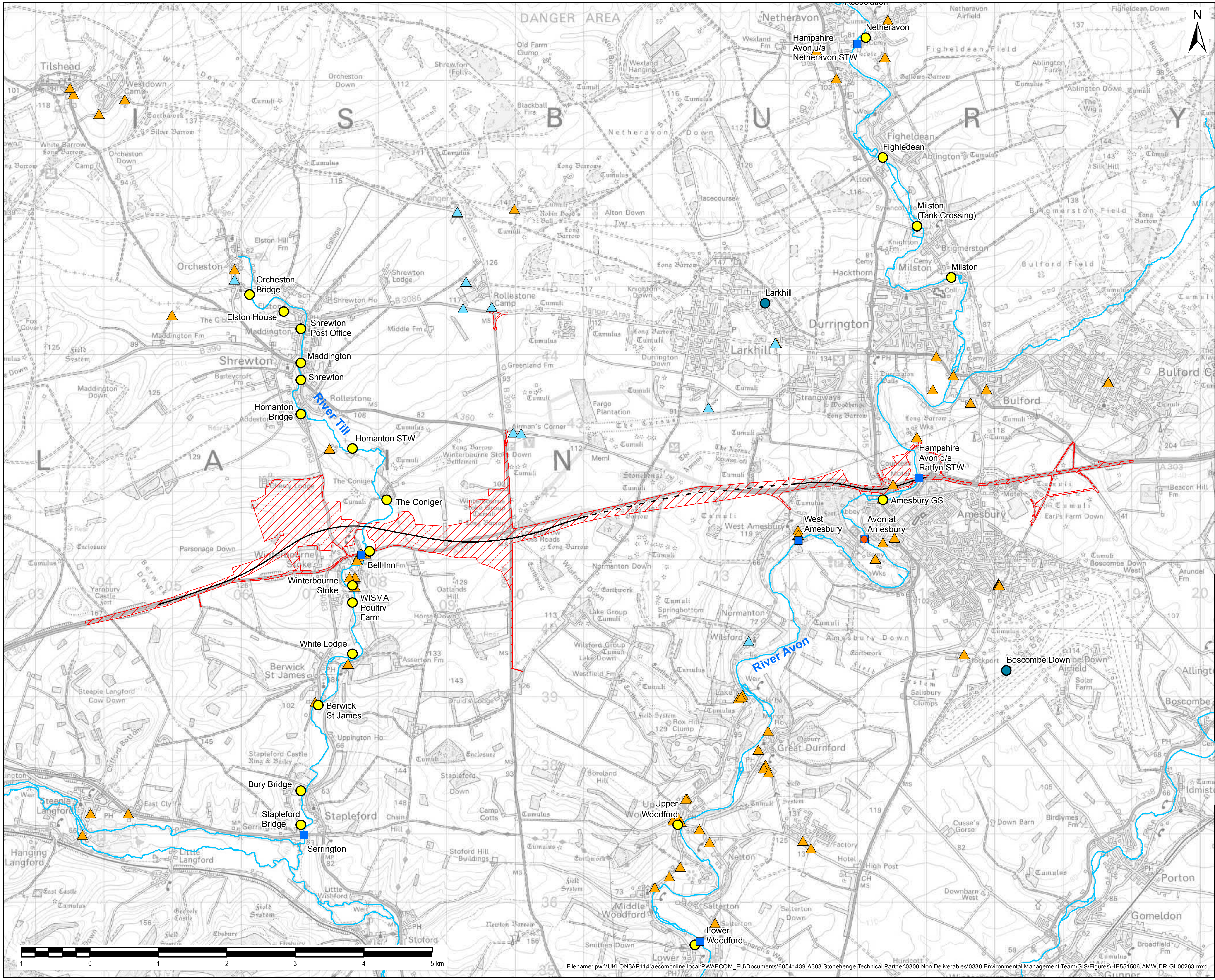
Locations

7.2.9 The existing available monitoring boreholes are proposed to be utilised for on-going monitoring where possible, along with additional boreholes installed for detailed design purposes in the vicinity of the western portal and the tunnel, the East Parsonage Down habitat creation area, and potentially in the vicinity of Druids Lodge and Rollestone Corner to provide monitoring of the wider catchment suitable for the EA groundwater flood warning system.

7.2.10 Table 7.3 provides the strategy behind the location and length of time the boreholes are to be maintained. Those highlighted in grey are located in the Phosphatic Chalk area.

Table 7.3: Current groundwater baseline monitoring locations

Borehole ID	Period of Monitoring Proposed	Location in Relation to Tunnel or wider Scheme	Rationale for Monitoring Period
PX505A	Baseline and Construction	Down hydraulic gradient	Will provide monitoring for the impact on groundwater levels during construction.
PX506	Baseline, Construction and Post Construction	Down hydraulic gradient	Will provide monitoring for the impact on groundwater levels.
R503B	Baseline, Construction and Post Construction	Down hydraulic gradient	Borehole is located down hydraulic gradient of the Western Portal and will provide monitoring for the impact on groundwater levels.
R507A	Baseline, Construction and Post Construction	Close to the Eastern Portal	Will provide monitoring of any impact on groundwater levels towards the area of the Blick Mead Archaeological Site
RX506	Baseline and Construction	Up hydraulic gradient	Borehole will allow wider pattern of groundwater flow to be monitored through construction. The borehole is affected by abstraction in the area
RX507A	Baseline and Construction	Up hydraulic gradient	Borehole will allow wider pattern of groundwater flow to be monitored through construction. The borehole is affected by abstraction in the area
RX508A	Baseline, Construction and Post Construction	Up hydraulic gradient	Will provide monitoring of any impacts on groundwater levels from the tunnel
RX509	Baseline, Construction and Post Construction	Up hydraulic gradient	Will provide monitoring of any impacts on groundwater levels from the tunnel
RX510A	Baseline, Construction and Post Construction	Up hydraulic gradient	Will provide monitoring of any impacts on groundwater levels from the tunnel
RX511B	Baseline, Construction and Post Construction	Till Valley	To confirm wider limits of extent of any changes to groundwater level in a borehole located in the Till valley, and monitor any changes associated with infrastructure in the Till valley
RX512A	Baseline, Construction and Post Construction	Till Valley	To confirm wider limits of extent of any changes to groundwater level in a borehole located in the Till valley, and monitor any changes associated with infrastructure in the Till valley
RX513A	Baseline, Construction and Post Construction	Down hydraulic gradient	Monitoring borehole to assess extent of impact on groundwater levels
RX514A	Baseline, Construction and Post Construction	Down hydraulic gradient	To confirm wider limits of extent of any changes to groundwater level
R158	Baseline, Construction and Post Construction	Down hydraulic gradient	Borehole monitored in 2003 period so will be retained to provide long term data comparisons



NOTES / LEGEND

- Indicative centreline
- Proposed tunnel
- WFD River Waterbody
- Proposed scheme boundary
- Environment Agency Current Rainfall Monitoring Station
- Environment Agency Flow Accretion Monitoring Site
- Environment Agency Flow Gauge Location
- Environment Agency Surface Water Quality Monitoring Location

Discharge Consents

- Discharge to ground
- Discharge to surface water

Revision Details	By Check	Date	Suffix

Purpose of issue: FINAL

Client: Highways England

Working on behalf of highways england

Project Title: A303 AMESBURY TO BERWICK DOWN

Drawing Title: APPENDIX 11.4 FIGURE 3.1 ENVIRONMENT AGENCY SURFACE WATER MONITORING

Designed	Drawn	Checked	Approved	Date
AB	KD	HC	CC	31/08/18

Internal Project No. 60547200

Scale @ A3: 1:50,000 | Zone: SW

Highways England
Temple Quay House
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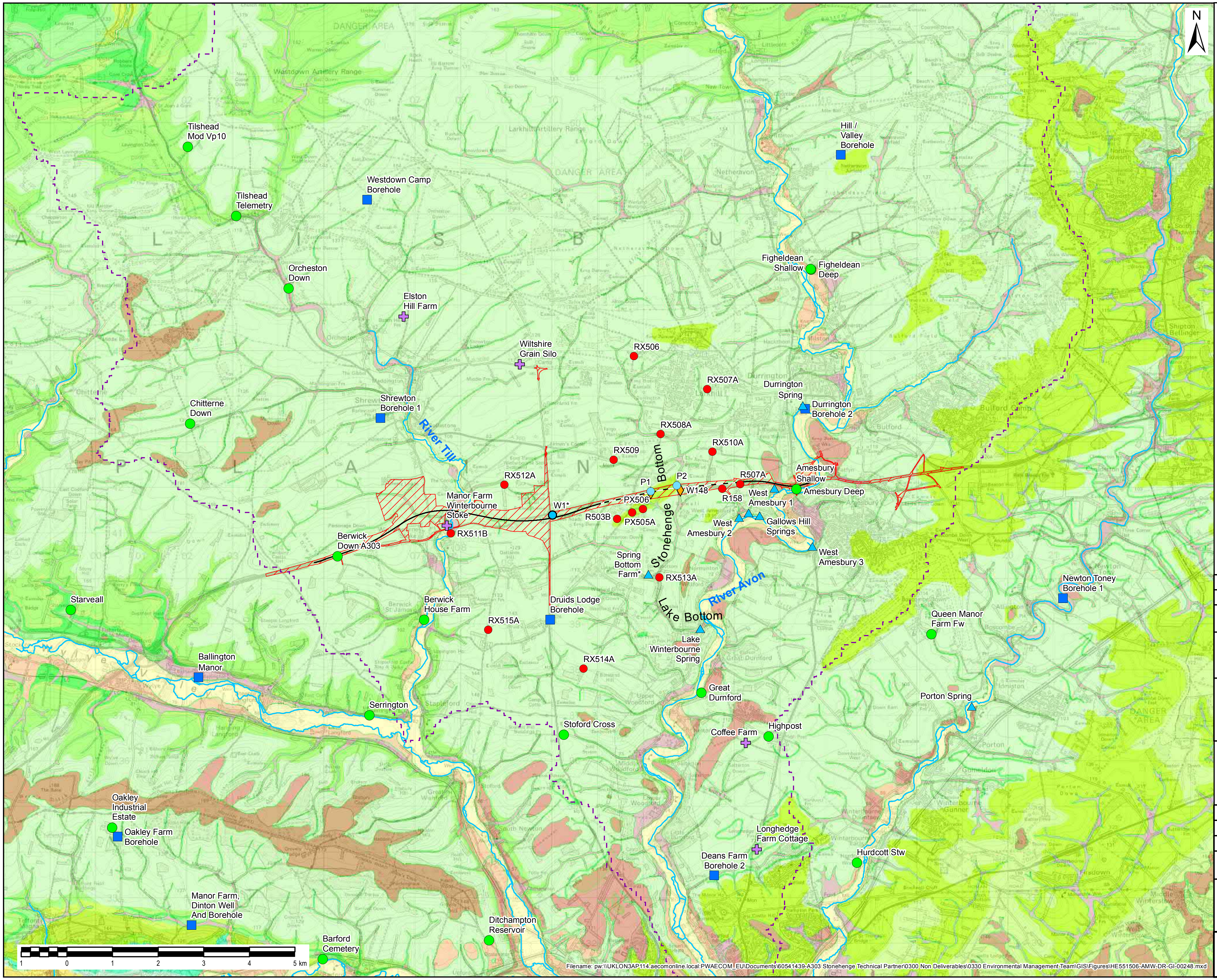
AmW AECOM + mace + WSP

Drawing Number

Highways England PIN	Originator	Volume	Rev
HE551506	AMW	GEN	01

Location	Type	Role	Number
SCHEME WIDE	DR	GI	00263



NOTES / LEGEND

- Indicative centreline
- Proposed tunnel
- WFD River Waterbody
- Proposed scheme boundary
- Boundary of wider study area
- Current Monitoring Borehole
- Historic Piezometer
- Spring
- Environment Agency Groundwater level Monitoring Borehole
- Environment Agency Water Quality Monitoring Borehole
- Environment Agency Disused Monitoring Borehole
- Historic Pump Test Borehole

Geology Legend

- Lewes Nodular Chalk Fn
- Newhaven Chalk Fn
- Seaford Chalk Fn
- Stockbridge Rock Mb - Limestone
- Head - Gravel
- Head - Clay, Silt Sand & Gravel
- River Terrace Deposits
- Alluvium
- Clay with Flints Fn

Notes:

Abbey Spring previously labelled Blick Mead Spring on PEIR Figure 11.1.

* Approximate location

Revision Details	By	Check	Date	Suffix

Purpose of issue: FINAL

Client: Highways England — Working on behalf of highways england

Project Title: A303 AMESBURY TO BERWICK DOWN

Drawing Title: FIGURE 3.2 GEOLOGY AND GROUNDWATER MONITORING LOCATIONS

Designed	Drawn	Checked	Approved	Date
AB	KD	HC	CC	31/08/18

Internal Project No. 60547200

Scale @ A3: 1:75,000 — Zone: SW

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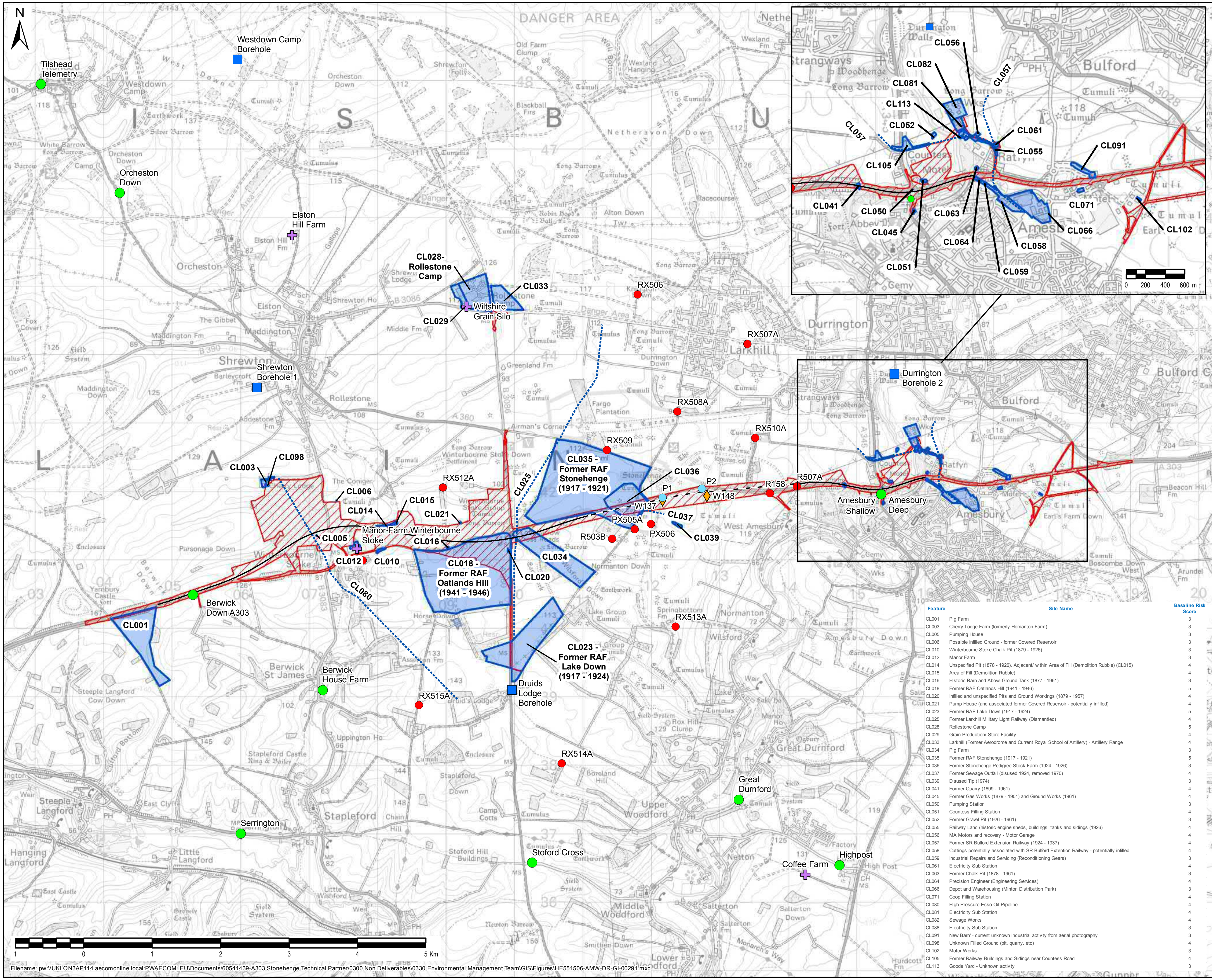
Drawing Number

Highways England PIN	Originator	Volume	Rev
HE551506	AMW	GEN	01
SCHEME WIDE	DR	GI	00254
Location	Type	Role	Number



NOTES / LEGEND

- Indicative centreline
- Proposed tunnel
- Proposed scheme boundary
- Potential Land Use Source
- Potential Linear Land Use Source
- Current Monitoring Borehole
- Historic Piezometer
- Environment Agency Groundwater level Monitoring Borehole
- Environment Agency Water Quality Monitoring Borehole
- Environment Agency Disused Monitoring Borehole
- Historic Pump Test Borehole

Feature	Site Name	Baseline Risk Score
CL001	Pig Farm	3
CL003	Cherry Lodge Farm (formerly Homanton Farm)	3
CL005	Pumping House	3
CL006	Possible Infilled Ground - former Covered Reservoir	3
CL010	Winterbourne Stoke Chalk Pit (1879 - 1926)	3
CL012	Manor Farm	3
CL014	Unspecified Pit (1878 - 1926). Adjacent/ within Area of Fill (Demolition Rubble) (CL015)	4
CL015	Area of Fill (Demolition Rubble)	4
CL016	Historic Barn and Above Ground Tank (1877 - 1961)	3
CL018	Former RAF Oatlands Hill (1941 - 1946)	5
CL020	Infilled and unspecified Pits and Ground Workings (1879 - 1957)	4
CL021	Pump House (and associated former Covered Reservoir - potentially infilled)	4
CL023	Former RAF Lake Down (1917 - 1924)	5
CL025	Former Larkhill Military Light Railway (Dismantled)	4
CL028	Rollestone Camp	5
CL029	Grain Production/ Store Facility	4
CL033	Larkhill (Former Aerodrome and Current Royal School of Artillery) - Artillery Range	4
CL034	Pig Farm	3
CL035	Former RAF Stonehenge (1917 - 1921)	5
CL036	Former Stonehenge Pedigree Stock Farm (1924 - 1926)	3
CL037	Former Sewage Outfall (disused 1924, removed 1970)	4
CL039	Disused Tip (1974)	3
CL041	Former Quarry (1899 - 1961)	4
CL045	Former Gas Works (1879 - 1901) and Ground Works (1961)	4
CL050	Pumping Station	3
CL051	Countess Filling Station	4
CL052	Former Gravel Pit (1926 - 1961)	3
CL055	Railway Land (historic engine sheds, buildings, tanks and sidings (1926)	4
CL056	MA Motors and recovery - Motor Garage	4
CL057	Former SR Bulford Extension Railway (1924 - 1937)	4
CL058	Cuttings potentially associated with SR Bulford Extention Railway - potentially infilled	4
CL059	Industrial Repairs and Servicing (Reconditioning Gears)	3
CL061	Electricity Sub Station	4
CL063	Former Chalk Pit (1878 - 1961)	3
CL064	Precision Engineer (Engineering Services)	4
CL066	Depot and Warehousing (Minton Distribution Park)	3
CL071	Coop Filling Station	4
CL080	High Pressure Esso Oil Pipeline	4
CL081	Electricity Sub Station	4
CL082	Sewage Works	4
CL088	Electricity Sub Station	3
CL091	New Barn' - current unknown industrial activity from aerial photography	3
CL098	Unknown Filled Ground (pit, quarry, etc)	4
CL102	Motor Works	3
CL105	Former Railway Buildings and Sidings near Countess Road	4
CL113	Goods Yard - Unknown activity	3

Revision Details	By / Check	Date	Suffix

Purpose of issue: FINAL

Client: Highways England

Working on behalf of highways england

Project Title: A303 AMESBURY TO BERWICK DOWN

Drawing Title: APPENDIX 11.4 FIGURE 3.3 POTENTIALLY CONTAMINATED LAND USES

Designed	Drawn	Checked	Approved	Date
CM	KD	CC	CM	31/08/18

Internal Project No. 60541200

Scale @ A3: 1:50,000 | Zone: SW

Highways England
Temple Quay House
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AmW AECOM + mace + WSP

Drawing Number: Highways England PIN | Originator | Volume: HE551506 AMW GEN
Location | Type | Role | Number: SCHEME WIDE DR GI 00291
Rev: 01

Filename: pw:\\UKLON3AP114.aecomonline.local:PWAECOM_EU\Documents\60541439-A303 Stonehenge Technical Partner\0300 Non Deliverables\0330 Environmental Management Team\GIS\Figures\HE551506-AMW-DR-GI-00291.mxd

NOTES / LEGEND

- Indicative centreline
- Proposed tunnel
- Proposed scheme boundary
- Wider Study Area
- Typical High groundwater levels
- Typical Low groundwater levels
- WFD River Waterbody
- Current Monitoring Borehole
- Historic Piezometer
- Spring
- Environment Agency Groundwater level Monitoring Borehole
- Environment Agency Water Quality Monitoring Borehole
- Environment Agency Disused Monitoring Borehole
- Historic Pump Test Borehole

Notes:

Abbey Spring previously labelled Blick Mead Spring on PEIR Figure 11.1.

* Approximate location

	Revision Details	By Check	Date	Suffix

Purpose of issue: FINAL

Client: Highways England

Working on behalf of highways england

Project Title: A303 AMESBURY TO BERWICK DOWN

Drawing Title: APPENDIX 11.4 FIGURE 3.8 ENVIRONMENT AGENCY REGIONAL MODEL GROUNDWATER ELEVATION CONTOURS

Designed	Drawn	Checked	Approved	Date
AB	KD	HC	CC	31/08/18

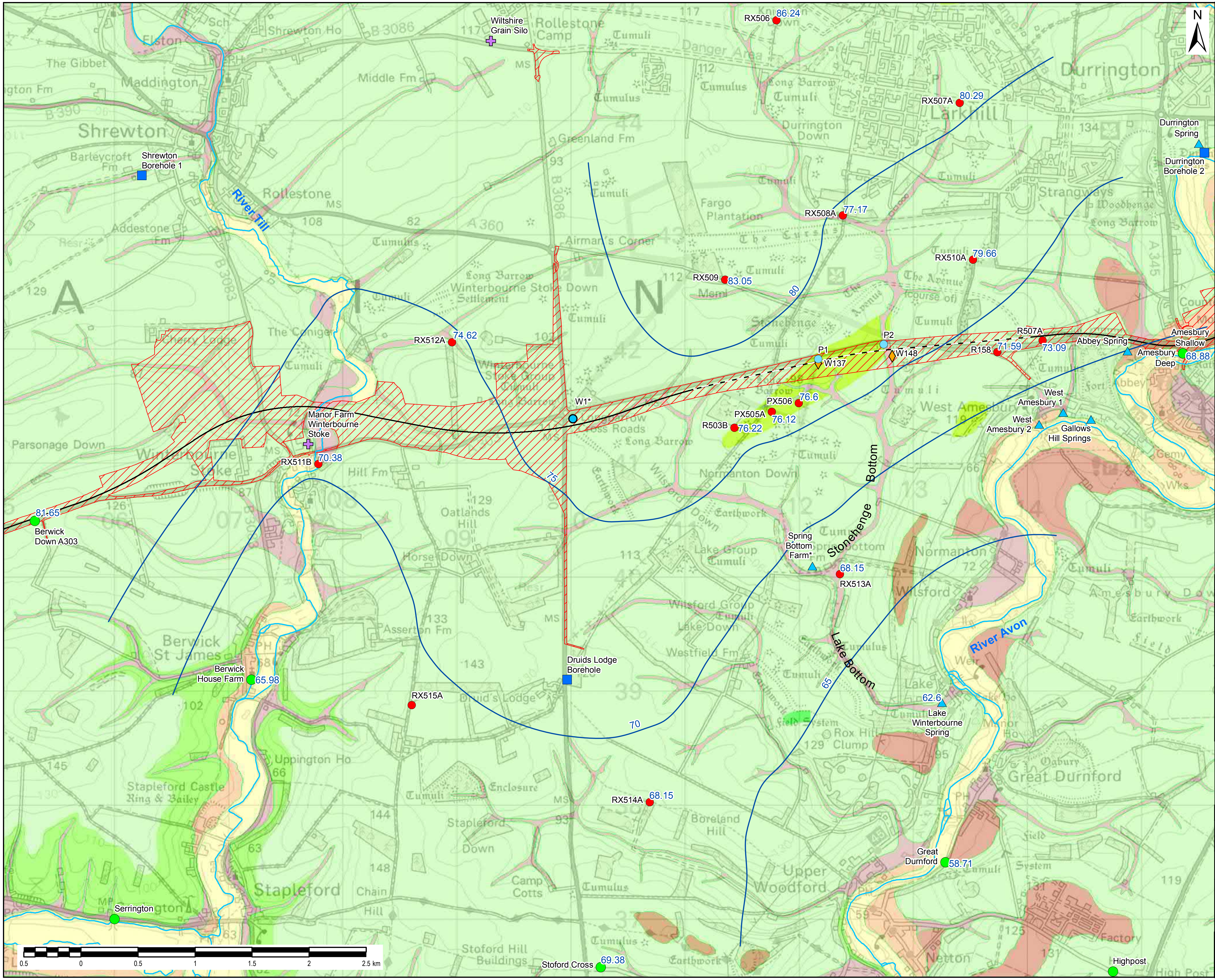
Internal Project No. 60547200

Scale @ A3: 1:75,000 | Zone: SW

Highways England
Temple Quay House
2 The Square, Temple Quay
Bristol
BS1 6HA

AmW AECOM + mace + WSP

Drawing Number Highways England PIN	Originator	Volume	Rev
HE551506	AMW	GEN	01
SCHEME WIDE (Location)	DR (Type)	GI (Role) 00259 (Number)	



NOTES / LEGEND

- Indicative centreline
- Proposed tunnel
- Proposed scheme boundary
- Groundwater Elevation Contour April 2018
- XX.XX Groundwater Elevation recorded in April 2018
- Environment Agency Groundwater level Monitoring Borehole
- Environment Agency Water Quality Monitoring Borehole
- Environment Agency Disused Monitoring Borehole
- Current Monitoring Borehole
- Historic Piezometer
- Historic Pump Test Borehole
- Spring
- WFD River Waterbody

Geology Legend

- Lewes Nodular Chalk Fn
- Newhaven Chalk Fn
- Seaford Chalk Fn
- Stockbridge Rock Mb - Limestone
- Head - Gravel
- Head - Clay, Silt Sand & Gravel
- River Terrace Deposits
- Alluvium
- Clay with Flints Fn

Notes:

Abbey Spring previously labelled Blick Mead Spring on PEIR Figure 11.1.

* Approximate location

Revision Details	By	Check	Date	Suffix

Purpose of issue: FINAL

Client: Highways England

Working on behalf of highways england

Project Title: A303 AMESBURY TO BERWICK DOWN

Drawing Title: APPENDIX 11.4 FIGURE 3.9 GROUNDWATER ELEVATION CONTOURS APRIL 2018

Designed	Drawn	Checked	Approved	Date
AB	KD	HC	CC	31/08/18

Internal Project No. 60547200

Scale @ A3: 1:30,000 | Zone: SW

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AmW
AECOM + mace + WSP

Drawing Number: Highways England PIN | Originator | Volume: HE551506 AMW GEN
Location | Type | Role | Number: SCHEME WIDE DR GI 00260
Rev: 01

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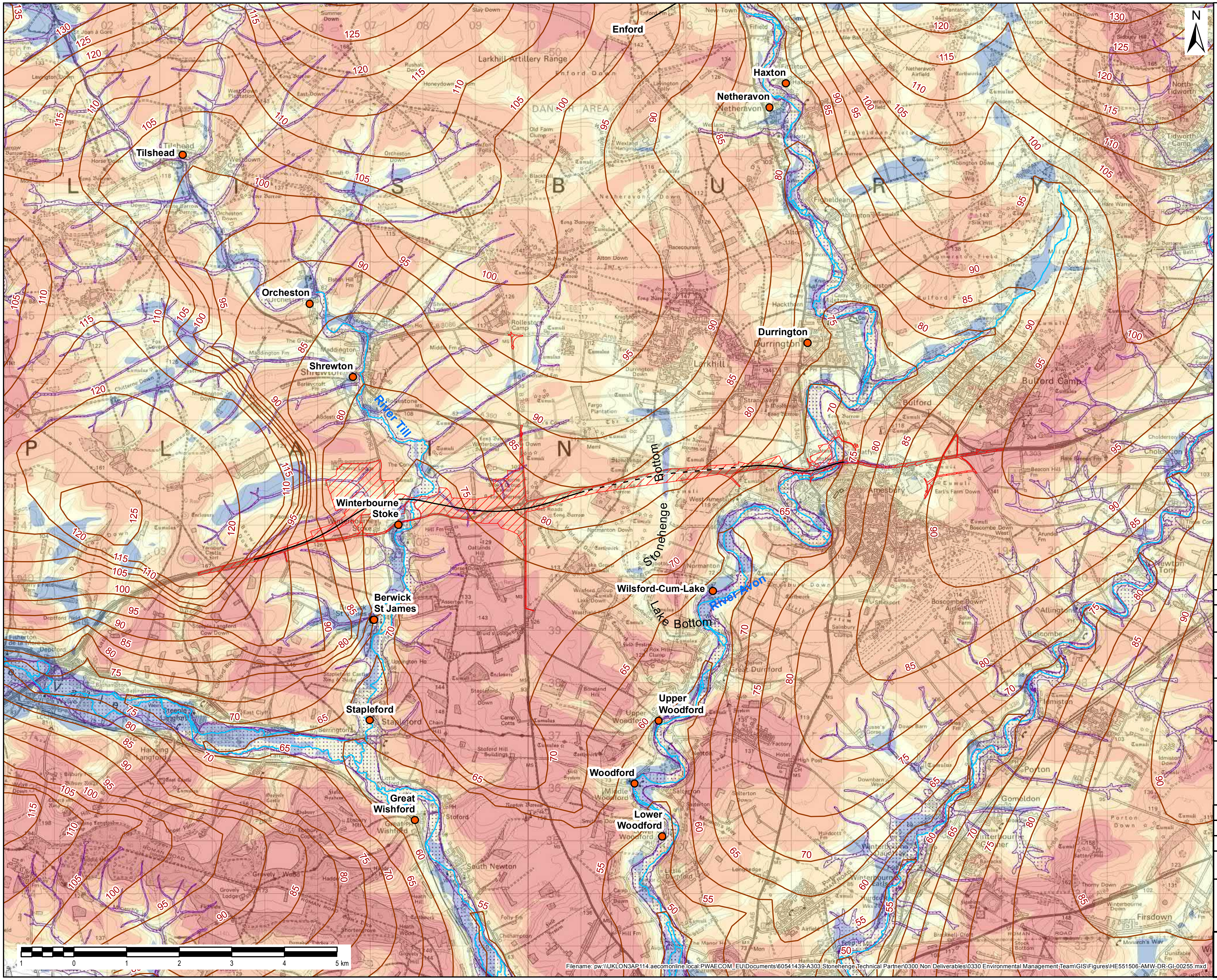

NOTES / LEGEND

- Indicative centreline
- Proposed tunnel
- Proposed scheme boundary
- EA Flood Warning Area
- Extreme high groundwater levels based on the 2013-2014 water level data
- WFD River Waterbody
- Historic Groundwater Flooding Location

Groundwater Flooding Vulnerability (Scale shows peak groundwater level below ground level (m))(from Wessex Basin Model groundwater levels)

- Above ground level -2
- 2.1 - 10
- 10.1 - 20
- 20.1 - 40
- > 40

Revision Details	By / Check	Date	Suffix

Purpose of issue: FINAL

Client: Highways England

Working on behalf of highways england

Project Title

A303 AMESBURY TO BERWICK DOWN

Drawing Title

APPENDIX 11.4
FIGURE 3.10
GROUNDWATER FLOODING

Designed	Drawn	Checked	Approved	Date
AB	KD	HC	CC	31/08/18

Internal Project No. 60547200

Scale @ A3: 1:65,000 | Zone: SW

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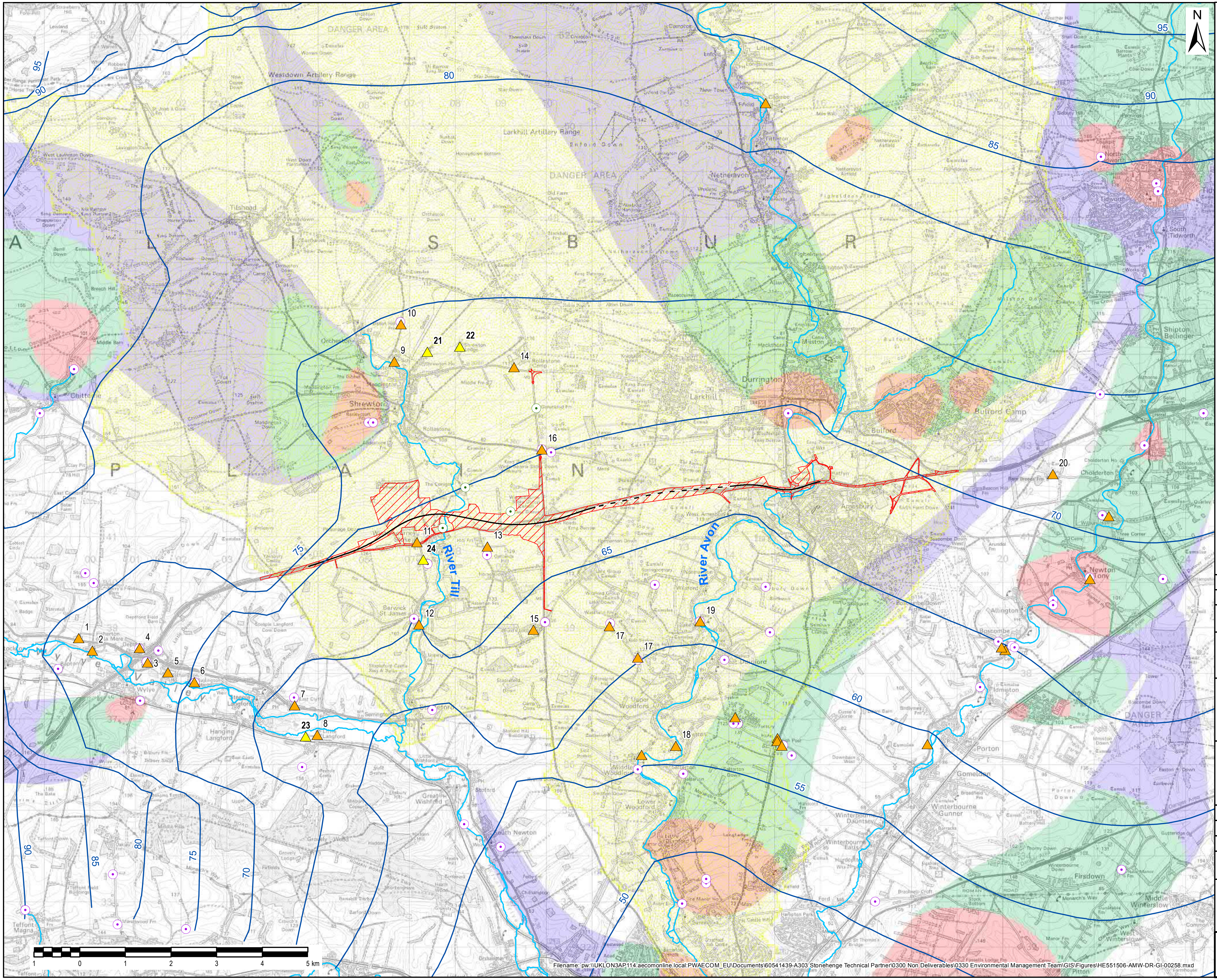
Drawing Number

Highways England PIN	Originator	Volume	Location	Type	Role	Number	Rev
HE551506	AMW	GEN	SCHEME WIDE	DR	GI	00255	01

Filename: pw:\\UKLON3AP114.aecomonline.local:PWAECOM_EU\Documents\60541439-A303_Stonehenge_Technical Partner\0300_Non Deliverables\0330 Environmental Management Team\GIS\Figures\HE551506-AMW-DR-GI-00255.mxd



NOTES / LEGEND

- Indicative centreline
- Proposed tunnel
- Proposed scheme boundary
- Licensed EA Groundwater Abstraction (symbol has diameter of 200m)
- Pending EA Licence Groundwater Abstraction (symbol has diameter of 200m)
- Wiltshire Council Private Water Supplies
- Other Private Water Supplies
- XX Water Features Survey ID
- Drought conditions based on the 1976 groundwater levels
- WFD River Waterbody
- Wider Study Area

EA Source Protection Zones

- Zone I - Inner Protection Zone
- Zone II - Outer Protection Zone
- Zone III - Total Catchment

Revision Details	By	Check	Date	Suffix

Purpose of issue

FINAL

Client

Highways England

Working on behalf of highways england

Project Title

A303 AMESBURY TO BERWICK DOWN

Drawing Title

APPENDIX 11.4 FIGURE 3.11 GROUNDWATER ABSTRACTION AND SOURCE PROTECTION ZONES

Designed	Drawn	Checked	Approved	Date
AB	KD	HC	CC	31/08/18

Internal Project No. 60541200

Scale @ A3 1:75,000 | Zone SW

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Highways England PIN	Originator	Volume	Rev
HE551506	AMW	GEN	01

Location	Type	Role	Number
SCHEME WIDE	DR	GI	0258

Abbreviations List

AOD	Above Ordnance Datum
bgl	Below ground level
BGS	British Geological Survey
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
OEMP	Outline Environment Management Plan
CFA	Continuous Flight Auger
DCO	Development Consent Order
DMRB	Design Manual for Roads and Bridges
DWS	Drinking Water Standard
EA	Environment Agency
ES	Environmental Statement
GRA	Groundwater Risk Assessment
HEWRAT	Highways England Water Risk Assessment Tool
MCC	Modified Concrete Columns
MoD	Ministry of Defence
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated biphenyl
PROW	Public Right of Way
PWS	Private Water Supplies
RBMP	River Basin Management Plan
SAC	Special Area of Conservation
SPZ	Source Protection Zone
SSSI	Special Site of Scientific Interest
TBM	Tunnel Boring Machine
TPH	Total Petroleum Hydrocarbons
WC	Wiltshire Council
WFD	Water Framework Directive
WHS	World Heritage Site

Glossary

Abstraction	The taking of water from either a ground or surface (river) resource
Accretion	The growth or increase by the gradual accumulation of flow.
Aquifer	A subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater
Discharge	Putting water back to the ground or to a surface (river) water resource
Groundwater	All water that is below the surface of the ground in the saturation zone (below the water table).
HEWRAT	Highways England Water Risk Assessment Tool
Hydraulic conductivity	Property of soils and rocks, that describes the quantification of the ease with which a fluid (usually water) can move through pore spaces or fractures
Hydraulic gradient	A measure of the change in groundwater head (or level) over a given distance. The maximum groundwater flow will normally be in the direction of the maximum hydraulic gradient.
Interfluve	An area of higher ground between the valleys of two rivers in the same drainage system.
Leaching	The washing out of a soluble constituent from a solid material.
Permeability	The capability of a porous rock or sediment to permit the flow of fluids through its pore spaces
Principal aquifer	Defined by the Environment Agency. 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 baseflow on a strategic scale.
Secondary aquifer	Defined by the Environment Agency. These are layers of rock or drift deposits that have some permeable layers that may capable of supporting water supplies at a local scale, and in some cases forming an important source of baseflow to rivers, or layers that may store and supply limited amounts of groundwater.
Source Protection Zone	Defined by the Environment Agency. These zones show the risk of contamination from any activities that might cause pollution of a water supply borehole in the area. The maps show three main zones (inner, outer and total catchment).
Water Framework	A European Union directive that commits European Union member

Directive	states to achieve good qualitative and quantitative status of all water bodies (including marine waters up to kilometre from shore) by 2015.
Winterbourne	A winterbourne is a stream or river that is dry through the summer months, due to the groundwater table falling below the level of the stream's bed, causing it to dry out.

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Ref 3.2 River Avon Nutrient Management Plan

Ref 3.3 Killeen IJ (2003) Ecology of Desmoulin's Whorl Snail. Conserving Natura 2000 Rivers Ecology Series No. 6. English Nature Peterborough.

Ref 3.4 David Jacques and Tom Philips with contributions by Peter Hoare, Barry Bishop, Tony Legge and Simon Parfitt, "Mesolithic settlement near Stonehenge: excavations at Blick Mead, Vespasian's Camp, Amesbury," 2014

Ref 3.5 http://www.landis.org.uk/soilscapes/index.cfm

Ref 3.6 Soil Survey of England and Wales (1983) - 1:250,000 scale Soil Map of South East England. Rothamsted Experimental Station, Harpenden

Ref 3.7 R.N. Mortimore. Making sense of Chalk: a total-rock approach to its engineering geology. The Eleventh Glossop Lecture. Quarterly Journal of Engineering and Hydrogeology 45, 252-334. 2012

Ref 3.8 AAJV. Preliminary Sources Study Report, 2016.

Ref 3.9 R.N. Mortimore, et al. Stonehenge – a unique Late Cretaceous phosphatic Chalk geology: implications for sea-level, climate and tectonics and impact on engineering and archaeology. Proceedings of Geological Association 2017.

Ref 3.10 A303 Stonehenge Improvement, Preliminary Geotechnical report (Balfour Beatty-Costain Halcrow Gifford, 2006)

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Ref 3.13 WJ Groundwater. A303 Stonehenge Improvement: Summer Pumping Tests - Interpretative Report, 2004.

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Ref 3.17 https://flood-warning-information.service.gov.uk/warnings

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Ref 3.19 Environment Agency, The Hampshire Avon Management Catchment: A summary of information about the water environment in the Hampshire Avon management catchment, 2014

Ref 4.1 Historic England, "Preserving Archaeological Remains: Appendix 3 - Water Environment Assessment Techniques," Historic England, 2016

Ref 5.1 Environment Agency, The Environment Agency's approach to groundwater protection. Version 1.2, 2018.

Ref 5.2 https://www.gov.uk/guidance/groundwater-risk-assessment-for-your-environmental-permit

Ref 5.3 Defra Government's Guidelines for Environmental Risk Assessment and Management, Green Leaves III, 2011

A303 Amesbury to Berwick Down

TR010025

6.3 Environmental Statement Appendices

Appendix 11.4 Annex 1 Numerical Model Report

Volume 6

APFP Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

October 2018

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1 Introduction

1.1.1 This report provides detail on the construction of a regional, numerical groundwater model that has been used to support the Environmental Statement in terms of the assessment of environmental impacts to groundwater, stream flow, water abstractions, sensitive environmental features and the risk of groundwater flooding of the Scheme.

1.1.2 The report is structured as follows:

a. Chapter 2 – Baseline Model. Describes the Environment Agency Wessex Basin groundwater model construction, calibration, and approach to using it.
b. Chapter 3 – Outlines modifications to the Wessex Basin model, changing model time period and aquifer properties based on scheme alignment ground investigation data. Compares the new calibration with the original model. Simulation of the tunnel in the model.
c. Chapter 4 – Model predictions at peak, average and drought groundwater level conditions, including river flows and groundwater level changes. A climate change scenario compares the baseline to climate change and to climate change with the tunnel.
d. Chapter 5 – Conclusions. Summary of how the Wessex Basin model was used and modified and its use in assessing the impacts of the scheme on groundwater and water dependent features.
e. References – list of references given within the document.

2 Baseline Model

2.1 Information sources

2.1.1 Between 2003 and 2017 the Environment Agency (EA) and Wessex Water have jointly been developing a MODFLOW groundwater model of the Chalk aquifer in Dorset, Wiltshire and Hampshire.

2.1.2 Originally several numerical models were created in which the Wylye and Nadder model covered the study area. This model was merged with other adjacent models (Bourne and Nine Mile) to form the Hampshire Avon model, and later this was merged with the Dorset area models (Frome and Piddle) to form a single model of the Chalk aquifer, named the Wessex Basin model.

2.1.3 These models were developed on behalf of the EA and Wessex Water by the consultants Amec (now Wood). Mott MacDonald provided peer review as part of the stakeholder group. The model is used to inform various environmental investigations.

2.1.4 This model therefore represents an accepted tool for use in assessing impacts to the water environment. AmW liaised with the EA on behalf of HE to use the model as a tool for considering the potential impacts of the proposed tunnel scheme. This approach meant that all interested parties would be using an accepted model as a starting point, which would be followed by ongoing consultation regarding the model calibration in the area of interest and local improvements that may be made. The edited version is a standalone model developed within Groundwater Vistas.

2.1.5 The model areal coverage and the area of interest for this study are shown in Figure 2.1.

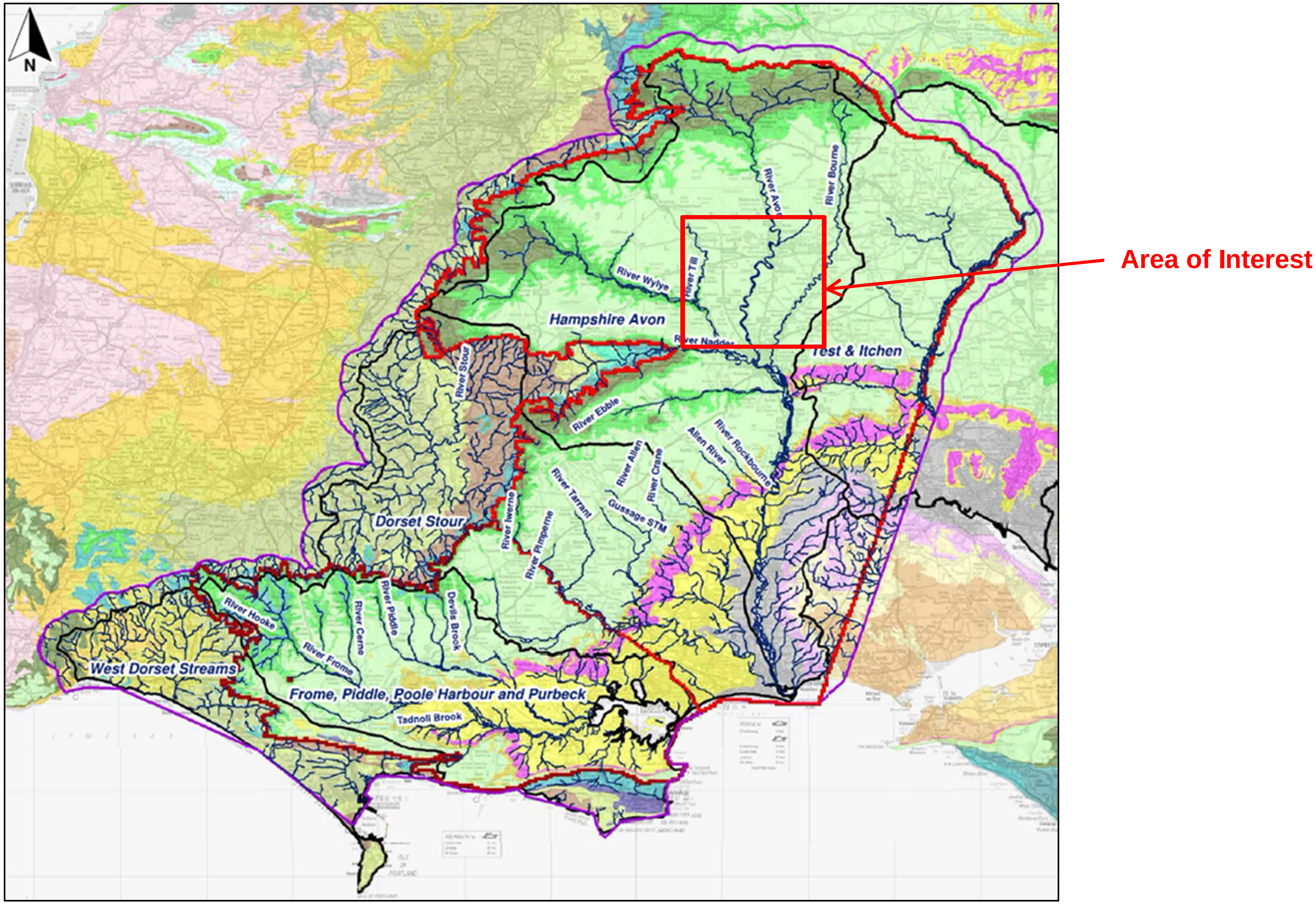

Figure from Environment Agency, 2011. Wessex Basin Groundwater Modelling Study. Phase 4 final report (prepared by Entec UK)

Figure 2.1 Wessex Basin Groundwater Model and area of interest

2.2 Wessex Basin Model structure

2.2.1 The Wessex Basin model was developed to simulate groundwater flow in the Chalk and Upper Greensand aquifers. The overlying Paleogene aquifer (Reading Beds) and London Clay were included in order to simulate stream flow over the confined aquifer to the estuaries. In the scheme area, the Chalk is the aquifer of interest.

2.2.2 The model comprises separately a recharge model and a groundwater model. The recharge model was developed using the 4R code, which requires inputs of rainfall, potential evaporation (PE), land use, soil type, geology, crop type, and urban mains leakage. Runoff is routed according to digital terrain mapping (Panorama DTM) and stream cells are mapped according to the Ordnance Survey mapping and extended into dry valleys of known or potential groundwater flooding.

2.2.3 Stream cells comprise a bed elevation and conductance to allow groundwater / surface water interaction. Surface water abstractions and discharges are input to the stream cells and take or add water to the flow in the appropriate cell. Runoff is routed to each stream cell. Details of the 4R setup can be found in the model report (EA, 2011).

2.2.4 The recharge model calculates recharge to the underlying aquifer and runoff to streams, directly and via interflow, and can accommodate bypass recharge where appropriate. The model creates a MODFLOW recharge file and stream file for use as input to the groundwater model.

2.2.5 The recharge and groundwater model are set up on the same cartesian grid that comprises 250m x 250m cells, extending 125km east to west and 102km north to south, giving 500 columns and 408 rows.

2.2.6 The models have the same time period consisting of 10 day stress periods (each month contains three stress periods, 10 day, 10 day, and remainder – 8, 9, 10 or 11 days). Over the model period this equates to 1872 stress periods.

2.2.7 The model run time is 1965 to 2016. The period 1965 to 1969 is a warm up period containing climate sequences for an average year which means the model can be well calibrated at periods of interest early in the simulation period, such as the 1976 drought.

2.2.8 The groundwater model comprises three layers representing London Clay and Reading Beds (Layer 1), Chalk (Layer 2), and Upper Greensand (Layer 3). The model boundaries are the rivers Bourne and Test in the east, designed to ensure the entire Avon catchment is within the model area and does not form a boundary (which would affect its calibration and usability). All other boundaries are the edge of the outcrop of Chalk or Upper Greensand (usually Upper Greensand is present and forms the boundary).

2.2.9 Layer elevations were derived from a geological model developed by the British Geological Survey (BGS). Elevations for each model cell were interpolated from borehole data to create a base of Palaeogene, base of Chalk, and base of Upper Greensand.

2.2.10 In the groundwater model setup these layers were modified to reflect likely active sections of the aquifers, with the base of layer 2 (Chalk) raging from the base of the Chalk to minimum water level minus 90m. The base of layer 3 (Upper Greensand) was modified in the same way (EA, 2011).

2.2.11 Aquifer properties were based on pumping test information and conceptual understanding such as the variation in the Chalk permeability between valley and interfluve areas, and older and younger Chalk. Variable hydraulic conductivity with depth (VKD) was implemented in some areas where a change in groundwater level pattern was observed above and below certain elevations; or conceptually-based, such as related to high permeability Chalk units (hard grounds such as the Chalk Rock), and to simulate the higher permeability in the shallow zone of water table fluctuation compared to the deeper Chalk (i.e. limiting the high permeability to the upper horizons rather than over the full layer thickness).

2.2.12 Despite implementing VKD, the model still calculates one overall transmissivity for the cell for each stress period based on the VKD properties across the full saturated thickness, rather than discrete permeability zones based on the location of hard grounds and the known flow horizons. Therefore while attempting to be a more accurate representation of aquifer properties it is still a general approximation.

2.2.13 Groundwater abstraction data was compiled from EA and Wessex Water data and input to the groundwater model. These data are generally monthly values and these were split into average daily rates per 10 day stress period (hence the resolution is generally monthly). There are 420 groundwater abstraction locations in the Wessex Basin model area.

2.3 Regional model calibration

2.3.1 Numerous model runs were undertaken from the starting input parameters, with various modifications to achieve a good calibration of groundwater level and stream flow. Details of the changes and sensitivity analysis are in the model report (EA, 2011).

2.3.2 The calibration was considered acceptable through discussion with the stakeholder group. This process involved reviewing time series hydrographs of groundwater level and stream flow, flow accretion profiles, groundwater contours, and flow duration curves.

2.3.3 It is recognised that it is difficult to obtain a good groundwater level calibration everywhere due to the local heterogeneity of the aquifer that is not known and cannot be simulated, whereas if flows are calibrated well then most of the water in a catchment is being simulated correctly most of the time, while the local groundwater level may be variably too high or too low at different locations across a catchment.

2.3.4 As a result the calibration was considered acceptable if stream flow, flow duration and accretion were accurate and if groundwater level patterns were accurate (seasonal trends) even if absolute groundwater level was several metres too high or too low.

2.3.5 Overall the model calibrates well to average conditions, typical summer lows and winter highs, as well as drought periods. The model simulates extreme highs above the normal range but absolute groundwater levels may be 10m or so too low. This is because the stress period setup tends to average out intense rainfall events preventing the model from producing extreme peaks, and also because extreme high groundwater levels are rare events. Pumping tests have not been completed at these times to estimate aquifer properties for the highest groundwater elevations of the aquifer.

2.3.6 Data on locations of groundwater flooding was sought from the EA and Wiltshire Council (WC) in order to assess the calibration against areas of known flooding. One location was confirmed as groundwater flooding with detailed elevation information in the study area (Tilshead Pub). The groundwater model also predicted groundwater levels above ground in this location with the modelled elevation simulated to be 1.4m higher than observed. This was considered a good calibration for predictive purposes.

2.3.7 Other anecdotal evidence of groundwater flooding was also provided by Wessex Water and is described in Table 2.1 below with comparison with model predictions as an indicator of the model's fitness for use at extreme high groundwater levels.

Table 2.1 Description of areal flood issues and model prediction

Anecdotal evidence	Model prediction
TILSHEAD – This catchment has been identified as suffering from groundwater inundation of the foul sewer network and during periods of elevated groundwater levels, Operations will deploy tankers to reduce the levels of surcharge in the system. We have an Infiltration Reduction Plan (IRP) in place, also an Operational Management Action Plan (OMAP).	Groundwater levels above ground level in Tilshead area
ORCHESTON – Similar to Tilshead. We have an IRP in place, also an OMAP. Operations will deploy tankers to reduce the levels of surcharge in the system.	Groundwater levels above ground level in Orcheston area
SHREWTON – Similar to Tilshead. We have an IRP in place, also an OMAP. Operations will deploy tankers to reduce the levels of surcharge in the system.	Groundwater levels above ground level in Shrewton area
BERWICK ST JAMES – Properties suffer restricted toilet use caused by groundwater inundation of the foul sewer network.	Groundwater levels above ground level in Berwick St James area
DURRINGTON – This is not on our database of catchments that suffer from groundwater infiltration.	Groundwater levels below ground level in excess of 5m in area outside river flood plain
AMESBURY – This is not on our database of catchments that suffer from groundwater infiltration.	Groundwater levels below ground level in excess of 5m in area, except southern Amesbury where groudnwater levels 2-3m below ground
WEST AMESBURY –not aware of any specific problems in West Amesbury	Village on edge of floodplain, floodplain model cell predicts groundwater levels less than 1m below ground, valley side model cell groundwater levels up to 7m bdelow ground.

Source: Wessex Water via Wiltshire Council

2.4 Study area calibration

2.4.1 The study area is generally contained within the area between the River Till and the River Wylye downstream of the confluence with the River Till in the west, and the River Avon in the east.

2.4.2 A gauging station is available to compare observed and simulated flows at South Newton on the River Wylye and at Amesbury on the River Avon. Flows are modelled well at both locations.

2.4.3 Groundwater level measurements are available from the EA Berwick Down borehole in the Till catchment from 2002-2016, and from observations made at some ground investigation boreholes along the proposed tunnel route. These measurements were made between 2001 and 2006.

2.4.4 Groundwater levels at Berwick Down are calibrated well in terms of seasonal trends, the rate of rising groundwater levels through the winters and the rate of recession in the spring and summer. Simulated groundwater levels are typically up to 2m too high during the summer low point and up to 5m too low at winter highs. Therefore overall the seasonal pattern is more subdued than the observed seasonal variation. However at extreme high groundwater levels such as 2001, 2003, and 2014 simulated levels are typically up to 10m too low. This is also the case at monitoring sites along the alignment and at the EA OBH at Wiltshire Grain Silo as well as Berwick Down.

2.4.5 The groundwater flow pattern is well calibrated, showing groundwater flow south into the Stonehenge Bottom valley area from the north, with flow to the west to discharge to the River Till and flow east to the River Avon. The overall flow regime is in keeping with the IGS hydrogeological map interpretation (IGS, 1979).

3 Groundwater Model Development

3.1 Time Period

3.1.1 The Wessex Basin model was adapted for use in the study area firstly by reducing the run times and file sizes. Rather than one model running from 1965 to 2016 several models were created with short run times for the periods of interest. The models are 'hot-started' using groundwater levels from the previous stress period to the starting date from the Wessex Basin model, and therefore the models do not need a warm up period.

3.1.2 The first period of interest is during periods of extreme high groundwater levels in order to assess the impact of the tunnel on the potential for groundwater flooding and to predict changes in maximum groundwater level. For this model the peak period is February 2014, and so a model run time from November 2013 to June 2014 was created using all the Wessex Basin model input data, to simulate the rate of rise of groundwater levels to the peak level, and then falling back through the summer of 2014.

3.1.3 The second period of interest is low groundwater levels during drought, to simulate whether low flows in the rivers Avon and Till are exacerbated by the presence of the tunnel. For this condition a model covering the worst drought on record was constructed, running from autumn 1975 through to summer 1977.

3.1.4 An average period model was also constructed so that models across the full flow profile could be simulated and impact assessments for the proposed tunnel undertaken. The conceptual study (EA, 2011) describes 1995 as an average climatic year and so a model covering the hydrological years 1994 to 1996 was developed, that is from April 1994 to the end of March 1996.

3.1.5 The models were first run with the Wessex Basin model aquifer properties and layering. Subsequent refinements would then be considered to improve the calibration and how to most appropriately simulate the way the proposed tunnel could interfere with groundwater flow.

3.2 Layering

3.2.1 The baseline model contains one Chalk layer representing the active Chalk aquifer. This is layer 2 and is the layer of interest for the study area.

3.2.2 VKD allows variation in Chalk hydraulic conductivity through the vertical section of the layer but the ultimate effect is to calculate one value of hydraulic conductivity per cell per stress period.

3.2.3 With a single layer of Chalk the different stratigraphic horizons are not explicitly accounted for, as it does not allow different transmissivities at different depths. The approach enables higher transmissivities than would otherwise be calculated with a rising water table only, using a hydraulic conductivity gradient up to a limiting value so that the transmissivity does not rise above a value considered realistic.

3.2.4 Previous investigations in the study area have postulated that there are low, medium and high permeability flow horizons in the Chalk beneath the tunnel alignment area and therefore the VKD approach does not explicitly represent this.

The objective of the model setup is to approximate the overall bulk aquifer properties in each cell, which at any given location may be achieved by a single hydraulic conductivity value or a VKD approach may be appropriate.

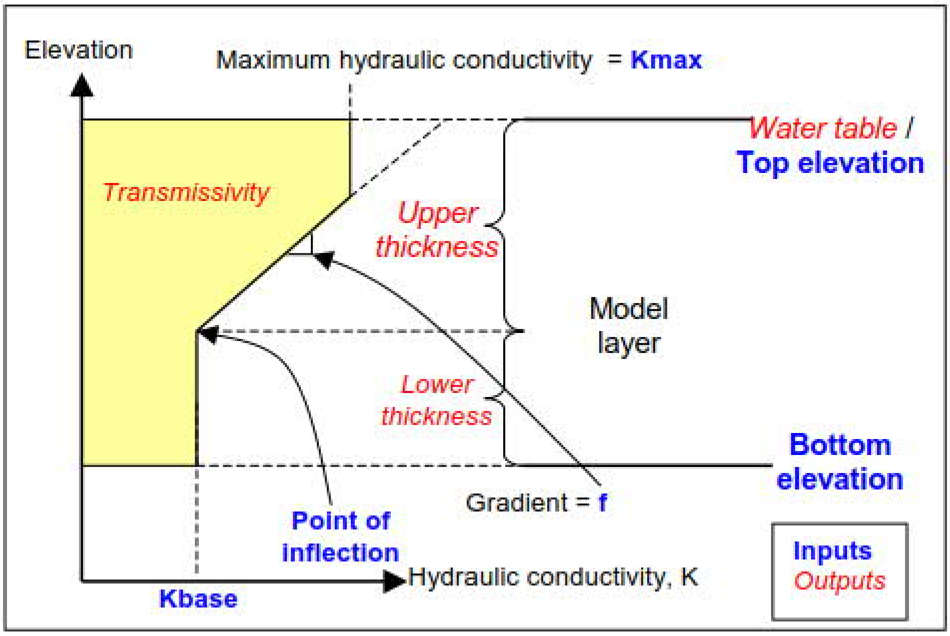

Figure 3.1Schematic representation of VKD.

3.2.5 Consideration was given to splitting the one Chalk layer into several layers to more closely represent the local Chalk aquifer. This created model instability and early attempts were not able to calibrate the groundwater levels to a similar, acceptable standard as the baseline model.

3.2.6 This would also represent a significant deviation from the regional model. The desire was to stay as close to the regional model as possible so that the EA conceptual and numerical model studies could also be used as a reference to this approach. As the Wessex Basin model was considered to have a good calibration already, only minor changes were considered in order to reflect the local study area.

3.3 Aquifer properties

3.3.1 The baseline model incorporates aquifer properties information from across the study area where available, such as pumping test analyses. These data are considered alongside conceptual information about higher and lower permeability areas such as valleys and interfluves, as well as strata changes such as from Upper to Middle and Lower Chalk, and the presence of hardgrounds.

3.3.2 The result is a hydraulic conductivity distribution across the model that is intended to be conceptually appropriate, relative to other hydrogeological domains such as valley and interfluve, and the values used related to observed data from pumping tests.

3.3.3 The Wessex Basin model contains one hydraulic conductivity zone (and VKD gradient) in the interfluve area between the rivers Avon and Till, and a higher hydraulic conductivity zone along the River Till. To the west there is a narrow zone of lower hydraulic conductivity limiting flow from the Chitterne catchment to the Till catchment. In the southern parts of the interfluve between the rivers Wylye and Avon, the Till valley high hydraulic conductivity zone crosses the interfluve enabling water to flow cross catchment more easily. East of the River Avon is a lower hydraulic conductivity zone compared to west of the River Avon. This zone also covers much of the Wylye catchment representing an anticlinal axis. All of these zones were created to represent the conceptual understanding of the Chalk aquifer.

3.3.4 It is believed that the A303 pumping tests, conducted in 2002-2004, were not available to the Wessex Basin study or its predecessors; Wylye and Nadder, and Hampshire Avon models. The results from these pumping tests were used to refine the aquifer properties in the scheme area of the model.

3.3.5 Pumping test findings for the study area are given in the Groundwater Risk Assessment report (AmW, 2018) and were compared to the model transmissivity in the model cell where the pumping test took place. Groundwater level was extracted from the model at the time of the pumping test and the VKD parameters were used to calculate transmissivity at that time in the model.

3.3.6 It was found that because the groundwater contours trend approximately east west across the Till to Avon catchment area, and there is no change in hydraulic conductivity; the groundwater level does not change significantly in the model from interfluve to Stonehenge Bottom dry valley. The dry valleys in the area of interest are not explicitly represented in the original EA groundwater model.

3.3.7 Model transmissivity in Stonehenge Bottom was calculated as 2,160m^2/d (based on the saturated thickness output) compared to the pumping test at W148 of 2650m^2/d in December 2002. This indicated the model was quite accurate in the Stonehenge Bottom valley area. Model transmissivity in the interfluve between the River Till valley and Stonehenge Bottom valley was calculated as 2120 m^2/d compared to the pumping test at W137 of 850m^2/d in December 2002.

3.3.8 Based on pumping tests in September 2004, model transmissivity in Stonehenge Bottom was calculated as 1430m^2/d compared to the pumping test at W148 of 1812m^2/d. Model transmissivity in the interfluve between the River Till valley and Stonehenge Bottom valley was calculated as 2120m^2/d compared to the pumping test at W137 of 400m^2/d.

3.3.9 Therefore the interfluve is not being represented as a lower hydraulic conductivity zone in the model. This is an explanation for the simulated groundwater hydrographs being more subdued than the observed groundwater levels from groundwater monitoring at W1, P1, P2 and R158. That is, the modelled groundwater levels do not fall sufficiently in summer recessions or rise enough in extreme winter peaks such as 2003 in the observation record. Average groundwater levels and lower winter peaks such as in 2004 and 2005 are quite well calibrated.

3.3.10 The model was run without VKD, using the base hydraulic conductivity in the model setup. That is, unlike VKD, this model maintained a single value of hydraulic conductivity and did not allow it to increase with a higher water table. The result is a lower transmissivity in the interfluve to better approximate measured pumping test transmissivity. This model calibrated the 2003 extreme winter peak well at the site investigation observation boreholes along the interfluve from Stonehenge Bottom to Longbarrow Roundabout, as well as at the EA's Berwick Down OBH (Figure 3.2). The changes actually cause the model to predict a groundwater level higher than that observed. The model was not modified further because the calibration was therefore conservative for groundwater flooding, and the parameters remained close to the original EA groundwater model. An exact match to observed levels could have been created by varying the hydraulic conductivity to a value between the base hydraulic conductivity and the VKD calculated value in the original EA groundwater model.

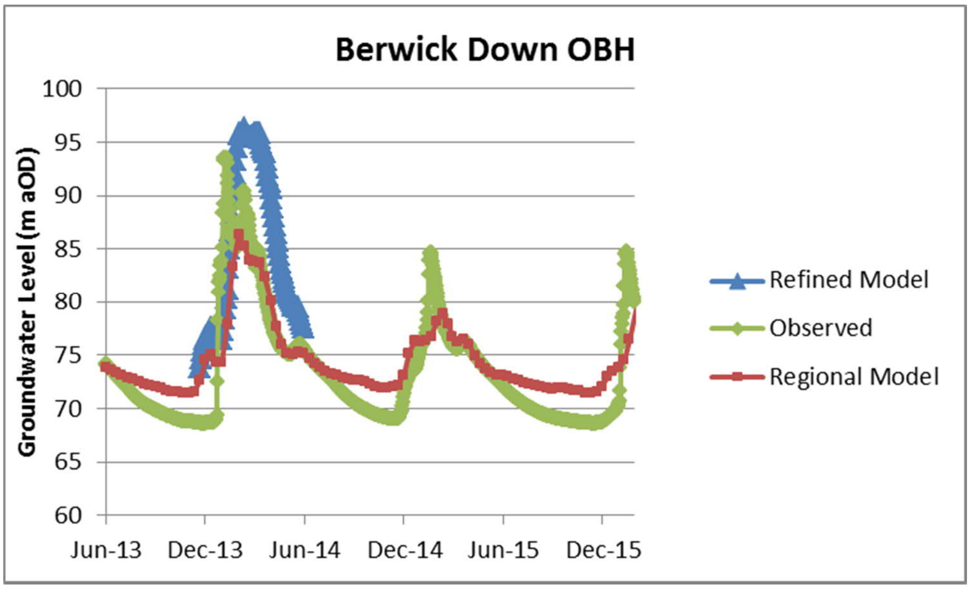

Figure 3.2 Groundwater level calibration for regional model with local refinements for peak groundwater levels.

3.3.11 The result of the lower hydraulic conductivity was a lower transmissivity in the Stonehenge Bottom valley Chalk, which was inconsistent with the hydraulic conductivity derived from the pumping tests. Therefore a new higher hydraulic conductivity zone was created in the model along the Stonehenge Bottom valley. The hydraulic conductivity used for this zone was essentially the value calculated by VKD (approximately three times the interfluve hydraulic conductivity) and therefore the model was set up to represent the aquifer properties of the Chalk in the study area based on the pumping test results. Hydraulic conductivity zones are given in Figure 3.3.

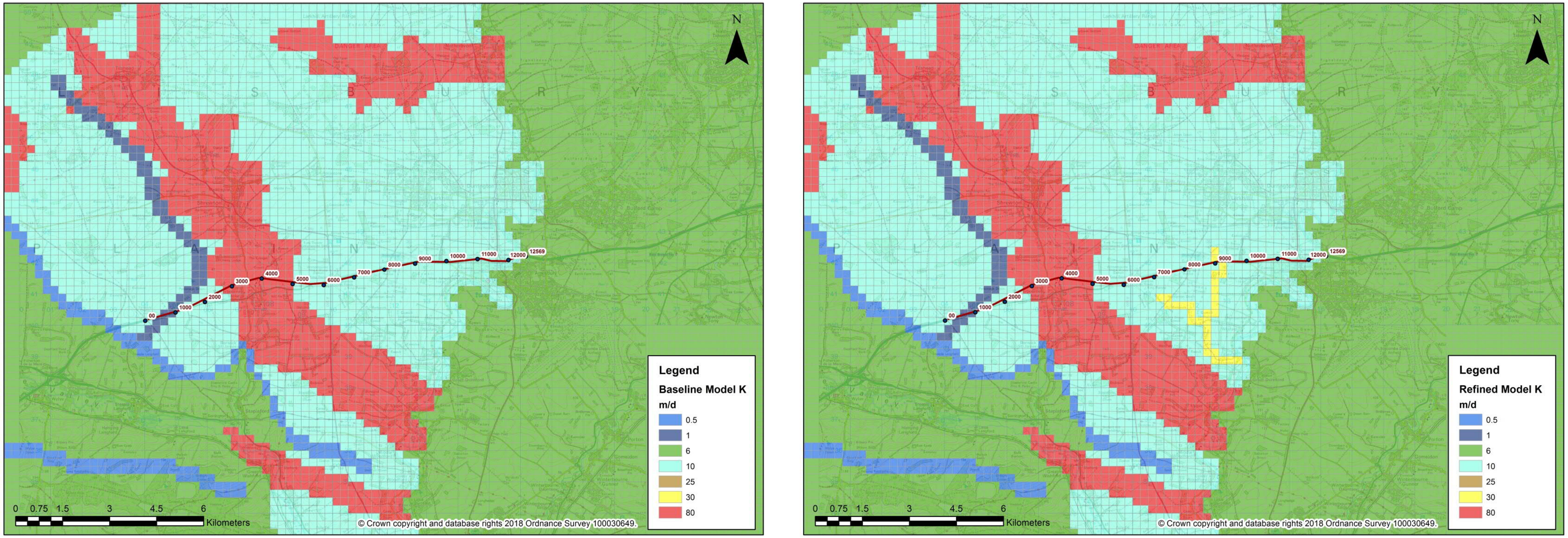

Figure 3.3 Comparison of regional baseline model and refined model hydraulic conductivity zones

3.3.12 This setup supports the conclusions from the pumping tests that *'there is a clear difference between the drawdown per unit of abstraction flow at the two test sites. For example W137 [interfluve] produced a drawdown approximately 10m away of 0.4m for a flow of 8 litres/sec after 10 hours, whereas W148 [Stonehenge Bottom] only achieved 0.2m with a flow of 18 litres/sec at a comparable distance and time. This indicates that transmissivities and hydraulic conductivity is significantly larger at the lower site [Stonehenge Bottom]'* (WJ Groundwater, 2003).

3.3.13 Additional pumping test data was available from a water supply and ground source heating and cooling investigation at the Stonehenge Visitor Centre during spring 2012 (very low groundwater levels) (SKM Enviros, 2012). Test pumping resulted in calculated transmissivities between 120 and 325 m^2/d. This is similar to the value of 400 m^2/d recorded at W137 during low groundwater conditions. This evidence further supports the change in the model to using the base hydraulic conductivity across the interfluve Chalk between the rivers Avon and Till.

3.3.14 The borehole drilling and geophysical survey at the Stonehenge Visitor Centre also identified very few groundwater flow horizons with the most significant fracture zone at 102-104m bgl, with another major flow horizon at 65.5 – 66.5m bgl, and a minor flow horizon at 78.2m bgl. The flow is fracture controlled but the results do not indicate an increasing permeability and flow with shallower depth. Fractures are apparent at depths in excess of 50m bgl. Pumping test data storage calculations indicated that the aquifer was confined, suggesting flow was largely in these discrete fractures, giving the flow horizon a confined aquifer character. This evidence supports not using VKD in the local area of interest in the groundwater model.

3.3.15 With an improved calibration of peak groundwater levels for groundwater flooding purposes, the refined model average and low stream flows were compared with the regional model such that the model could be used as a predictive tool for environmental impacts, which focus on low river flows in the rivers Till, Wylye and Avon.

3.3.16 Low flows were relatively unchanged because the VKD function makes little change to the transmissivity in the model at low groundwater levels. At average groundwater levels the typical high level is simulated above the level observed with the regional model closer to the observed, while the typical low is less well simulated by approximately 2m (Figure 3.4) compared to the regional model. Both models (regional and refined) are higher than observed at the typical summer low points by in excess of 5m.

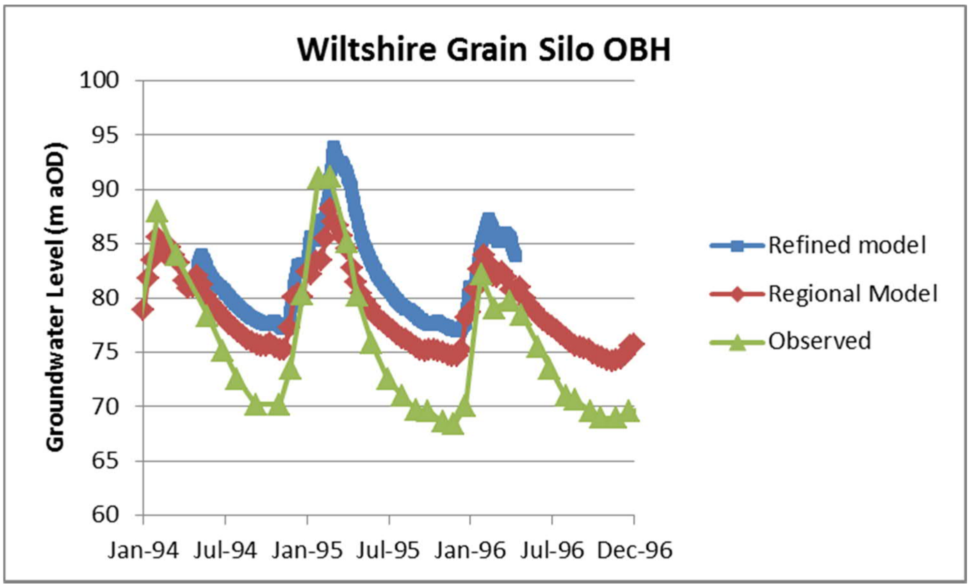

Figure 3.4 Groundwater level calibration for regional model and with local refinements for average groundwater levels.

3.3.17 For environmental impacts river flows are the key receptor in low groundwater level conditions, so the effect of changing hydraulic properties on the calibration at average and low flows was investigated.

3.3.18 Stream flows from regional and refined models were compared with observed data and were found to have similar correlations. The full model datasets were compared against available observed data as well as a dataset limited to where both models have common output dates and an observation.

3.3.19 Overall the models are similar with no significant changes in simulated flow caused by the model refinements made.

3.3.20 Figures 3.5 and 3.6 present the correlations for the datasets limited to the common dates between models showing a small improvement for the River Wylye and slight deterioration for the River Avon. Both effects are considered marginal changes not affecting the fitness for purpose of the refined model. Note that using the full dataset for each model individually shows an improvement in correlation at both gauges in the refined model.

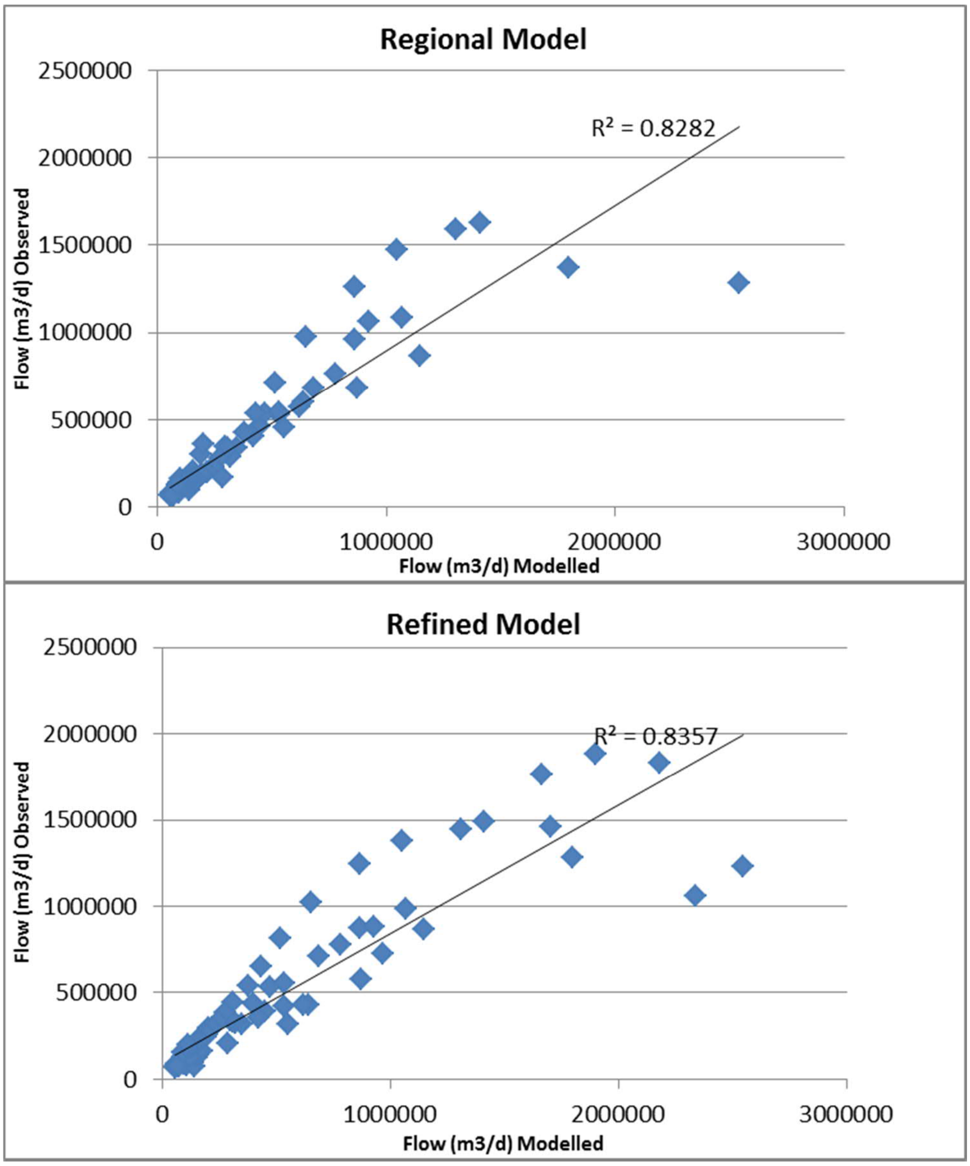

Figure 3.5 Comparison of stream flow calibration for River Wylye at South Newton using common dates only.

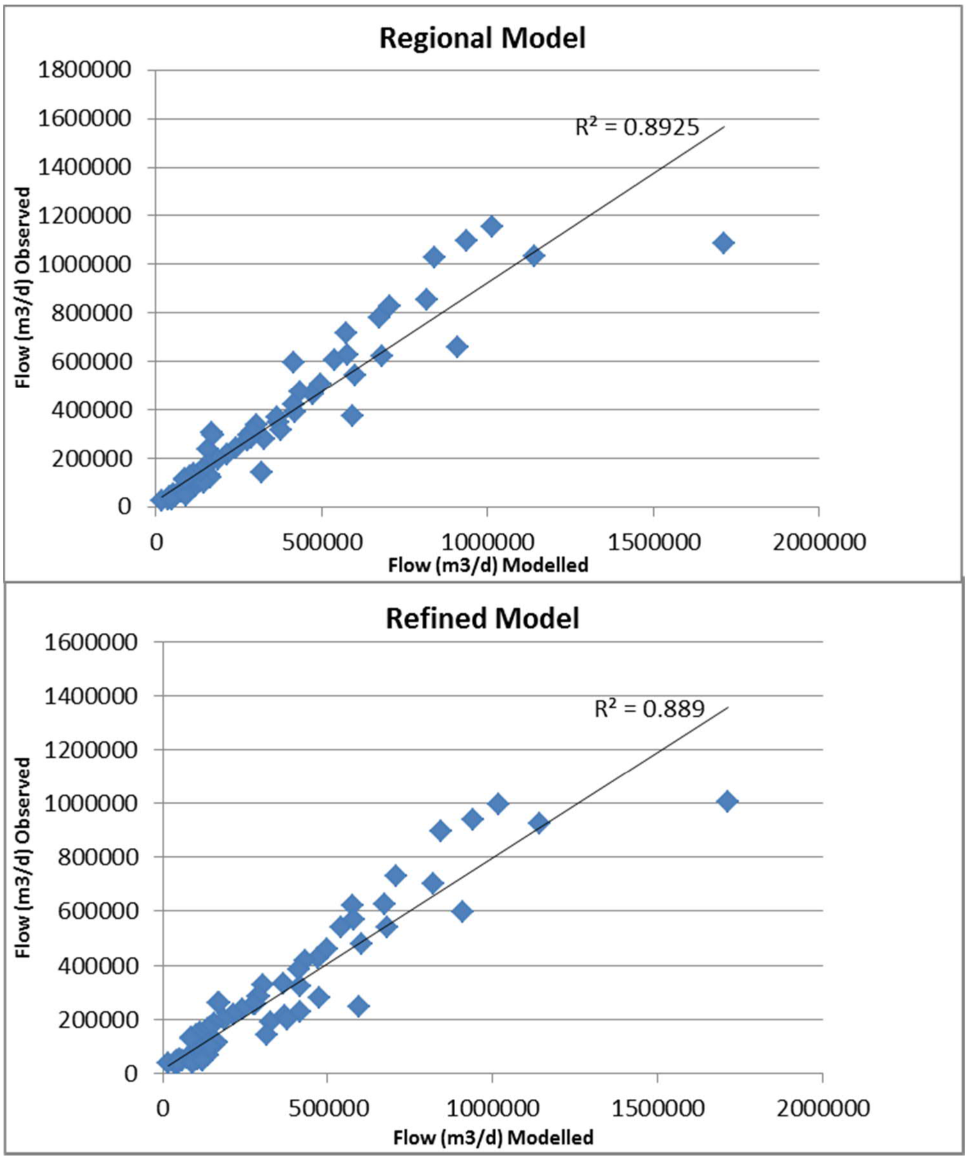

Figure 3.6 Comparison of stream flow calibration for River Avon at Amesbury using common dates only.

3.3.21 Hydrographs for the peak, average and drought periods at the flow gauges on the River Avon at Amesbury and the River Wylye at South Newton are shown in Figure 3.7 and Figure 3.8.

3.3.22 Overall flows are simulated well through the spring recession to the summer lows, while winter peaks are under-simulated. The environmental impact assessment is focussed on low flow periods so the deterioration of the peak flow in the refined model was not considered to be important for the assessment. As the peak flow is better calibrated in the original EA groundwater model, these values were used as inputs to the flood risk assessment.

3.3.23 Therefore the small modifications to the original EA groundwater model allowed peak groundwater levels near the scheme to be better calibrated while maintaining the good low flow calibration of the original model.

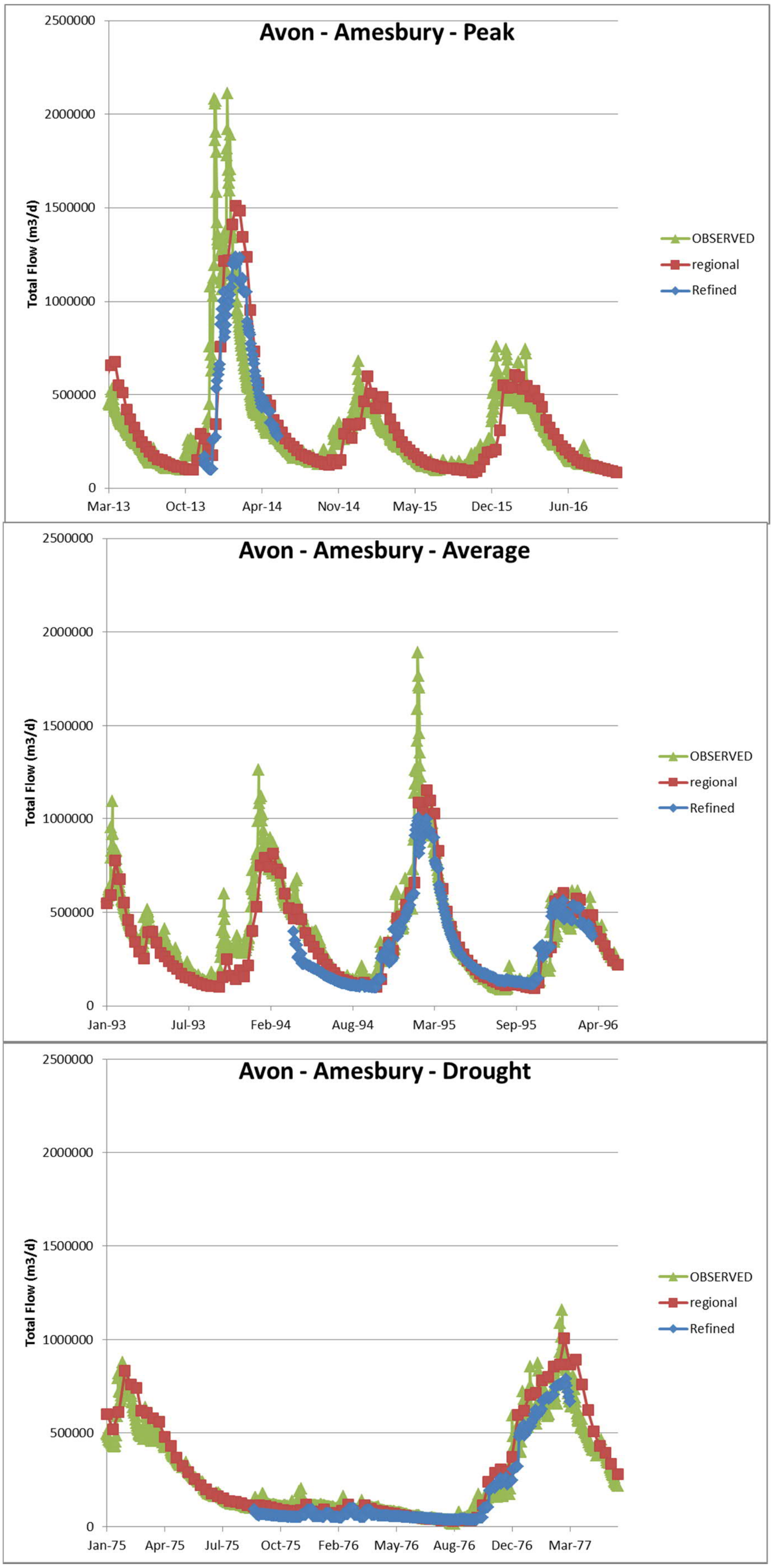

Figure 3.1 Flow hydrograph for Avon at Amesbury

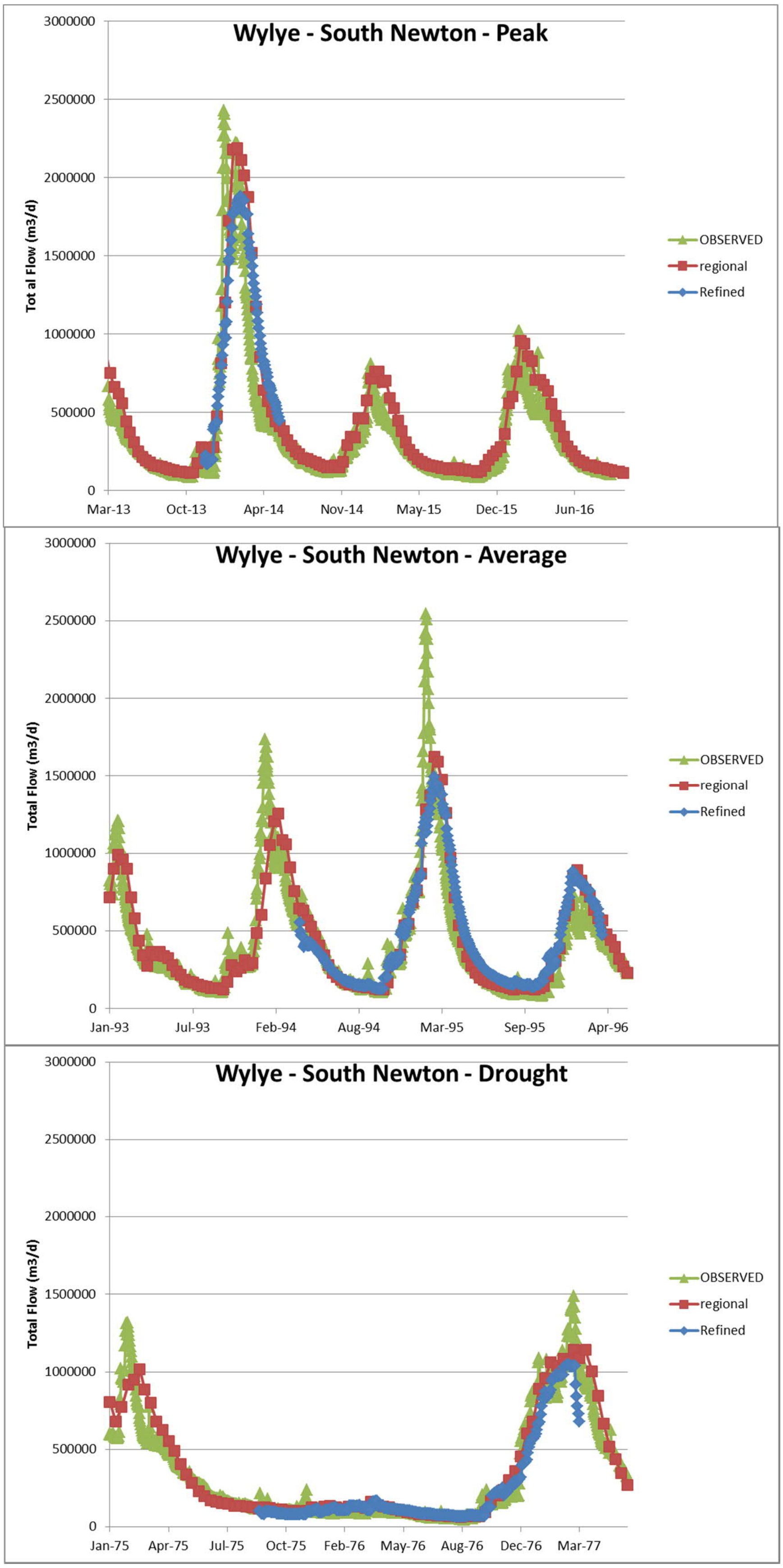

Figure 1.2 Flow hydrograph for Wylye at South Newton

3.4 Abstractions

3.4.1 The abstraction time series used was the recent actual rates provided by the EA, representing the typical abstraction rate at the present time, typically an average of the last five years. This was applied across the model time period so that the effect of abstraction could be predicted under different climate scenarios, such as a repeat of the 1976 drought.

3.5 Representation of the Tunnel

3.5.1 The tunnel was represented in MODFLOW by modifying cells along the tunnel chainage by way of lower hydraulic conductivity, representing an approximate vertical extent of aquifer thickness that would impede flow due to the tunnel compared to the available aquifer thickness for groundwater throughflow.

3.5.2 This approach resembles the actual processes taking place in the aquifer in modelling terms. As the model uses transmissivity in its calculations (saturated thickness x hydraulic conductivity), changing the hydraulic conductivity by a proportion relative to the aquifer thickness lost to the tunnel gives the same transmissivity of the aquifer for modelling of groundwater flow.

3.5.3 The alternative is maintaining the hydraulic properties and adding model layers with elevations based on the tunnel profile along the chainages. This approach is more complex and can give rise to model stability issues, and is a larger deviation from the regional model than the hydraulic properties approach.

3.5.4 The length of tunnel predicted to be below the water table was estimated for each of the drought, flood, and average models based on water table elevation in each model cell and the elevation of structures that would impede flow, such as the tunnel itself and retaining walls at each portal.

3.5.5 Using separate short duration models rather than the entire transient period of the Wessex Basin model enabled a more accurate representation of the extent of structures that impeded groundwater flow because model properties cannot be varied transiently as groundwater levels change. Therefore a tunnel representation for an extreme high groundwater level in the full Wessex Basin model would also impede flow during low groundwater levels when in reality in some areas the water table may be below the tunnel elevation, causing no flow impedance.

3.5.6 Figure 3.9 illustrates the different water table elevations compared to the design elevation of the construction elements, including the base and crown of tunnel excavation, and retaining wall depths near the portals.

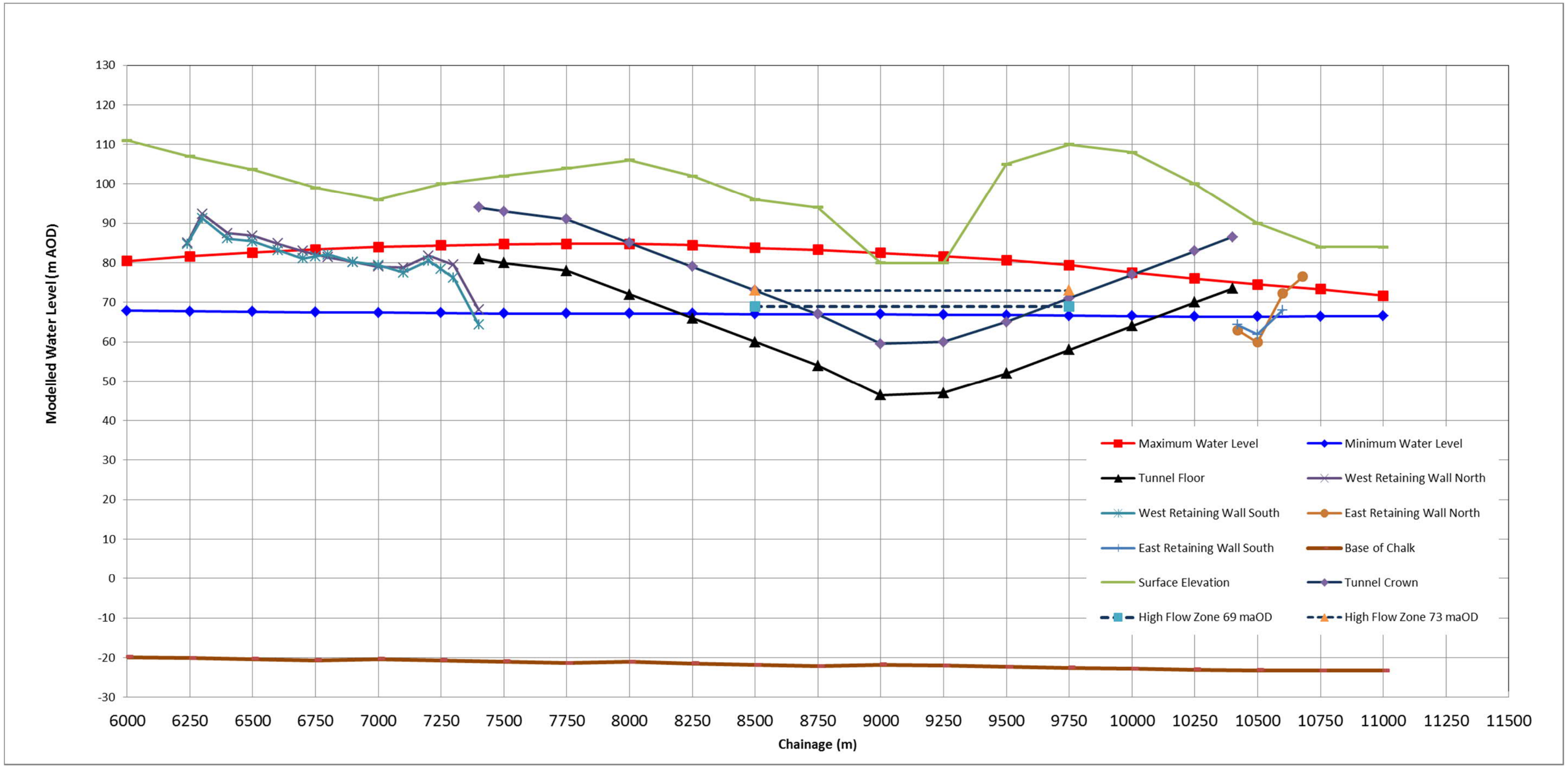

Figure 1.3 Elevations of Interest – water levels, flow horizons, tunnel and retaining walls

3.5.7 If the Chalk aquifer had a uniform flow through the vertical extent of the saturated thickness then the proportion to change the hydraulic conductivity by would be the tunnel thickness divided by the saturated thickness.

3.5.8 Geological information was reviewed in order to estimate whether preferential flow horizons exist in the Chalk strata which should be considered when the tunnel is simulated in the groundwater model. That is, if the tunnel crossed through a horizon considered to be a conduit for most of the flow, then it would be more realistic to reduce the hydraulic conductivity by more than just the vertical proportion of the saturated aquifer thickness blocked.

3.5.9 Data available to assess for the presence of preferential flow horizons are lithological changes, geotechnical log CIRIA grading (reflecting fracture frequency and openness), geophysical tests identifying flow horizons, packer tests calculating hydraulic conductivity in discrete vertical bands.

3.5.10 All previous site investigation reports were reviewed for relevant information. Those reports with relevant information were:

- WJ Groundwater, 2003. A303 Stonehenge Improvements. Pumping Test Factual Report.
- Mott MacDonald, 2001. A303 Stonehenge Geotechnical Interpretative Report for the Preliminary Investigation and Phase 1 of Main Ground Investigation.
- Pelorus, 2004. A303 Stonehenge Improvement Factual Report on Geophysical Investigation.
- Halcrow-Gifford, 2005. A303 Stonehenge Improvement. Geophysical Field Trials: Interpretative Report.
- Halcrow-Gifford, 2003. Phase 1A Supplementary Ground Investigation for A303 Stonehenge Improvement.
- Halcrow-Gifford, 2004. A303 Stonehenge Improvement. Geotechnical baseline for Tunnel Design.

3.5.11 Overall from the information available it was considered that away from Stonehenge Bottom, the saturated thickness as a whole should be used in the calculation of the proportion of the tunnel impeding flow across the alignment.

3.5.12 Within Stonehenge Bottom, the evidence suggests that the bulk of flow is between 69-73m AOD. Where the tunnel intercepts this depth a large proportion of flow was impeded, greater than the vertical extent compared to saturated thickness. The actual proportion is not known so a value of 80% reduction in hydraulic conductivity was used to be conservative.

3.5.13 Alignment site investigation boreholes do not penetrate to a depth below 50 mAOD, and therefore it is not known whether there are additional flow horizons below this depth that would inform the distribution of flow throughout the vertical profile. As the data do not show any particular trend with depth, the potential for flow is considered uniform below the 69-73m AOD horizon.

3.5.14 One borehole investigation (SKM Enviros, 2012) provides data below 50m AOD at the Stonehenge Visitors Centre. This was drilled to approximately 0m AOD and found a very uniform rock profile with several discrete flow horizons. The most significant fracture zone was at 102-104m bgl (~0m AOD), with another major flow horizon at 65.5 – 66.5mbgl (~35m AOD), and a minor flow horizon at 78.2m bgl (~22m AOD). This suggests that the full model Chalk layer thickness could be used to compare with the tunnel profile (if these fractures are persistent across the interfluve area), which is approximately 100m for the active aquifer.

3.5.15 However for conservatism, a 50m saturated thickness was used for consistency with most literature that describes the active Chalk aquifer as typically the upper 50m of saturated thickness (EA and BGS, 1997).

4 Model Predictions

4.1 Groundwater Level and River Flows

4.1.1 This section describes predicted impacts for flood risk at peak groundwater levels, and on groundwater and dependent features at low flows from the presence of the tunnel. Impacts for an average period are also described. The impact assessment compares the baseline historical period with the predictions for the same period with the scheme imposed on the model.

4.1.2 River flow accretion profiles have been created comparing flows in reaches of the rivers Avon and Till. For the River Avon, reaches have been included downstream of the confluence of the east and west Upper Avon branches. While for the River Till all reaches from the source are included, that is, all stream cells in the regional groundwater model.

Peak Flow/Groundwater Level Conditions

4.1.3 The February 2014 groundwater flooding event is used to represent the peak groundwater level/flow condition and is a worst case for flood risk.

4.1.4 Groundwater levels are predicted to rise up hydraulic gradient (north) of the tunnel in the order of 0.5-1.0m in the vicinity of the tunnel, reducing to less than 0.2m in the area of Larkhill. A rise in water table is not predicted in the areas where groundwater discharges to the rivers Avon and Till. The predicted increase in water table elevation with the tunnel in place is shown in Figure 4.1.

4.1.5 Groundwater level rise beneath built up areas around Larkhill is in an area where the water table is in excess of 10m deep. Therefore this predicted rise does not result in an increased risk from groundwater flooding. The modelled depth to groundwater with the tunnel in place is shown in Figure 4.2.

4.1.6 Groundwater flooding is known to have occurred in winters 2000-01 and 2013-14. February 1995 has the next highest groundwater levels. As this year is part of the climatic average estimated in the Wessex Basin conceptual study, it is assumed to be at a level lower than when flooding has been observed. Other groundwater flood events may have occurred in the past but not been recorded. Simulated groundwater levels at the tunnel alignment borehole P1 show the predicted level in 2001 and 2014 reflecting known flood events. It can be seen in modelled groundwater levels that in the historic climate back to 1970 this type of flood event may have occurred in February 1990, and therefore may have occurred three times in over 40 years. A simulated hydrograph for P2 is shown in Figure 4.1.

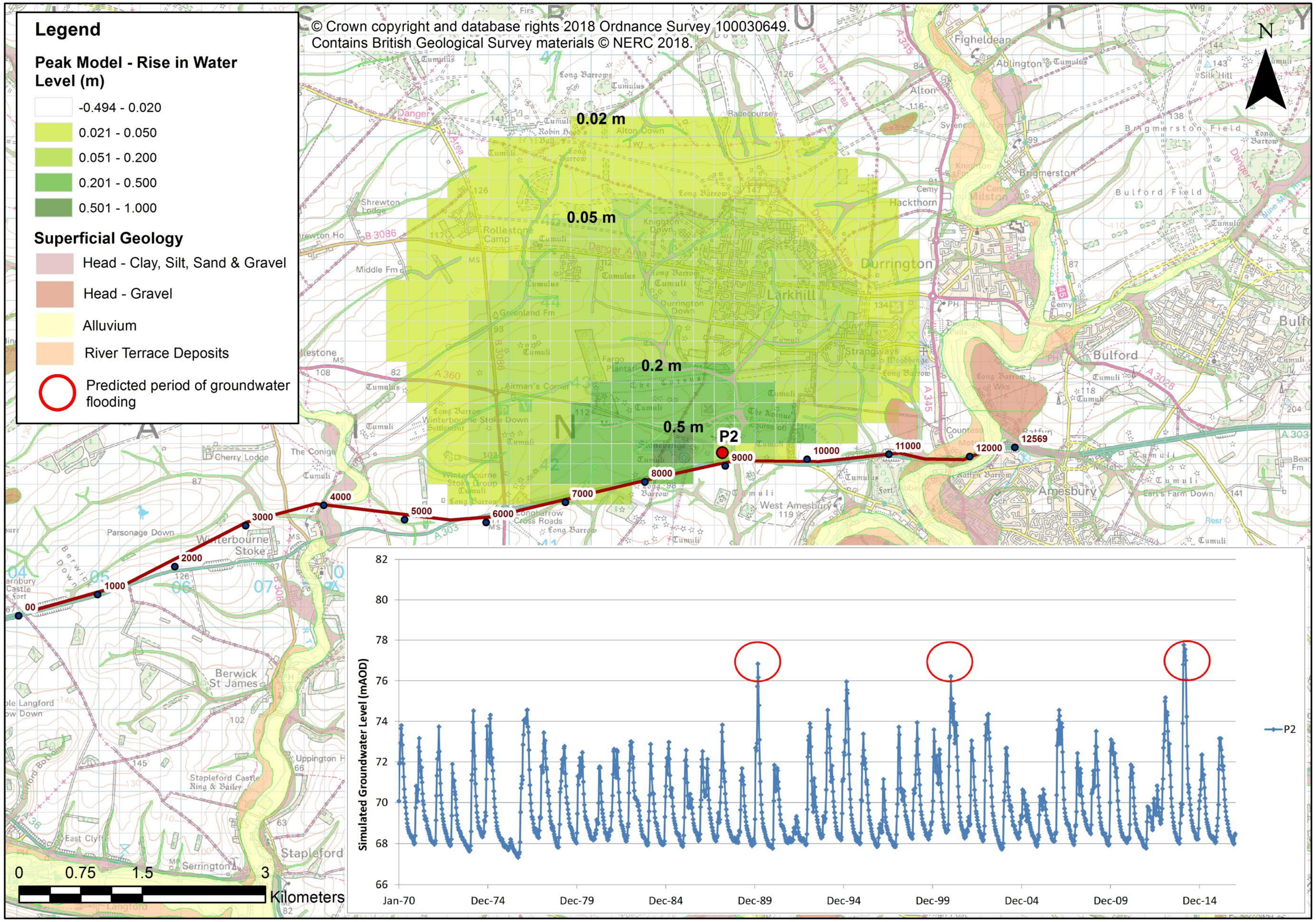

Figure 4.1 Rise in groundwater level at peak (flood) groundwater condition

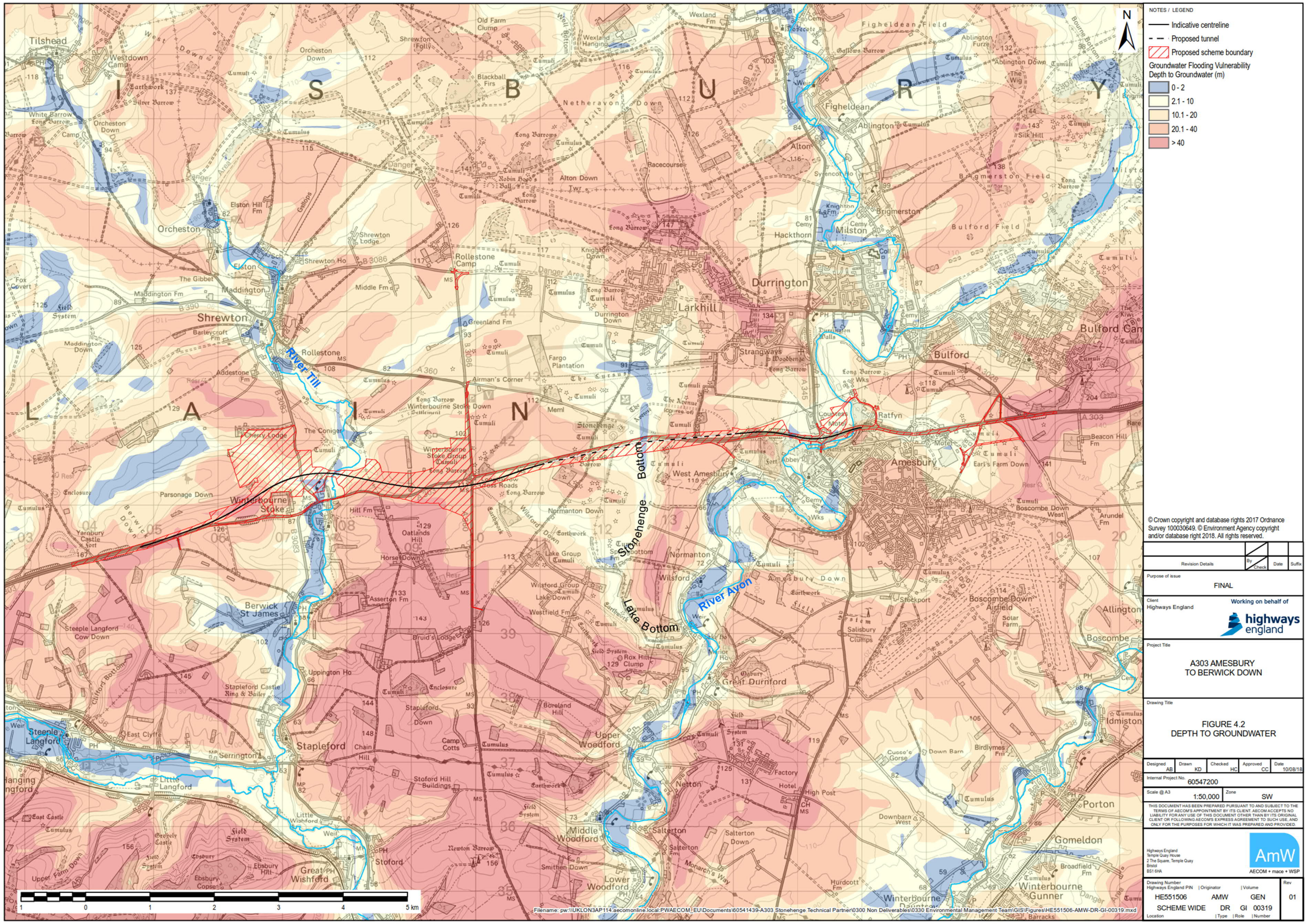

Figure 4.2 Depth to groundwater at peak (flood) condition with tunnel

4.1.7 A rise in water table elevation in areas with a baseline shallow water table during the 2014 peak or groundwater levels above surface would indicate an increased risk of groundwater flooding when the tunnel is in place. Areas where this occurs are limited to very small parts of Stonehenge Bottom valley, shown in Figure 4.3 below.

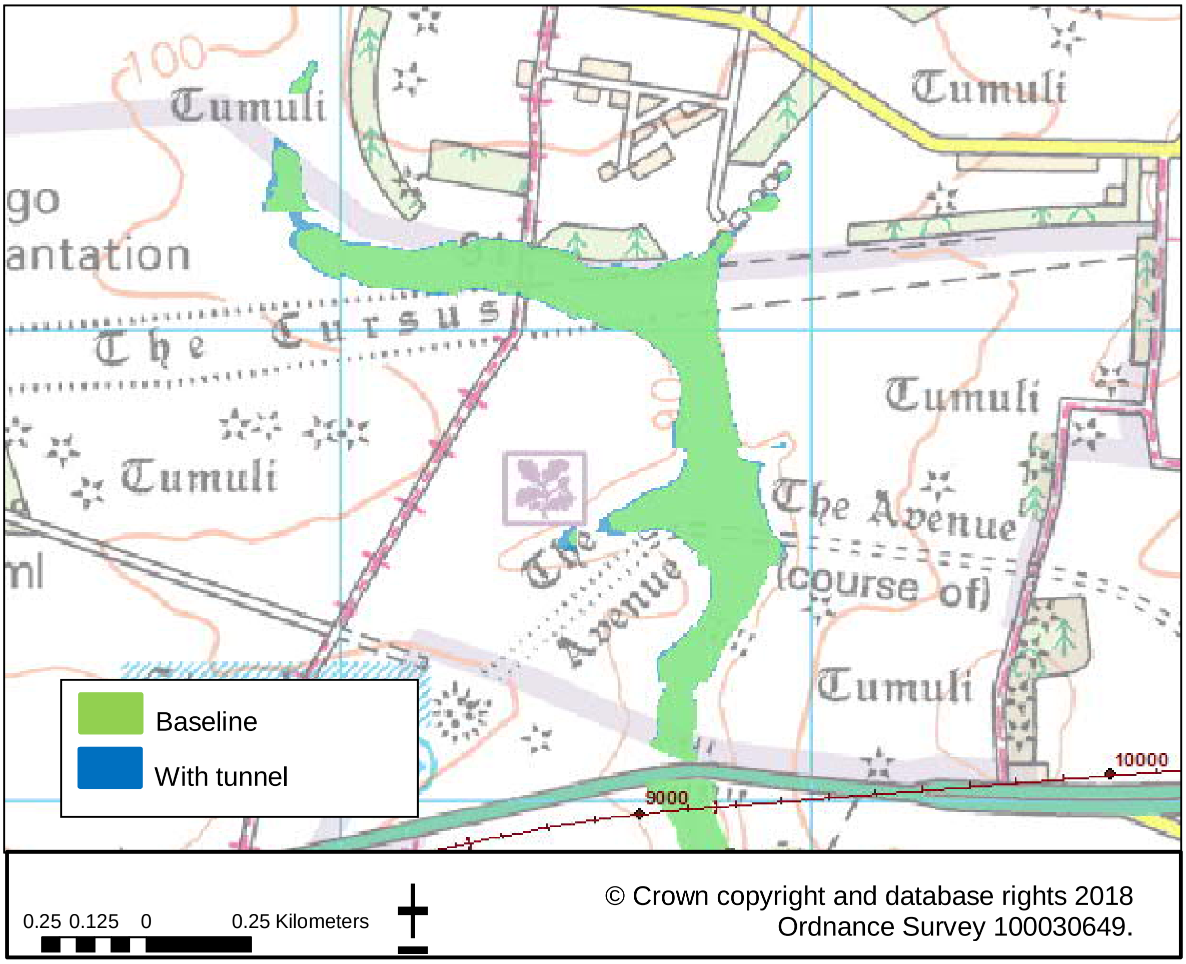

Figure 4.3 Groundwater level at depth shallower than 2m bgl

4.1.8 The model predicts no significant change in flow in any reach at peak flows in the River Avon or the River Till. The figures presented show little difference in the total flow scale, so a flow difference plot is also provided.

4.1.9 Flow changes in the River Avon average approximately 200m^3/d compared to flows in excess of 1,000,000m^3/d. In the River Avon flows are up to 78m^3/d higher from Durrington to Amesbury GS and up to 500m^3/d lower downstream of Amesbury GS to Little Durnford (a maximum change of 0.05% of the flow). River Avon accretion profile is given in Figure 4.4.

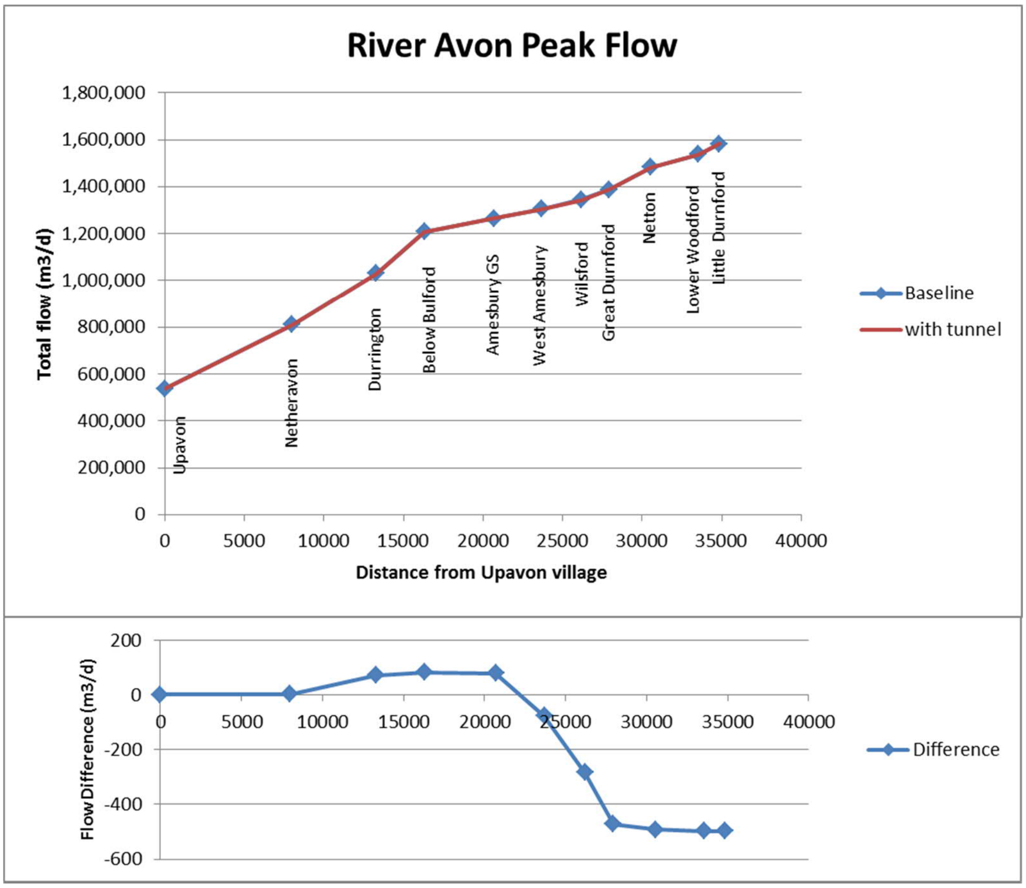

Figure 4.4 River Avon peak flow accretion profile

4.1.10 The flow is up to 128m^3/d higher in the River Till during baseline periods from approximately 300,000m^3/d. Below the confluence with the River Wylye, flows are in excess of 1,000,000m^3/d with a predicted increase of up to 118m^3/d. Flows increase from the baseline between Tilshead and Shrewton with the highest difference at Winterbourne Stoke (a maximum change of 0.04% of the flow). River Till and Wylye accretion profile is given in Figure 4.5.

4.1.11 Therefore the effects of the tunnel on high river flows are negligible.

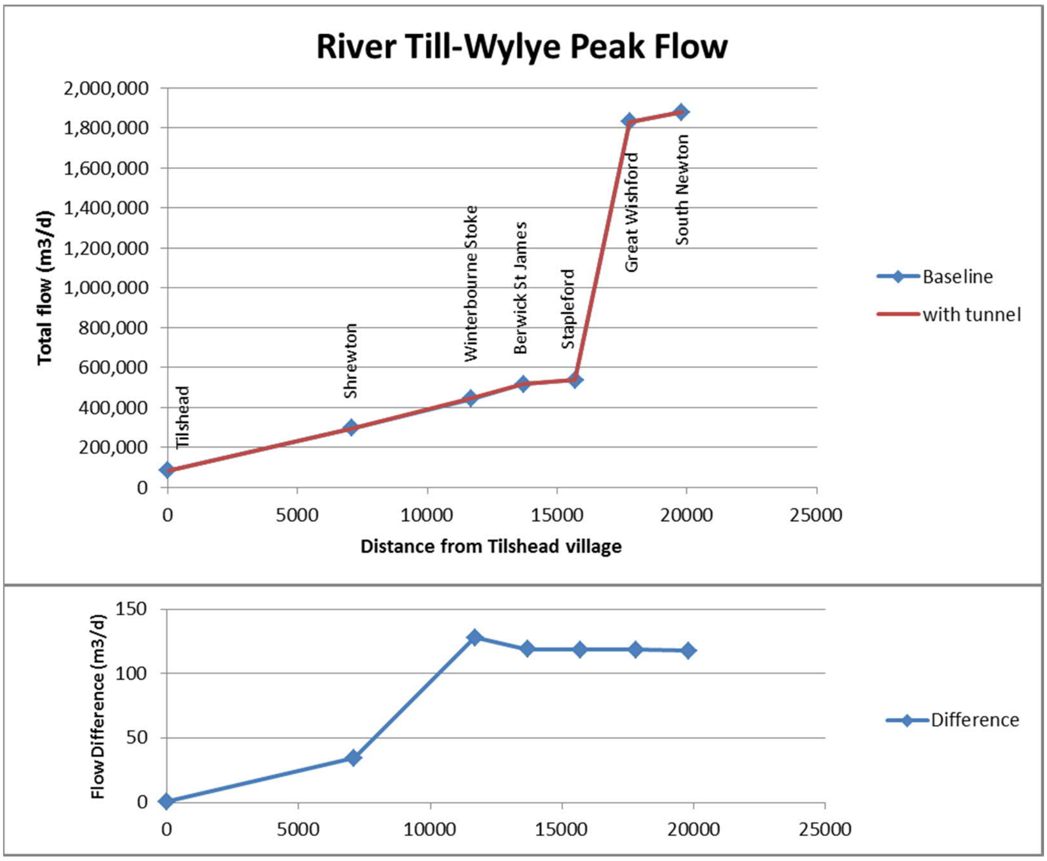

Figure 4.5 River Till and Wylye peak flow accretion profile

Average Flow/Groundwater Level Conditions

4.1.12 The modelled low groundwater level is used to represent the typical (average) summer low condition.

4.1.13 Groundwater levels are predicted to rise up hydraulic gradient (north) of the tunnel in the order of 0.2m in the vicinity of the tunnel, reducing to less than 0.05m in the area of Larkhill. A rise in water table is not predicted in the areas where groundwater discharges to the rivers Avon and Till. Effects on the groundwater level are predicted to be less extensive north of the tunnel but more extensive south of the tunnel compared with periods of peak groundwater levels.

4.1.14 Down hydraulic gradient (south) of the tunnel groundwater levels are predicted to fall in the order of 0.05m in the vicinity of the tunnel. Lower water table elevations do not extend to the rivers Avon and Till or to Blick Mead. The change in water table elevation with the tunnel in place is given in Figure 4.6.

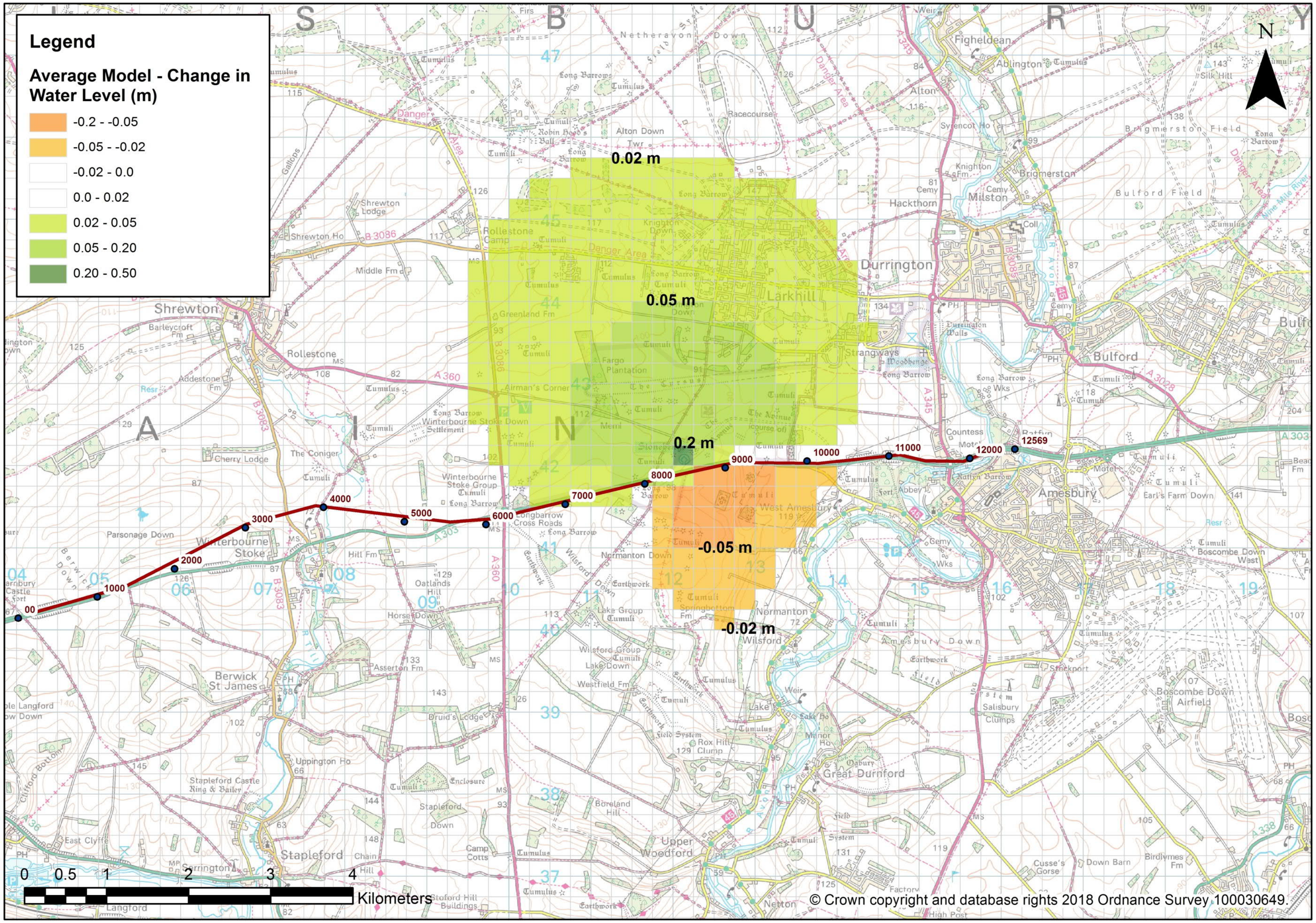

Figure 4.6 Change in groundwater level at average summer low groundwater condition

4.1.15 The model predicts no significant change in flow in any reach at low flows in an average year in the River Avon or the River Till.

4.1.16 Flow changes in the River Avon average approximately 20m^3/d compared to flows averaging approximately 100,000m^3/d. In the River Avon flows are up to 66m^3/d higher from Netheravon to West Amesbury and up to 44m^3/d lower downstream to Little Durnford (a maximum change of 0.07% of the flow). River Avon accretion profile is given in Figure 4.7.

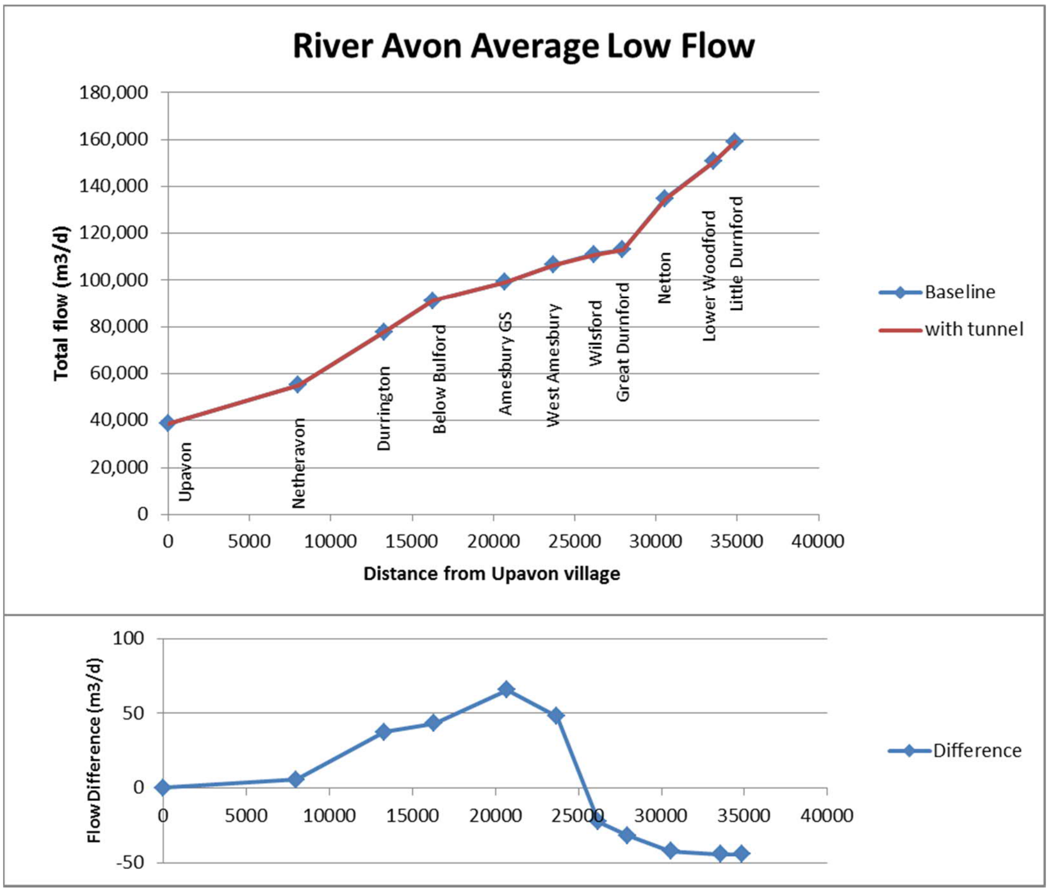

Figure 4.7 River Avon average low flow accretion profile

4.1.17 Flows are 25m^3/d higher in the River Till from approximately 15,000m^3/d baseline flow, and a flow in excess of 100,000m^3/d in the River Wylye after the confluence with the River Till (a maximum change of 0.17% of the flow). Flows increase beyond the baseline downstream of Shrewton. River Till and Wylye accretion profile is given in Figure 4.8.

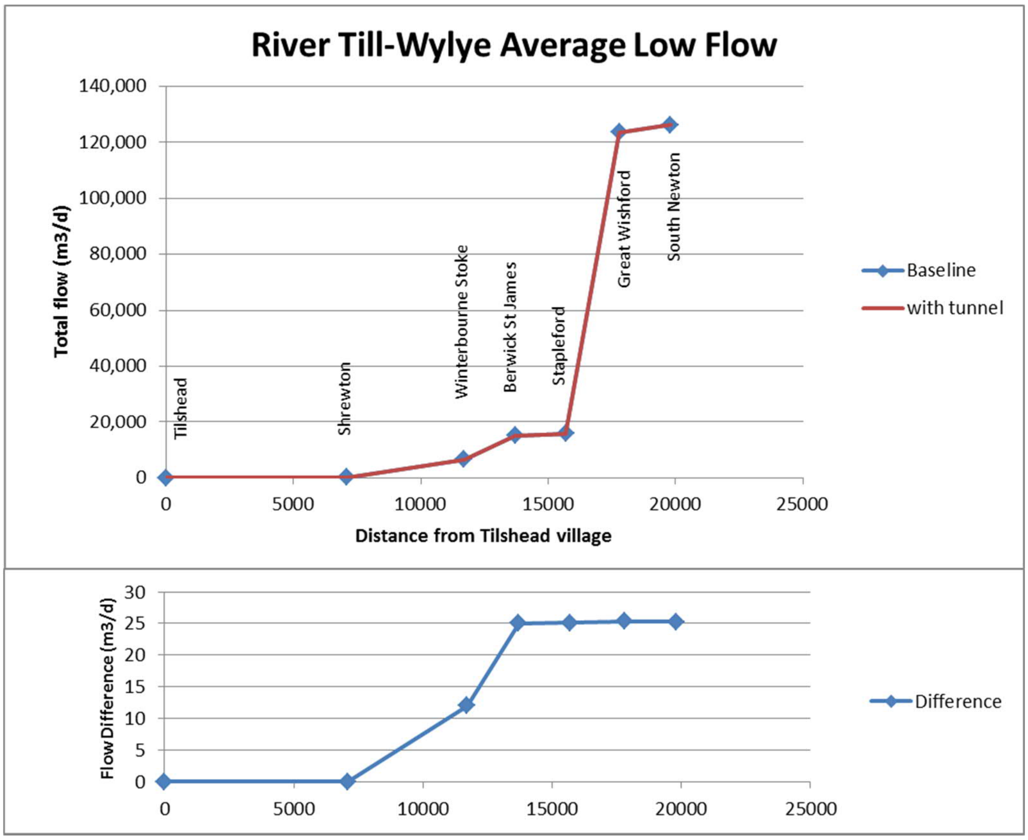

Figure 4.8 River Till and Wylye average low flow accretion profile

4.1.18 Flow hydrographs from the average condition model show the seasonality of flow occurring most of the time, that is, within the bounds of the extreme conditions of groundwater flooding and drought.

4.1.19 On the River Avon, flows (shown on Figure 4.9) are approximately 100m^3/d higher with the tunnel in place during average winters, and approximately 50m^3/d higher during average summers, a predicted increase of 0.01% in flow during winter and 0.05% during summer.

4.1.20 There is no flow gauge along the River till to interpret any seasonal variation. The South Newton gauge on the River Wylye downstream of the confluence with the River Till measures the combined Till-Wylye flows.

4.1.21 On the River Wylye, flows (shown on Figure 4.10) are approximately 30m^3/d higher with the tunnel in place during average summers, and approximately 130m^3/d higher during winter, a predicted increase of 0.01% in flow during winter and 0.02% during summer.

4.1.22 Considering the very small difference to the predicted River Till flows shown in the accretion profiles, it is considered unlikely that the seasonal changes in the River Till will be significantly different to the predictions for the River Wylye at South Newton shown in Figure 4.10.

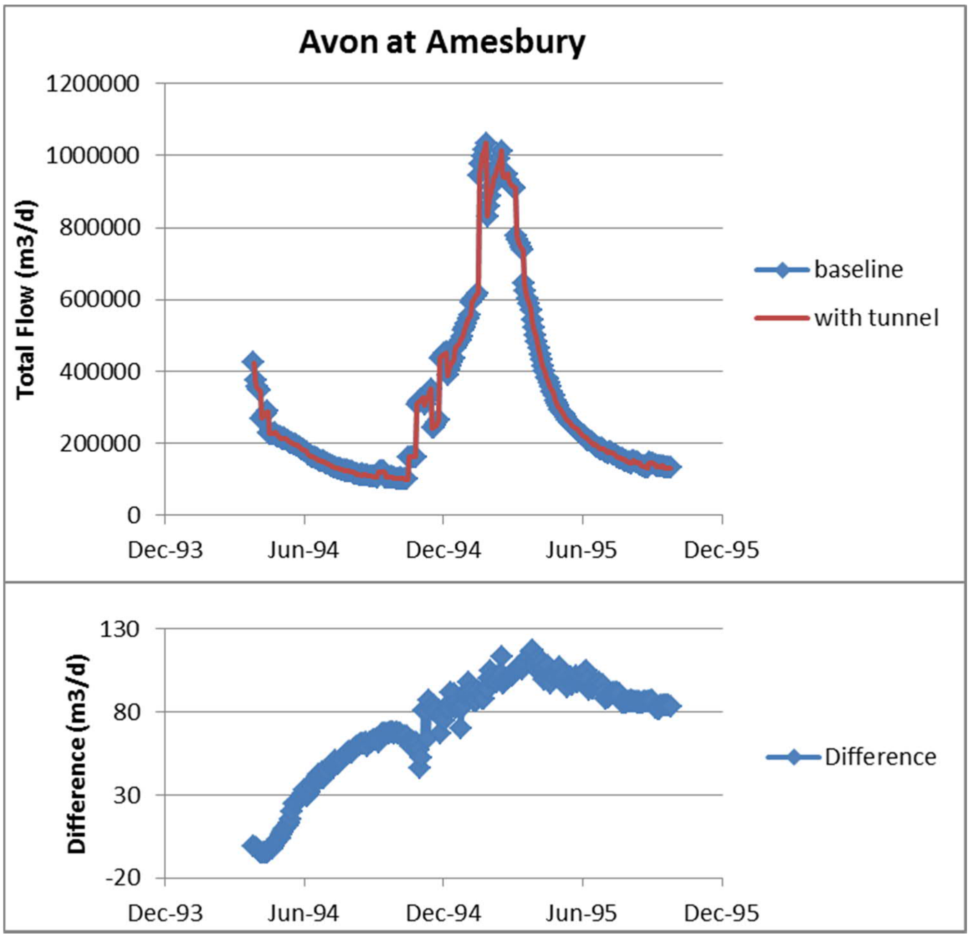

Figure 4.9 Average Flows in River Avon

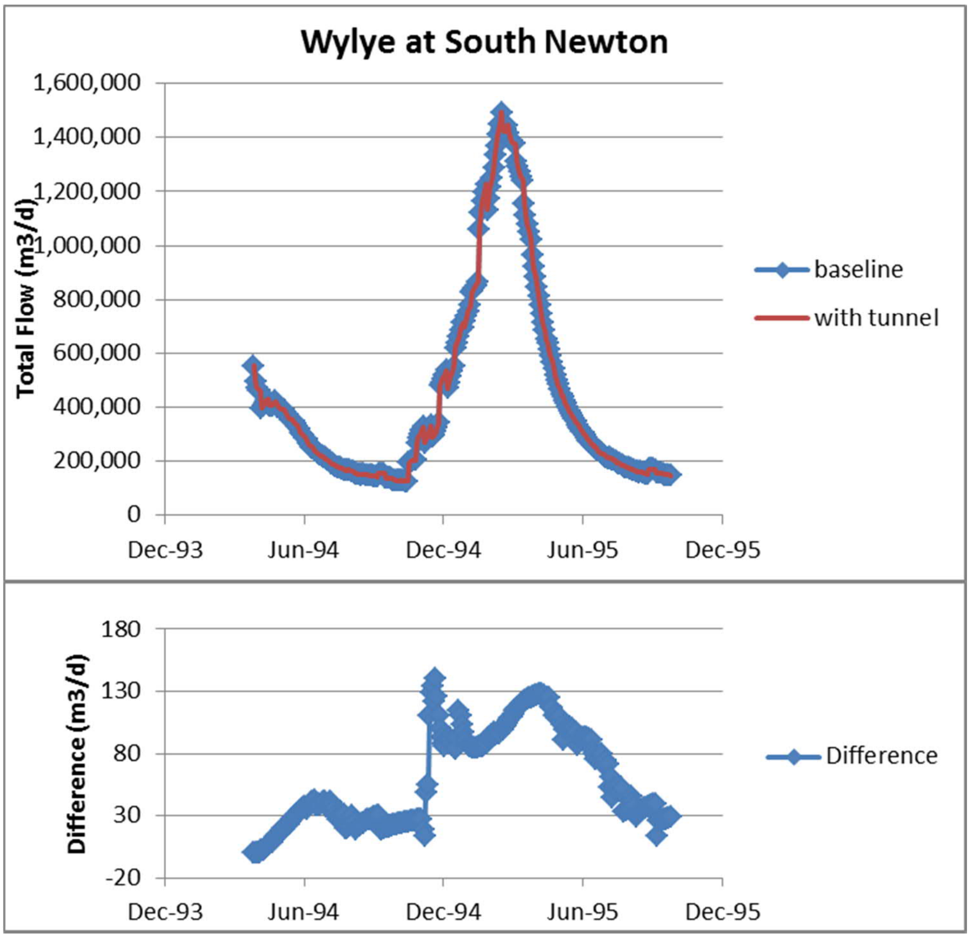

Figure 4.10 Average Flows in River Wylye

Lowest Groundwater Level/Flows

4.1.23 The low point in groundwater levels in the 1976 drought is used to represent a worst case for environmental impacts.

4.1.24 Groundwater level change in this scenario is less than the peak and average scenario because baseline groundwater levels are lower and therefore the tunnel creates less impedance to flow than at higher groundwater levels.

4.1.25 Groundwater levels fall approximately 0.02m down hydraulic gradient (south) of the tunnel (Figure 4.11).

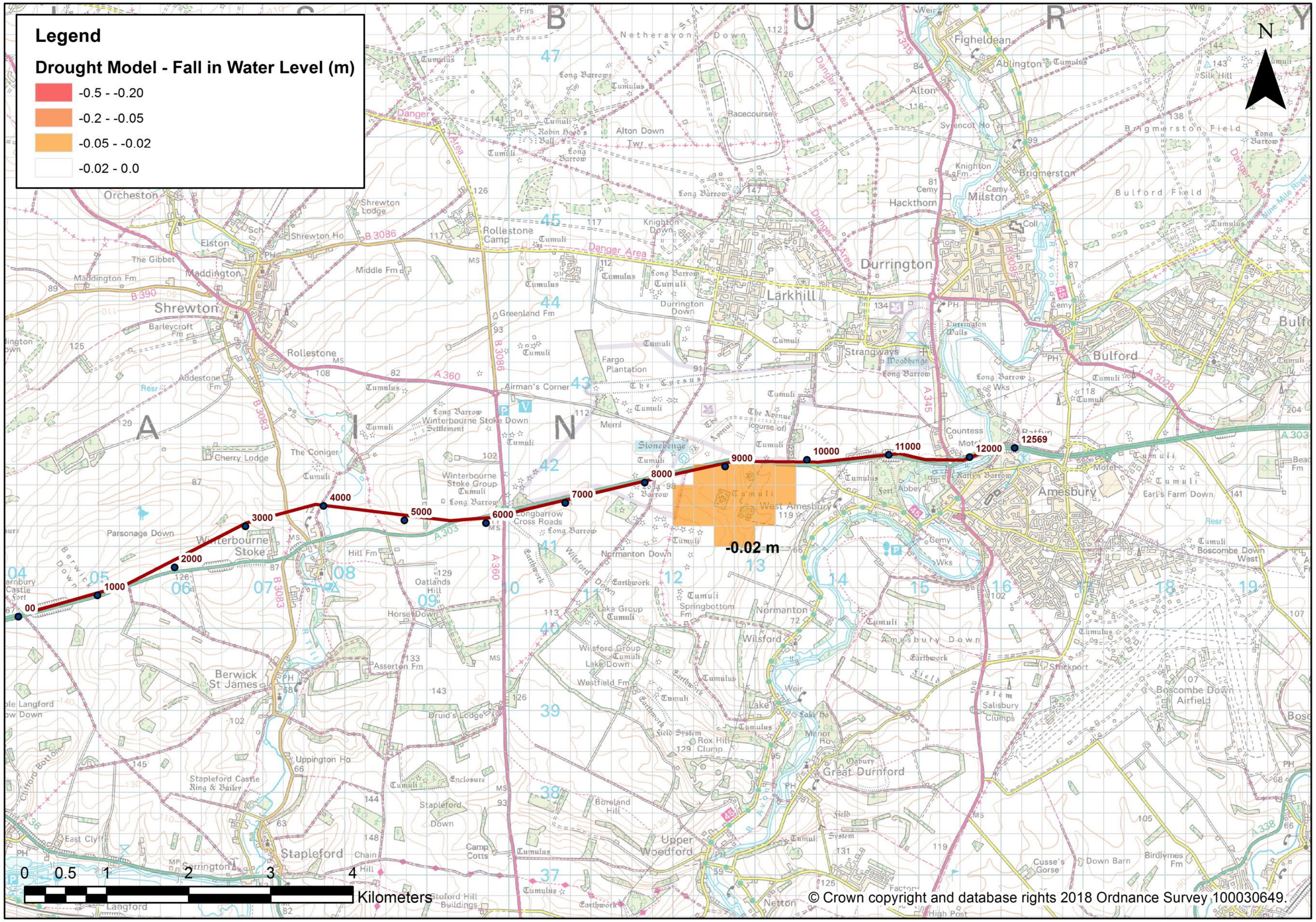

Figure 4.11 Fall in groundwater level at drought groundwater condition

4.1.26 The model predicts no significant change in flow in any reach at low flows in a drought year in the River Avon or the River Till.

4.1.27 Flow changes in the River Avon average approximately 20m^3/d compared to flows averaging approximately 70,000m^3/d. Increases in flow in the River Avon peak at Amesbury gauge at 28m^3/d, with the increase in flow then reducing and becoming a flow loss of up to 14m^3/d downstream of Wilsford (a maximum change of 0.06% of the flow). The River Avon accretion profile is given in Figure 4.12.

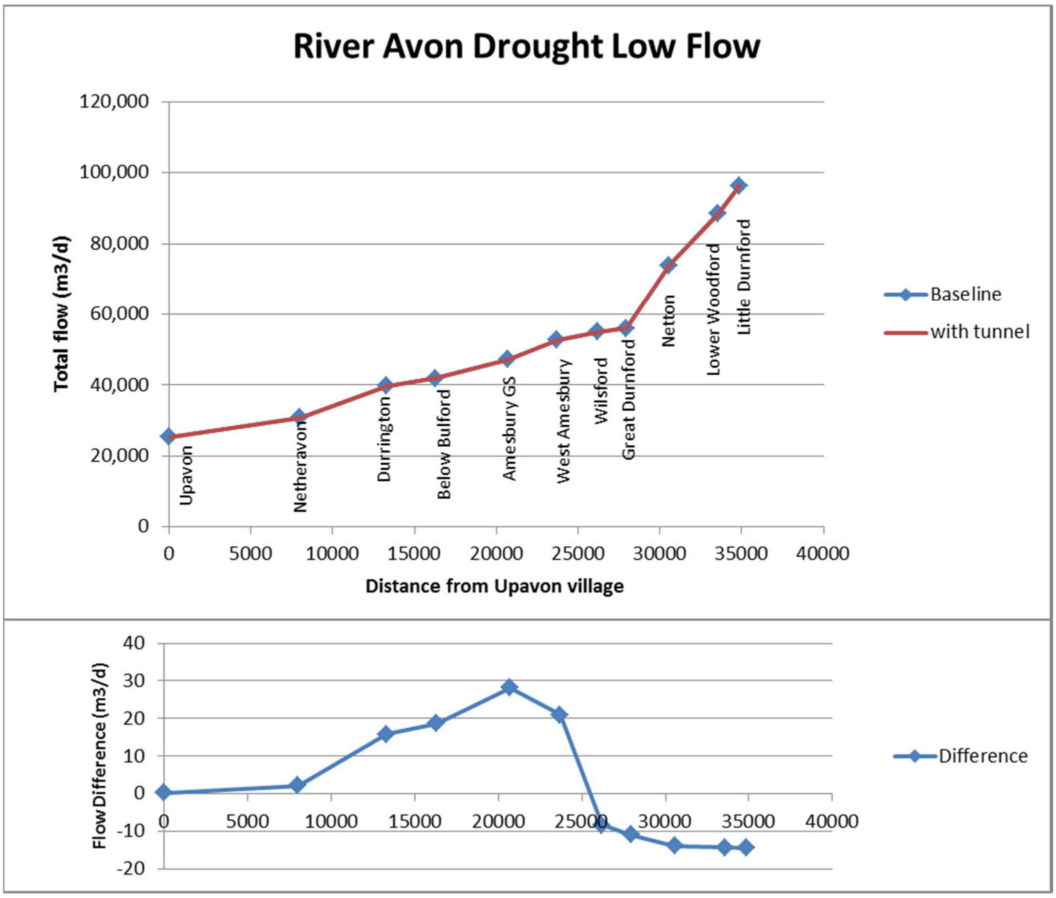

Figure 4.12 River Avon average low flow accretion profile

4.1.28 No flow changes are predicted in the River Till as during drought conditions there is very little flow in this river. Below the confluence with the River Wylye flow is predicted to be 36m^3/d less compared to flows of approximately 70,000m^3/d (a maximum change of 0.05% of the flow), as shown on Figure 4.13.

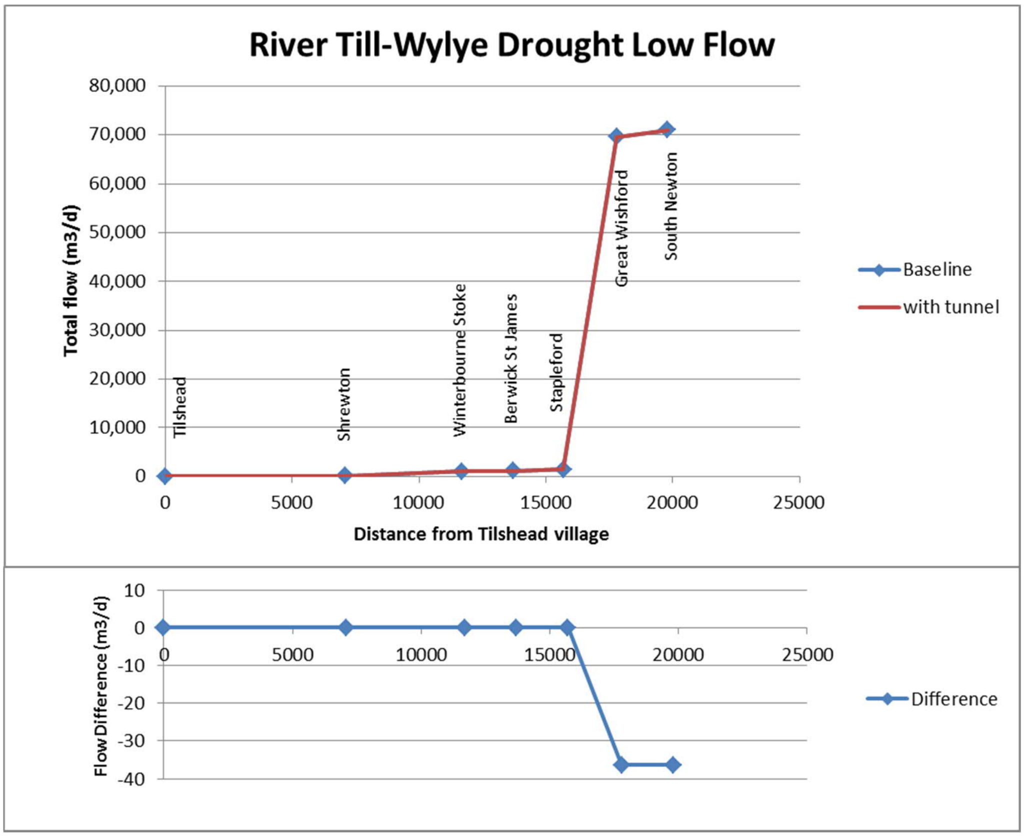

Figure 4.13 River Till-Wylye average low flow accretion profile

4.2 Abstractions

4.2.1 Modelled groundwater levels of baseline conditions and with the tunnel imposed were compared at licensed and unlicensed abstractions in the area predicted to show a change in water table, see Figures 4.1, 4.6 and 4.9. Abstractions immediately outside this area were also considered where negligible groundwater level changes (less than 0.01m) are predicted.

4.2.2 Abstractions within this area of impact are Wiltshire Grain Ltd, Shrewton Lodge Stud, Wessex Water Durrington, English Heritage Airman's Corner, Lake Settlement Estate, and Manor Farm

4.2.3 At peak groundwater levels the following changes are predicted.

Table 4.1 Predicted range of groundwater level change at abstractions during peak groundwater levels

Abstraction	Maximum Rise (m)	Maximum Fall (m)
Wiltshire Grain Ltd	0.046	0
Shrewton Lodge Stud	0.014	0
Wessex Water Services Ltd DURRINGTON A-C	0.015	0
English Heritage BOREHOLE AT POINT 'A' AIRMAN'S CORNER	0.132	0
English Heritage BOREHOLE 'B' AT AIRMAN'S CORNER	0.110	0

Abstraction	Maximum Rise (m)	Maximum Fall (m)
Trustees of Lake Settlement Estate WILSFORD-CUM-LAKE Borehole B – out of service	0	0.04
MANOR FARM Well 1	0.082	0
MANOR FARM Well 2	0.004	0
MANOR FARM Well 3	0.022	0

4.2.4 At average groundwater levels the following changes are predicted.

Table 4.2 Predicted range of groundwater level change at abstractions during average groundwater levels

Abstraction	Maximum Rise (m)	Maximum Fall (m)
Wiltshire Grain Ltd	0.015	0
Shrewton Lodge Stud	0.007	0
Wessex Water Services Ltd DURRINGTON A-C	0.007	0
English Heritage BOREHOLE AT POINT 'A' AIRMAN'S CORNER	0.034	0
English Heritage BOREHOLE 'B' AT AIRMAN'S CORNER	0.029	0
Trustees of Lake Settlement Estate WILSFORD-CUM-LAKE Borehole B – out of service	0	0.025
MANOR FARM Well 1	0.024	0
MANOR FARM Well 2	0.004	0
MANOR FARM Well 3	0.008	0

4.2.5 At drought groundwater levels the following changes are predicted.

Table 4.3 Predicted range of groundwater level change at abstractions during drought groundwater levels

Abstraction	Maximum Rise (m)	Maximum Fall (m)
Wiltshire Grain Ltd	0.006	0
Shrewton Lodge Stud	0.003	0
Wessex Water Services Ltd DURRINGTON A-C	0.004	0
English Heritage BOREHOLE AT POINT 'A' AIRMAN'S CORNER	0.011	0
English Heritage BOREHOLE 'B' AT AIRMAN'S CORNER	0.009	0
Trustees of Lake Settlement Estate WILSFORD-CUM-LAKE Borehole B – out of service	0	0.007
MANOR FARM Well 1	0.009	0
MANOR FARM Well 2	0.002	0

Abstraction	Maximum Rise (m)	Maximum Fall (m)
MANOR FARM Well 3	0.003	0

4.3 Springs

4.3.1 Groundwater level hydrographs at each identified spring location were extracted from the baseline average and drought model and compared against the same models with the tunnel imposed, to assess any potential environmental impacts.

4.3.2 In the drought model, changes in groundwater levels at known springs were negligible, typically less than 0.01m. At most locations groundwater levels fall, with the maximum fall predicted during the winter. Table 4.4 lists the springs with minimum and maximum predicted groundwater level change between September 1975 and March 1977.

Table 4.4 Predicted range of groundwater level change at springs during drought

Spring	Maximum Rise (m)	Maximum Fall (m)
Amesbury Abbey Spring	0.002	0.001
West Amesbury 1	0	0.009
West Amesbury 3	0	0
West Amesbury 2	0	0.020
Spring Bottom Farm	0	0.009
Lake Winterbourne	0	0.001
Durrington Spring	0.005	0
Gallows Hill Springs	0	0.005

4.3.3 In the average period model, changes in groundwater levels at known springs were less than 0.04m. At most locations groundwater levels fall, with the maximum fall predicted during the winter. Table 4.5 lists the springs with minimum and maximum predicted groundwater level change between April 1994 and March 1996.

Table 4.5 Predicted range of groundwater level change at springs during average period

Spring	Maximum Rise (m)	Maximum Fall (m)
Amesbury Abbey Spring	0.003	0.002
West Amesbury 1	0	0.015
West Amesbury 3	0	0
West Amesbury 2	0	0.035
Spring Bottom Farm	0	0.033
Lake Winterbourne	0	0.004
Durrington Spring	0.009	0
Gallows Hill Springs	0	0.008

4.4 Climate Change

4.4.1 The peak groundwater model was modified for climate change predictions by modifying the recharge per stress period, with an increase of 20%.This was chosen for consistency with fluvial modelling of climate change and is precautionary when compared with the 2050 climate change projections.

4.4.2 This model was compared with the baseline to consider the effects of the change in climate compared with the historic period used in the baseline model representing the wettest period on record (2014).

4.4.3 The climate change model estimated increases in groundwater level of several metres on the interfluves with increases of up to 1m near rivers. This is to be expected as the rivers form discharge locations effectively controlling the local groundwater level. Increasing groundwater hydraulic gradients lead to higher river flows.

4.4.4 In the area of interest groundwater levels are predicted to rise in excess of 3m in the Stonehenge-Larkhill area. Figure 4.14 shows the difference between the baseline peak groundwater levels and the peak groundwater levels with climate change assuming a 20% increase in recharge.

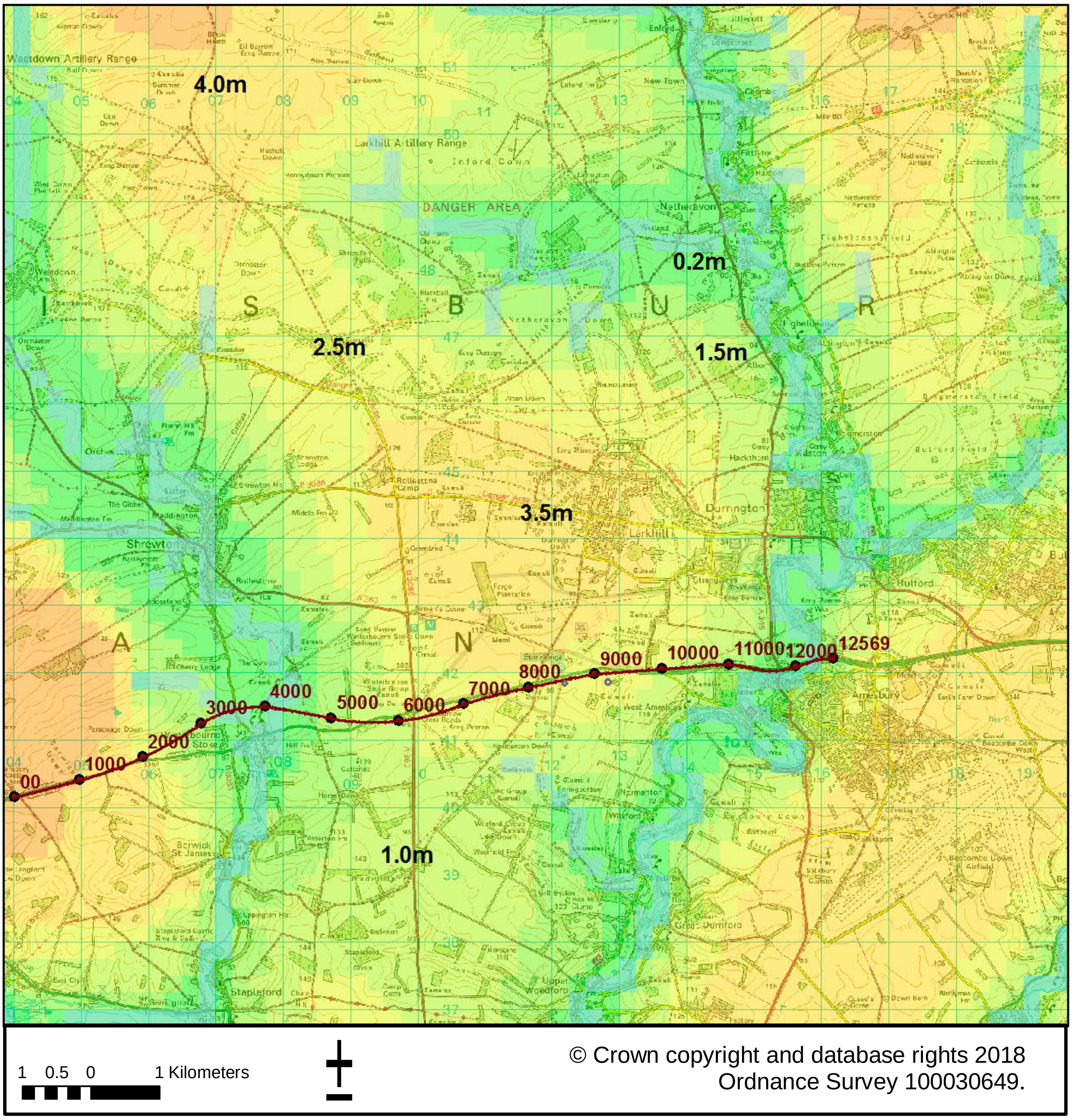

Figure 4.14 Rise in peak groundwater level with climate change

4.4.5 A similar process was adopted for climate change during drought. In the drought groundwater model recharge was reduced 20% to consider the effects of lower groundwater levels on river flows compared to the worst drought on record (1976).

4.4.6 The drought model predicted groundwater levels would be approximately 0.4m lower with climate change in the area of interest, with smaller reductions in the river valleys of approximately 0.2m.

4.4.7 When the tunnel is imposed on the peak groundwater level climate change model, the effect of the tunnel is very similar to the effect in the baseline peak conditions model, except near the tunnel where groundwater level rises up to an additional 0.1m north of tunnel. Elsewhere changes of less than 0.01m are predicted when comparing the tunnel impact against the baseline model and baseline with climate change models.

4.4.8 Therefore overall the effect of the tunnel is very small compared to the effect of climate change. That is, imposing the tunnel does not exacerbate the risk of flooding from climate change.

4.4.9 Figure 4.15 shows the difference in modelled groundwater level between the baseline with climate change and the baseline with climate change with a tunnel imposed.

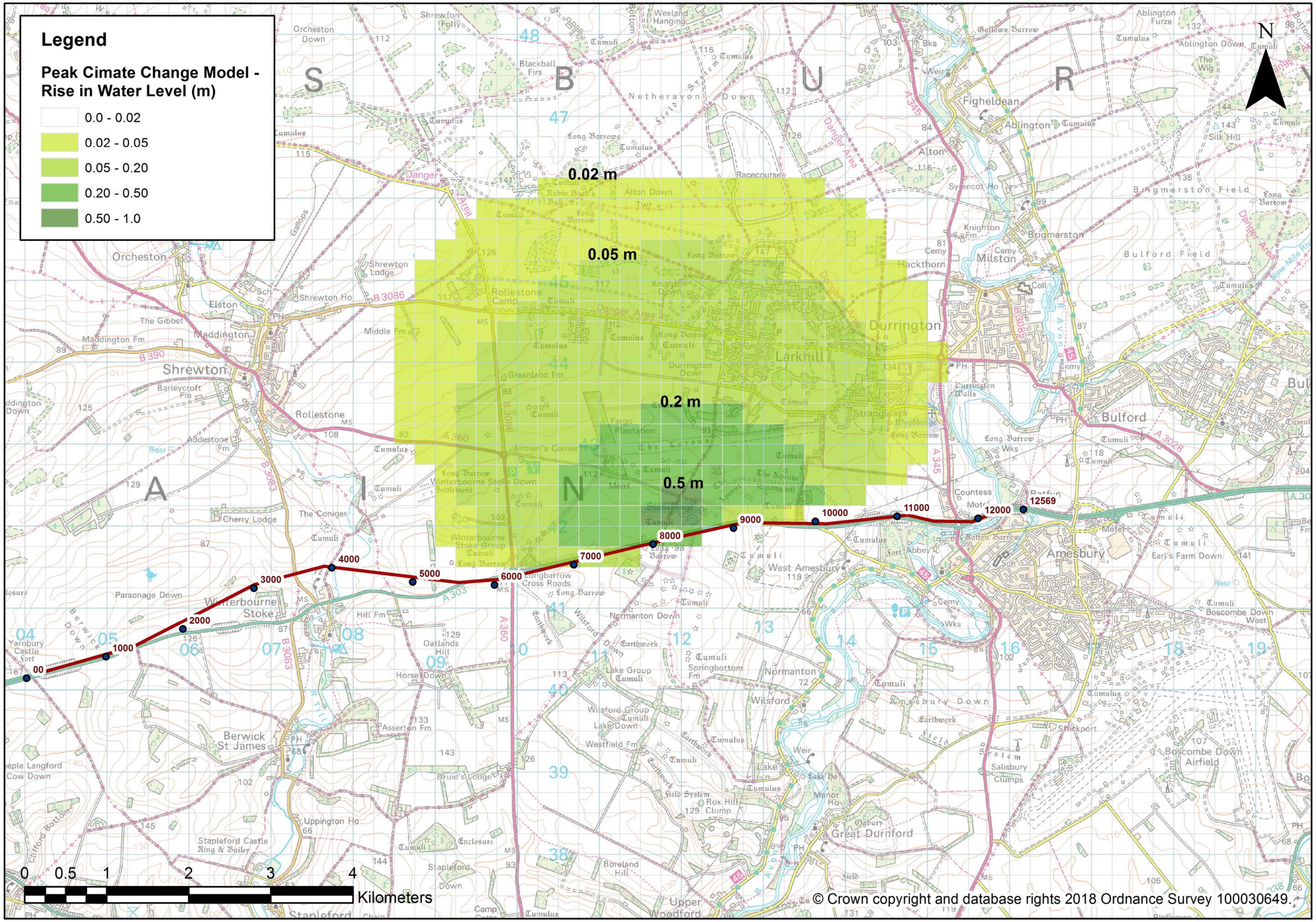

Figure 4.15 Rise in groundwater level when tunnel imposed on peak groundwater level with climate change scenario

4.4.10 The tunnel was not imposed on the average and drought periods as a modelled scenario because the impacts are reduced as groundwater level falls, as the tunnel creates a reduced impediment to groundwater flow. That is, the tunnel in the baseline average and drought period scenarios would have greater impact than a climate change scenario in these cases.

5 Conclusions

5.1 Model Development

5.1.1 The EA Wessex Basin model has been used to simulate the effects of a tunnel constructed within the Chalk aquifer. This model was developed between key stakeholders for the groundwater and surface water systems, the EA and Wessex Water, and was signed off as fit for predictive purposes by a technical working group.

5.1.2 Ground investigation data was used to check the local calibration of the model and some refinements were made to the hydraulic conductivity distribution.

5.1.3 These changes had the effect of raising peak groundwater levels closer to that observed in the flood event of February 2014. Groundwater level is the critical element for calibration for groundwater flooding prediction.

5.1.4 River flows were compared with the original model to check these changes did not make the calibration worse for low flows, which is the critical element for considering environmental impacts. Changes during drought were negligible because the changes to hydraulic conductivity affected the model at high groundwater levels but not at low groundwater levels due to the VKD setup.

5.1.5 Overall the model calibration was improved for groundwater flood periods and a negligible change was made to the calibration for average and drought low flows in the rivers Avon and Till.

5.1.6 The tunnel was simulated by considering the proportion of the saturated aquifer thickness profile that would be blocked by the tunnel and the portal sheet pile walls. This proportion of lost aquifer was simulated in the model by changing hydraulic conductivity. A higher proportion of blocked aquifer was assigned where the tunnel crossed preferential flow horizons identified in ground investigations.

5.2 Model Predictions

5.2.1 During the peak, average and drought groundwater level periods the model predicts a rise in water table elevation north of the tunnel and a fall in water table elevation south of the tunnel.

5.2.2 During the peak groundwater level period groundwater levels are predicted to rise up to 1m. As the groundwater level is estimated to be at a depth in excess of 10m in built-up areas, the predicted rise has no adverse impacts on flooding. The small increase in hydraulic gradient causes an increase in river flows of less than 1%.

5.2.3 At average summer low flows, representing the typical stressed condition for the environment, flows are reduced by less than 1% from the baseline flows. During drought the impact of the tunnel is less than at average condition because the baseline groundwater level is lower, so the tunnel creates a reduced impediment to flow.

5.2.4 Flow reductions are calculated to be very small because the model does not predict a lower water table beneath the rivers, the change in flow is related to a small change in the hydraulic gradient from the tunnel area to the discharge point at the rivers. The typical changes in river flows are less than 0.2% in the River Till before it joins the River Wylye, and 0.02% in the River Avon. The River Till is dry during drought and so no impact is measured, and the small difference in flow during recovery from drought means there is no significant delay to the restoration of flow.

5.2.5 Abstractions may be impacted if groundwater levels fall lower than pump positions or rise to a level that may damage equipment. The maximum rise during the peak groundwater level period was 0.13m at English Heritage Airman's Corner point A, while a fall of 0.04m at Lake Settlement Estate Borehole B is predicted down hydraulic gradient of the tunnel.

5.2.6 At average and drought periods the predicted rise and fall is less than at peak groundwater levels because the tunnel creates a reduced impediment to groundwater flow. The fall in groundwater level at Lake reduces to 0.025m at average summer lows and 0.007m at drought lows. The maximum rise in levels predicted at English Heritage Airman's Corner point A reduces to 0.034m in average winters and 0.01m in post-drought winter recovery.

5.2.7 The model predicts changes of less than 0.01m at all springs identified in the study area except West Amesbury 2 and Spring Bottom Farm, where 0.03m is predicted during average summer low groundwater levels.

5.2.8 Climate change has been simulated by increasing recharge in the peak model by 20%. Groundwater levels rise up hydraulic gradient of the tunnel by up to 4m. The tunnel does not exacerbate this water table rise. Climate change during drought simulated by decreasing recharge in the peak model by 20%. Under climate change groundwater levels fall up to 0.4m, which means the tunnel is less of an impediment to flow than under the baseline condition.

5.2.9 Overall the groundwater model predicts negligible changes to river flows, and groundwater levels at spring and abstractor locations and at Blick Mead during average summer low levels as well as drought low levels. Increases in groundwater level at peak periods are sufficiently small to not increase the risk of groundwater flooding from the baseline risk to communities in the area.

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6.3 Environmental Statement Appendices

Appendix 11.4 Annex 2 Water Features Survey Results

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Water Features Survey Results Summary

Table 1: Summary of Private Water Supplies (Names in bold are within ES study area)

Name	ID number	Council Reference Number	Corresponding EA Licence Number	Main Activity	Access during water features survey	Additional details gained during water features survey	Depth of Borehole/Well m bgl	Water level m bgl	Date of visit/water level measurement
Fisherton Manor Farm, Manor Farm, Fisherton-de-la-mere	1	PW/000001091		Domestic	No	No well at location provided by Council, information gained from other correspondence suggests that the well is located at Manor Farm slightly to the East.			NA
Fisherton-de-la-mere House, Fisherton-de-la-mere	2	PW/000001092		Domestic	No	Landowner was not available to show location of well.			NA
Water Source 1, Deptford Farm, Wylye, Warminster	3	PW/000001097	13/43/023/G/215*	Domestic	Yes	Borehole supplies drinking water for farmhouse, water is treated with UV and chlorinated	Could not remove well cover for dips		21/02/2018
Water Source 2, Deptford Farm, Wylye, Warminster	4	PW/000001098	13/43/023/G/215*	Domestic	Yes	Borehole supplies 12 houses	45.04	24.34	21/02/2018

Name	ID number	Council Reference Number	Corresponding EA Licence Number	Main Activity	Access during water features survey	Additional details gained during water features survey	Depth of Borehole/Well m bgl	Water level m bgl	Date of visit/water level measurement
Bathampton Farm, Bathampton, Wylye, Warminster	5	PW/000001150		Domestic	No				NA
Ballington Manor, Wylye, Warminster, Wiltshire	6	PW/000001154	13/43/023/G/085	Domestic	No	Information on borehole depths provided by the EA	25m depth Plain casing to 3.85m, slotted 3.85 to 25m.		NA
East Clyffe Farm, Salisbury Road, Steeple Langford	7	PW/200701172	13/43/023/G/239*	Domestic	No	Well not visited but information provided by abstractor: Pump at 52.5 m	208ft (provided by abstractor)	31 m bgl (provided by abstractor)	NA
Little Langford Farm, Little Langford, Salisbury	8	PW/000001072		Commercial	Yes	Water is UV treated	19.82	3.35	22/02/2018
Sceptre Lodge, Elston Lane, Shrewton, Salisbury	9	PW/000000911		Domestic	Yes	Borehole Open hole, water is UV treated. Borehole supplies the house and Manor house which is now a school	23.3	4.855	21/02/2018
Elston Hill Farm, Orcheston, Salisbury, Wiltshire	10	PW/000000912	13/43/023/G/209	Domestic	No	Information on borehole depths provided by the EA	91.4 m		NA

Name	ID number	Council Reference Number	Corresponding EA Licence Number	Main Activity	Access during water features survey	Additional details gained during water features survey	Depth of Borehole/Well m bgl	Water level m bgl	Date of visit/water level measurement
Scotland Lodge, Winterbourne Stoke, Salisbury	11	PW/000000932		Domestic	Yes	Well cover could not be removed	30.9m depth, may be steel support as owner believed well is a lot deeper (around 300ft)	23.49 (to datum, top of steel support)	21/02/2018 the pump was turned off and the dip did not change
G E Street & Son, Berwick Hill Farm, Berwick St James	12	PW/000000929	13/43/023/G/083*	Domestic	Yes	Water is not treated. Logger in well by Wessex water. The well is also used by EA as a monitoring borehole which they try to monitor every month.	12.13	1.96	21/02/2018
Druids Lodge (source 2), Hill Farm, Winterbourne Stoke	13	PW/000000933	13/43/023/G/065 (Point A and B)	Commercial	No	Information on borehole depths provided by the EA 2 wells and 1 borehole	Point A (well) 27.44m depth, Point B (well and BH) 22.86m and 67.06m depth	NA	NA
			13/43/023/G/245 (licensed Borehole)			Information on borehole depths provided by the EA 1 borehole	94m depth	NA	

Name	ID number	Council Reference Number	Corresponding EA Licence Number	Main Activity	Access during water features survey	Additional details gained during water features survey	Depth of Borehole/Well m bgl	Water level m bgl	Date of visit/water level measurement
Wiltshire Grain Ltd, Rollestone Silo	14	PW/000001137		Commercial	Yes	Supplies their small office (toilets and Kitchen tap) Pump suction at 61 mbgl	91m bgl from owners details 88.1m bgl from dip (but there is an old pump at the bottom of the borehole)	38.85	15/03/2018
Druids Lodge, Water Source 1, Middle Woodford	15	PW/000000937	13/43/021/G/251	Commercial	No	Information on borehole depths provided by the EA	125m		NA
Stonehenge Visitor Centre	16	PW439	SW/043/0021/003	Commercial	Yes	Borehole used for water supply	Depth can't be taken safety, logger in borehole	25.05	22/02/2018
						Borehole used for Ground heat	Depth can't be taken safety, logger in borehole	19.99	22/02/2018
						Borehole used for Re injection	Depth can't be taken safety, logger in borehole	Couldn't get did due to location of the dip tube	22/02/2018
						Borehole used for ground source heating and re injection	Depth can't be taken safety, logger in borehole	21.51	22/02/2018

Name	ID number	Council Reference Number	Corresponding EA Licence Number	Main Activity	Access during water features survey	Additional details gained during water features survey	Depth of Borehole/Well m bgl	Water level m bgl	Date of visit/water level measurement
Westfield Farm, Middle Woodford, Salisbury, BH-A	17	PW/000000934	13/43/021/G/236 Point A	Domestic	Yes	Supplies farm and 2 cottages and fills reservoir to 12 m Information on borehole depth provided by the EA	Owner believes approximately 95 m but not confirmed Environment Agency state 80m	No dip access	11/04/2018
Westfield Farm, Middle Woodford, Salisbury, BH-B	17	PW/000000934	13/43/021/G/236 Point B	Domestic		Fills the reservoir and submersible pump runs on a generator in tandem with BH A , if the electric cuts out this one is run	Owner believes approximately 40-50 m but not confirmed Environment Agency have no details	No dip access	11/04/2018
Heale House, Middle Woodford	18	PW/000000903 The coordinate provided by the council for Heal stables was incorrect		Domestic	Yes	Used for the manor house, submersible pump with 3cm rising main	27.9	2.65	09/03/2018
Lake Estate, Wilsford-cum-Lake, Salisbury	19	PW/000000917	13/43/021/G/212	Commercial	Yes	Used for cottages near the estate	6.14	0.79	15/03/2018

Name	ID number	Council Reference Number	Corresponding EA Licence Number	Main Activity	Access during water features survey	Additional details gained during water features survey	Depth of Borehole/Well m bgl	Water level m bgl	Date of visit/water level measurement
Cholderton Rare Breeds Farm, Amesbury Road	20	PW/000001170		Commercial	Yes	Borehole supplies Youth hostel	Owner believes 80m	Owner believes approximately 45m No dip as head plate is sealed	08/03/2018
Shrewton Farm	21	Not on council list		Agricultural	Yes	Well used for dairy farm Owner also has a well at Rockery Farm which was not visited.	41.9	27.07	21/02/2018
Shrewton Lodge Stud	22	Not on council list		Agricultural	Yes	Well for agriculture including sheep and horses. There is also a house well which is 23.85m deep, no access due to heavy cover, this supplies the main house, water is treated with UV sediment filter and softener.	24.5m bgl (owners notes) 16.1m bgl (measured but believed to be deeper as casing gets skinnier)	10.27	21/02/2018
The Old Rectory	23	Not on council list		Domestic	Yes	Borehole used for water supply, filtered before tap. Dip access from unscrewing belt. Pump at 5.8m bgl	24.06	1.76 (pump off)	22/02/2018

Name	ID number	Council Reference Number	Corresponding EA Licence Number	Main Activity	Access during water features survey	Additional details gained during water features survey	Depth of Borehole/Well m bgl	Water level m bgl	Date of visit/water level measurement
WISMA Berwick St.James	24	Not on council list	13/43/023/G/246	Domestic	Yes	Use of borehole is uncertain, other correspondence suggested that the site uses mains water and boreholes are not used due to bacterial issues.	29.9	6.72	09/03/2018
Manor Farm		Not on council list	13/43/023/G/074 licence being reapplied for	Agricultural (General and Domestic)	No	Details provided by owner and Environment Agency for four wells	Details provided by owner/EA Well 1 – 10 m / 24.38 m Well 2 – 12 m / 12.19 m Well 3 – 30.5 m /30.4 m Well 4 – 10 m/9.14 m		NA
Stonehenge Ales		Not on council list		Commercial (Stonehenge Naturally Still Spring Water)	No	Details provided during call with owner. Source Reference 447. Near River Avon.	15		

Table 2: Summary of Springs Survey

Name of Spring	Date and time visited	Easting	Northing	Notes	Conductivity (µS/cm)	Temperature (°C)	pH (pH)	ORP (mV)	Dissolved Oxygen (mg/l)	Sample taken for analysis (sample name in brackets)
West Amesbury 1	15/11/17	414312	141443		541.96	12.12	8.25		8.25	Yes (W AM SP)
West Amesbury 2	15/11/17	414100	141340	Seepage to river						No
West Amesbury 3	26/01/18	415709	140707	Spring emerges around 10 m from the river	574.79	7.53	7.09*	101.63	6.19	Yes (WA3)
Abbey Spring (previously referred to as Blick Mead Spring (BM)	26/01/18 08:00	414875	141981		483.88	10.13	8.30*	102.70	8.75	Yes (AS) (BM)
Durrington Spring		415500	143800	Possible location of spring found, but dry.						No
Spring Bottom Farm*	26/01/18 12:20	412115	140097	Exact location not known, the area is slightly boggy but dry						No
Gallows Hill Springs	15/03/18	414557	141381	Some emergences from ground into the river branches of the river Avon	484.2	10.7	7.36			No
Lake Winterbourne Spring	15/03/18			Observed from the road						No
Chinese House (Abbey Pond)	26/01/18 08:32	414795	141823		398.69	9.47	8.50*	120.83	9.73	Yes (AL2)
Upstream River Avon	26/01/18 09:10	414960	141911		488.87	7.08	8.99*	128.53	11.01	Yes (AL1)
Downstream River Avon	26/01/18	414845	141616		495.31	6.83	9.037*	137.22	11.45	Yes (AL3)

* pH probe was not calibrating on site on 26/01/18 –pH results may not be reliable

Photo 1: West Amesbury Spring 1

Photo 2: West Amesbury Spring 3

Photo 3: Abbey Spring

Photo 4: Gallows Hill Springs

Photo 5: Lake Winterbourne Spring

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6.3 Environmental Statement Appendices

Appendix 11.4 Annex 3 Blick Mead Tiered Assessment

Volume 6

APFP Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

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1 Introduction

1.1 Background

1.1.1 Archaeological excavations carried out since 2005 at Blick Mead, a triangle of land within Amesbury Abbey Park south of the A303, have located Mesolithic deposits in association with what is reported as a springhead depression [1]. The date of the Mesolithic deposits at Blick Mead reflects the earliest known human activity in the World Heritage Site (WHS). It is understood that deposits of comparable date are also known to have been found at Countess Farm on the northern side of the A303 [1].

1.1.2 Whilst the Scheme requires no new land-take outside the existing highway boundary into the Blick Mead area, questions have been raised regarding how the Scheme might affect the hydrogeology at Blick Mead. The Archaeologist who led the excavations (Professor. D Jacques) has suggested in consultation discussions that changes to the water environment could affect the conditions of archaeological preservation at the site.

1.2 Tiered assessment and the current report

1.2.1 Historic England has produced guidance on preserving archaeological remains, including water environment assessment techniques [2]. This sets out the need to develop a hydrogeological conceptual model to explain the assessor's knowledge on the local geology and water cycle, with consideration of groundwater – surface water interactions. The information required to form the conceptual model includes [2]:

- *The identification and hydrogeological characteristics of different aquifers i.e. lithology, thickness, permeability and geological structure.*
- *The principal groundwater flow mechanism in each aquifer unit, for example intergranular or fracture.*
- *The extent to which groundwater is able to flow between the different aquifers; this may be influenced by intervening lower permeability strata or structural features such as faults.*
- *The nature of interactions between groundwater and surface water i.e. discharge points.*
- *The identification of sources of recharge: rainfall infiltration, regional groundwater input, artificial infiltration sources or a combination of mechanisms.*

1.2.2 The different tiers of assessment are [2]:

- *Tier 1: Desk study and site walkover to derive 'first conceptual model'*.
- *Tier 2: Basic qualitative assessment of water balance to identify groundwater levels, flow directions and identify key potential influences on the groundwater system.*
- *Tier 3: Conceptual model testing using site-specific measurements, simple analytic equations and long-term average water balances, to arrive at a 'better conceptual model'.*
- *Tier 4: Development of a numerical groundwater model, calibrated and validated against monitoring data from the site and surrounding area. The*

model is then tested using detailed data, such as time variant levels, and more sophisticated analytical tools.

1.2.3 Tier 2 and Tier 3 assessments can be performed on the same amount of data, although there is a more detailed assessment of the data in Tier 3. The investigation should continue through the tiers until the reliability of the conceptual model has reached an acceptable level. A Tier 4 assessment may be required where mitigation is considered necessary to facilitate long-term preservation. Conversely, in some cases just Tier 1 may be sufficient.

1.2.4 The current document follows the guidance and presents an assessment for the Blick Mead site. There is sufficient information for this to be representative of a Tier 2 assessment, and also contribute towards a Tier 3 assessment should it be considered that one be required.

1.2.5 A regional groundwater model of the Chalk aquifer, the Wessex Basin groundwater model, was developed by the Environment Agency and has been used to support the A303 Amesbury to Berwick Down Environmental Statement in terms of the assessment of environmental impacts to water and sensitive environmental features such as Blick Mead.

1.3 Data sources

1.3.1 A number of data sources are used to inform the conceptual model of the Blick Mead site and the assessment. These are as follows:

- British Geological Survey and Environment Agency data sets [3], [4], [5], [6].
- Archaeological and environmental investigations carried out by the University of Buckingham and Reading University in 2014 and 2015 [7].
- Various ground investigations [8], [9], [10], [11].
- Environmental information collected by AECOM during visits to the Amesbury Abbey Estate in 2017 and 2018.

1.3.2 These data sources are referenced where appropriate within the tiered assessment.

2 Water Environment Assessment

2.1 Introduction

2.1.1 This chapter develops the conceptual model for the site and completes the water environment assessment by answering the following Tier 1 and 2 questions [2]:

- Tier 1: *Are the deposits in which significant waterlogged archaeological remains are located, hydraulically connected to the wider groundwater system?*
- Tier 1: *Are these remains likely to be located under the water table or have been so in the past?*
- Tier 2: *Will the deposits in which significant waterlogged archaeological remains are located be underwater all year?*
- *Tier 2: If not, what variation can be expected and what is influencing the variation (anthropogenic or natural)? And are these variations short-term or long-term / permanent?*

2.1.2 The development of the conceptual model is provided below.

2.2 The heritage asset boundaries

2.2.1 The Blick Mead archaeological site is located within the grounds of Amesbury Abbey Park, to the north west of the town of Amesbury. It lies around 100m west of the River Avon and immediately south of the existing A303. A photo of the site is provided in Figure 2.1.

2.2.2 The vertical and lateral extent of the Blick Mead archaeological deposits of interest are characterised within source [7]. The archaeological investigation indicated that "*the thin waterlain deposit containing the Mesolithic assemblage in Trenches 19, 22 and 23 (H3a) rested on a gravel bench about 1 m above the general level of the alluvial floodplain*".

2.2.3 The Mesolithic layer is shown on borehole transects within source [7] and these are reproduced in Figure 2.2, Figure 2.3 and Figure 2.4. They show that the Mesolithic layer occurs between 67m aOD and 68m aOD, immediately overlying sands and gravels. The depth to the Mesolithic layer below surface is variable, but ranges between around 0.75m and 2m beneath made ground and undifferentiated alluvium.

2.2.4 The borehole transects (particularly Figure 2.4) also demonstrate the 'gravel bench' (i.e. the 'higher gravel surface'). The higher gravel surface undulates, ranging between around 67.25m aOD and 68m aOD. The lower gravel surface, nearer the River Avon, occurs at around 66m aOD and below i.e. there is around 1 m difference between the two gravel surfaces. The transects indicate there were no Mesolithic layers recorded above the lower gravel surface where the peat deposits are recorded closer to the River Avon.

2.2.5 The southern extent of the Blick Mead site is marked by "*an eighteenth-century causeway/avenue*" (see Figure 2.2). The northern extent is delineated by the existing A303, the western extent is represented by the extent of the alluvial deposits and the eastern extent by the edge of the higher gravel surface.

Figure 2.1 Blick Mead Archaeology Site (November 2017)

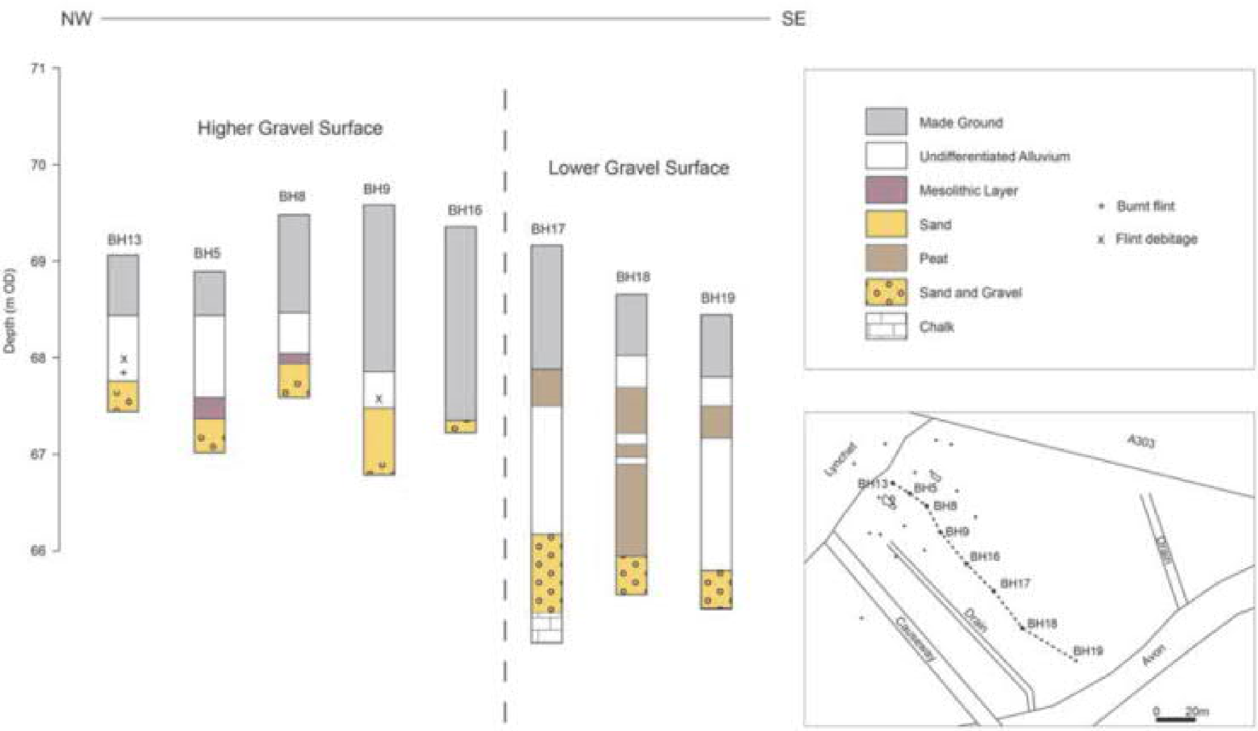

Figure 2.2 North-west to south-east borehole transect, from low to high ground (reproduced from source [7])

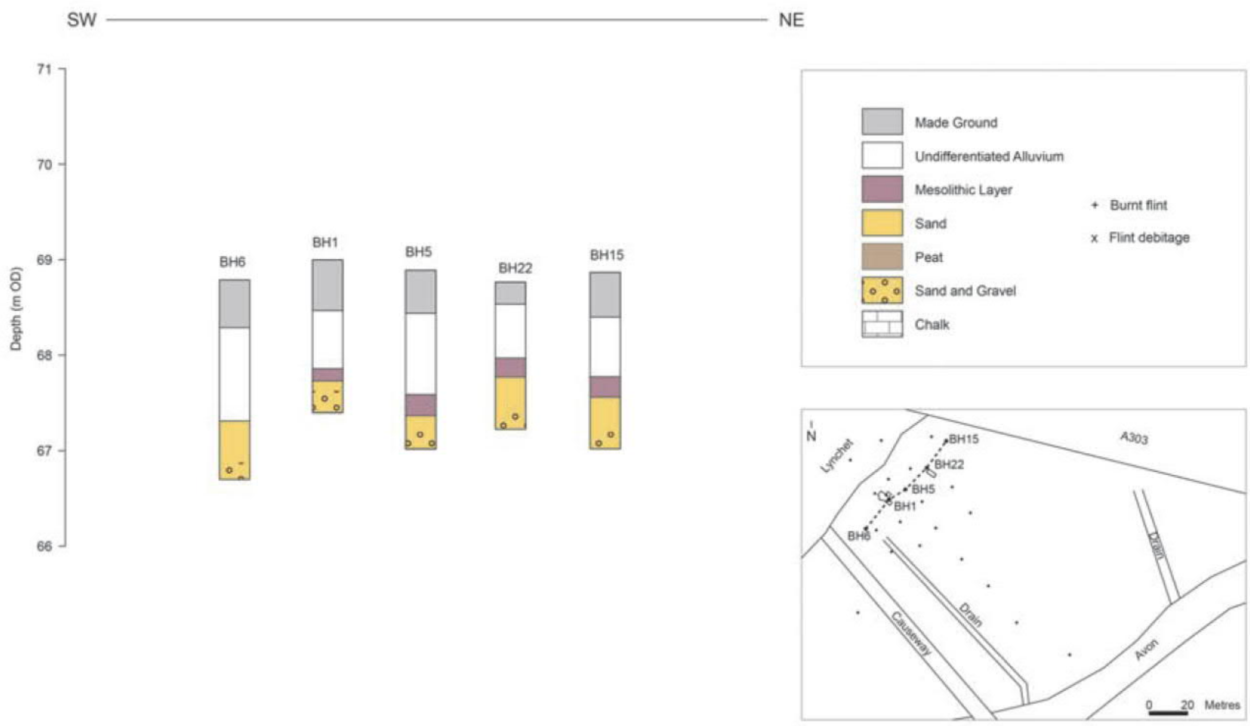

Figure 2.3 South-west to north-east transect across low-lying ground (reproduced from source [7])

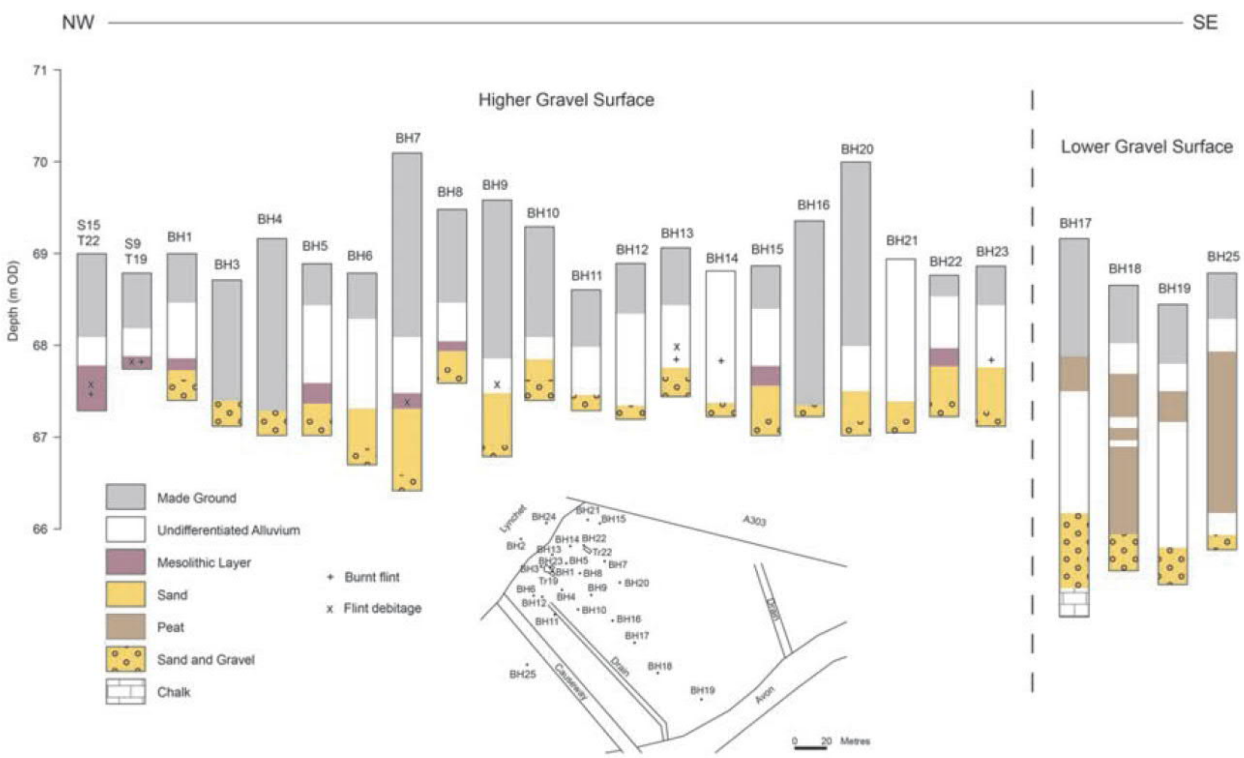

Figure 2.4 Borehole data from the Blick Mead basin showing higher and lower gravel surfaces, and the stratigraphic position of the Mesolithic horizons (reproduced from source [7])

2.3 Water features

2.3.1 A sketch of the water features in the study area is reproduced and adapted from source [1] in Figure 2.5. This shows the Blick Mead archaeological site including a 'winter-forming pond' and a 'winter-flowing channel' (referred to as the 'Blick Mead drain' in this report). On the opposite side of a trackway/causeway to the Blick Mead archaeological site, 'winter-flowing springs' are marked (referred to in this report as the 'Amesbury Abbey springs'), which feed a permanent spring-fed pool (referred to in this report as the 'Amesbury Abbey pond'). All of these water features drain into the nearby River Avon.

2.3.2 Walkover surveys of the area were undertaken in November 2017, January 2018 and March 2018 and noted the following:

- **Amesbury Abbey pond:** This is an elongated and shallow area of surface water to the southwest of the Blick Mead archaeological site, which connects to the River Avon beyond the Chinese House. The pond is described by the landowner as having a constant level all year round. However the margin around the observed water level in the photo taken in November 2017 suggests at least a small degree of water level fluctuation (see Figure 2.6). The site visit occurred in November following dry weather and therefore possibly reflects a typical annual low point. The bed was silted indicating it is likely that hydraulic continuity with groundwater is impeded.

- **Amesbury Abbey springs:** The springs are not shown on the current Ordnance Survey mapping (although they do appear on the 1877 historical map) and were not located / observed in November 2017. Return visits in January and March 2018 did locate the springs at approximate NGR 414875 141981 (+ / -10 m owing to tree cover) (see Figure 2.7). The spring location was gravelly with Chalk observed.

- **Blick Mead drain:** The drain was visited in January 2018 and was observed to be dry except for a depression near the River Avon (see Figure 2.8). The drain contained terrestrial vegetation (i.e. grassed over) confirming that it is not a permanently flowing feature.

- **Winter-forming pond at the Blick Mead site:** No surface water ponding was observed at the Blick Mead site itself during the November 2017 and January 2018 visits but there was evidence that water had been present during visits later in 2018.

2.3.3 The approximate elevations of the study area are known from LiDAR survey data (see Figure 2.9). This shows that the Blick Mead archaeological site is around 68.5 to 69m aOD (which is consistent with Figure 2.3). There is a clear depression at the northern end where the 'winter-forming pond' is expected to develop. To the north the land rises up to the existing A303 road, which has a surface of between 71.5m aOD to 73m aOD at this location i.e. at least 1.5 m above the level of the Blick Mead site. The land also rises westwards to 75m aOD and above, representing the rising Chalk valley slope of the River Avon.

2.3.4 The Blick Mead drain feature can be seen on Figure 2.9 as running from the Blick Mead archaeological site in a south east direction, dropping to below 68.5m aOD nearer to the River Avon (which is the wetted depression in Figure 2.8). The River Avon itself is at an elevation of between 67.5m aOD and 68m aOD.

2.3.5 The causeway separating the Blick Mead drain and the Amesbury Abbey springs reaches approximately 69.5m aOD, and the springs themselves emerge at between around 68m aOD to 68.5m aOD. The discharge from the springs flows in a southerly direction to the Amesbury Abbey pond, which is at a similar elevation to the River Avon i.e. between 67.5m aOD and 68m aOD.

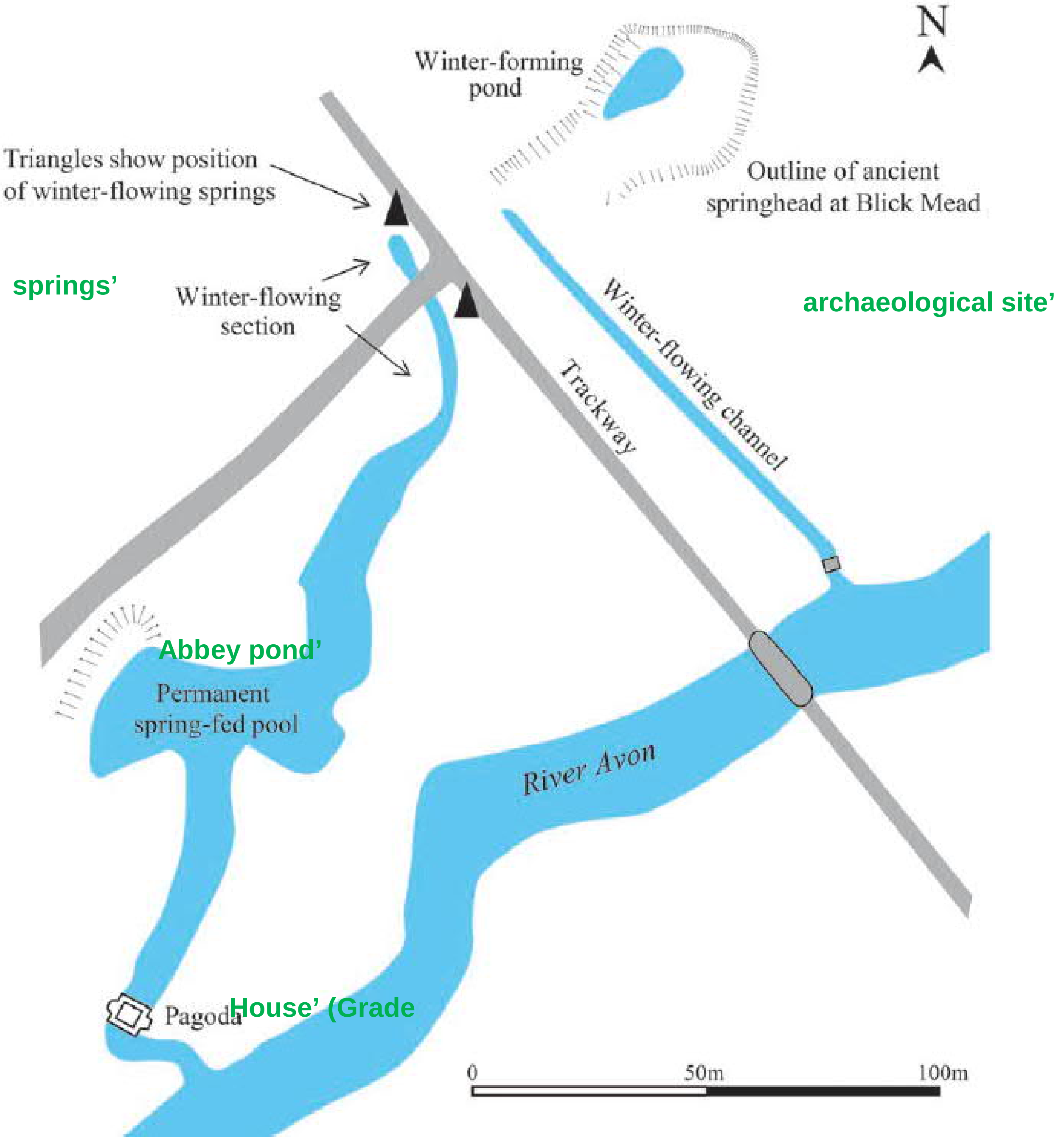

Figure 2.5 Map showing the outline of Blick Mead, nearby seasonally flowing springs and watercourses and the spring-fed pool that flows into the River Avon (reproduced and adapted from source [7])

Figure 2.6 Amesbury Abbey Pond (November 2017)

Figure 2.7 Amesbury Abbey Springs (March 2018)

Figure 2.8 Blick Mead drain (January 2018); upper dry reach (left) and wetted depression nearer the river (right)

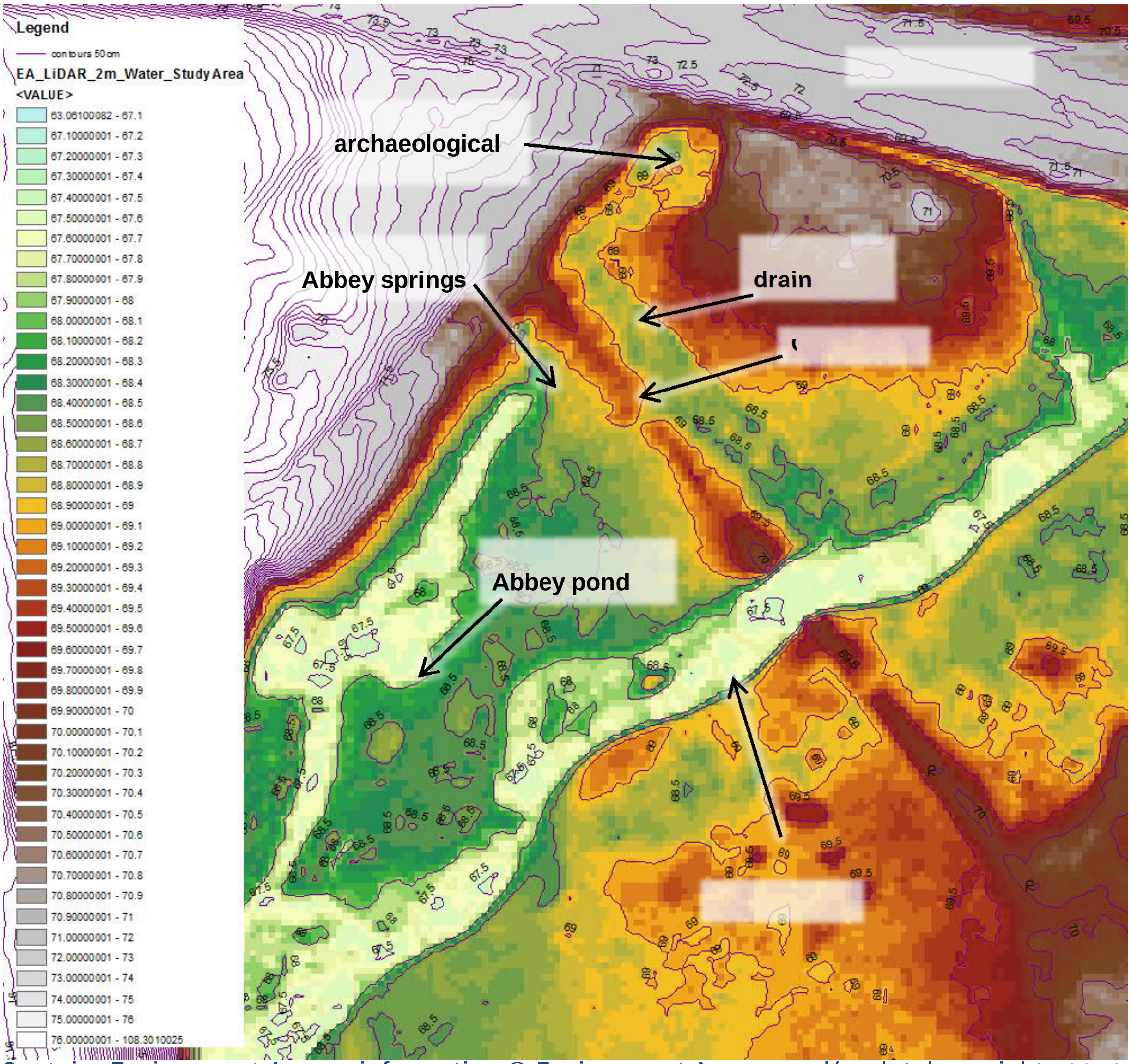

Figure 2.9 LiDAR ground elevation data in the vicinity of the Blick Mead archaeological site including 50cm contours

2.4 Geology and hydrogeology

2.4.1 The British Geological Survey (BGS) mapping indicates that the Blick Mead area comprises superficial deposits of head (clay, silt, sand & gravel), peat, alluvium (clay, sand & gravel) and river terrace deposits (sand & gravel), overlying bedrock comprising the Seaford Chalk Formation (see Figure 2.10).

2.4.2 Further characterisation of the geology and hydrogeology of the area is given below.

Peat

2.4.3 The peat deposits are shown to outcrop on the north western side of the River Avon and the geological memoir of the Salisbury area [4] describes the deposits as fibrous, black peaty silty clay. Peat deposits are mapped as being present at the Blick Mead archaeological site (see Figure 2.10), although it is noted that investigation boreholes for the site only identified peat deposits in those boreholes closest to the River Avon (see Figure 2.4).

2.4.4 The peat deposits are up to around 2m thick as recorded by the investigation associated with the Blick Mead archaeological site. This is similar to other site investigation holes e.g. BH7, BH8 and BH9 (dated 1965) from source [8] shows silty peat up to 0.9 m thick.

2.4.5 The peat is expected to behave as an aquitard relative to other geological units in the area (i.e. unproductive strata with a low permeability) restricting groundwater flow.

Alluvium

2.4.6 The alluvium is shown to be present within the river valley. The geological memoir [4] describes the alluvium as sandy gravel at depth (2 to 3 m thick), below fine sandy mud and peat (also 2 to 3 m thick). The fine grained sandy muds are described as over bank deposits (i.e. deposited during flood events) and are pale grey, wet, sticky mud with varying amounts of very fine and fine grained sands; they often contain peat and organic material and very thin fine-grained gravel beds of flint and Chalk.

2.4.7 The investigation boreholes for the Blick Mead archaeological site identified alluvium (undifferentiated - but largely sandy silt, silty clay or clay) overlying sands and gravels, which is commensurate with the two units described in the geological memoir (see Figure 2.4). It is noted that the investigation boreholes also identify made ground, up to 3.9m thick at surface, which is not identified on the BGS mapping. These are likely to originate from the A303 roadworks and landscaping, comprising layers of blocky chalk rubble and sandy organic silty clay similar to topsoil.

2.4.8 The fine sandy mud and peat units are not expected to allow significant movement of groundwater and behave as an aquitard (i.e. unproductive strata with low permeability) relative to the lower sandy gravel unit, which is expected to behave as a Secondary aquifer (i.e. capable of supporting local water supplies and potentially a source of base flow to rivers) facilitating groundwater movement.

River terrace deposits

2.4.9 The river terrace deposits are mapped as occurring in small areas adjacent to the alluvium and outside of the main river channel (see Figure 2.10). The geological memoir [4] identifies these as comprising flint gravel of various sizes with clay, occurring 1.5 to 5m above river level separated from the existing alluvial flat floodplain by a small bluff (broad rounded cliff).

2.4.10 The BGS geology map (schematic sections) shows the river terrace deposits as occurring at higher elevations above the flood plain and also beneath the alluvium and River Avon, although the geological memoir [4] only shows the deposits as occurring at higher elevations. The deeper 'sandy gravel' described as a unit of alluvium within the latter may be equivalent to the 'lower gravel surface' identified by the Blick Mead archaeological investigation (see Figure 2.4), with the 'upper gravel surface' equivalent to river terrace deposits.

2.4.11 The sands and gravels, whether shown as a unit within the alluvium or as a separate river terrace deposit, also are expected to behave as a Secondary aquifer. Where the sands and gravels are overlain by low permeability alluvium and peat, it is likely that these deposits produce confined or partially confined groundwater conditions in the sands and gravels.

Head deposits

2.4.12 The head deposits occur in the dry valley to the north of the existing A303. The BGS mapping (see Figure 2.10) indicates these are deposits largely comprising gravel, although those lower in the valley (including those mapped at the northern end of the Blick Mead archaeological site) are identified as comprising clay, silt, sand and gravel.

2.4.13 The head deposits in the lower part of the dry valley are expected to behave as an aquitard relative to the gravel deposits higher in the valley, which are expected to behave as a Secondary aquifer.

Seaford Chalk Formation

2.4.14 The Seaford Chalk Formation is the bedrock of the study area and outcrops at surface along the western edge of the Blick Mead archaeological site and also near the western border of the Amesbury Abbey pond. The Chalk was encountered in the deepest Blick Mead investigation borehole at an elevation of around 65.5m aOD (see Figure 2.4), beneath sands and gravels.

2.4.15 The Chalk is classed as a Principal aquifer. Chalk has a low intergranular permeability but an enhanced fracture permeability and supports water supply and/or river base flow on a strategic scale.

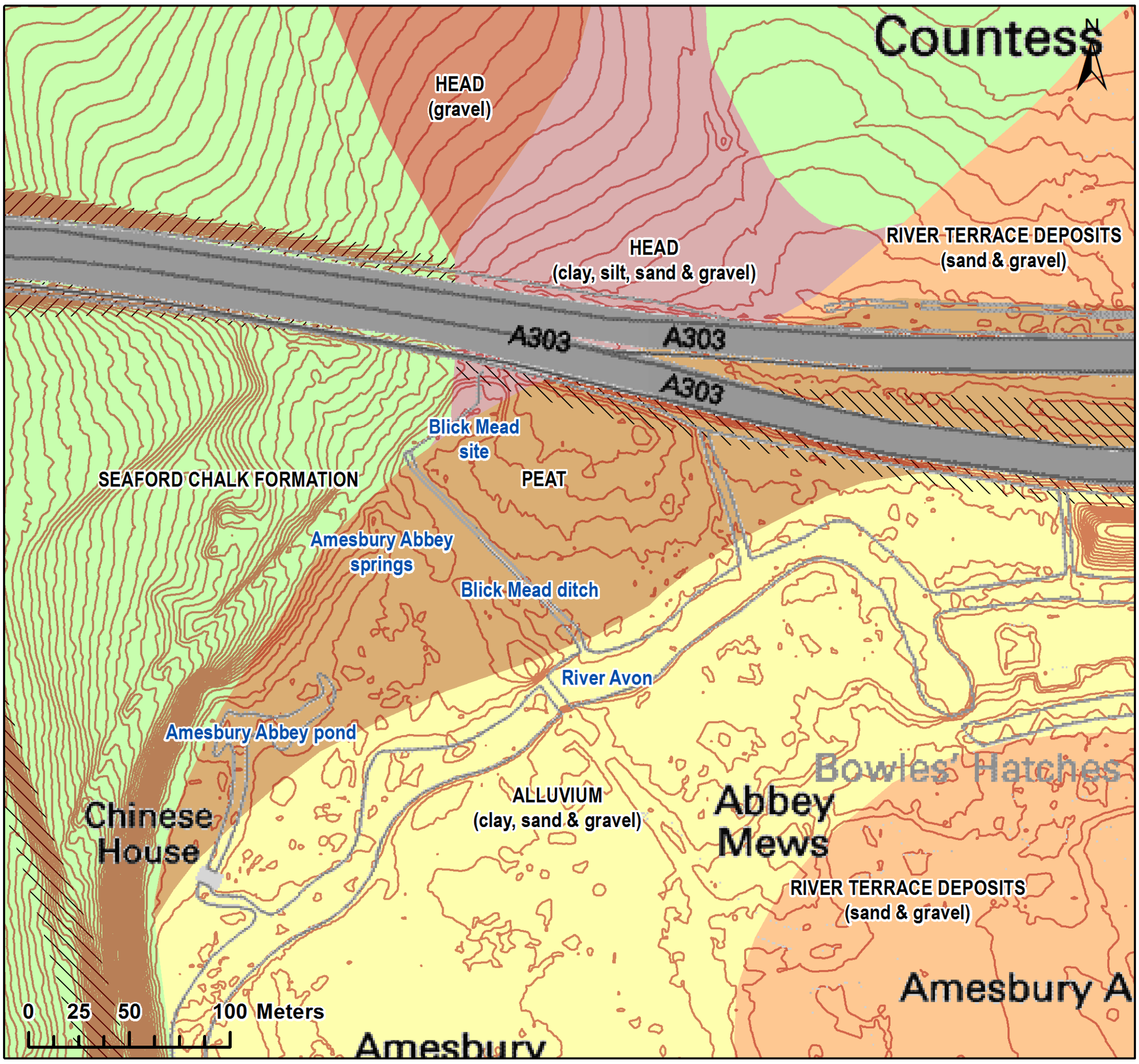

Figure 2.10 Superficial and bedrock geology in the vicinity of the Blick Mead archaeological site, including 50cm LiDAR contours

2.5 Groundwater and surface water levels

Blick Mead site

2.5.1 There are no known available groundwater level data for the Blick Mead site itself, despite the previous investigation boreholes associated with archaeological investigation. However it was reported that the water level within investigation trenches was on average around 0.5 m below ground level [1] i.e. between around 68 to 68.5m aOD.

2.5.2 The strata containing the archaeological material was described as *"overwhelmingly but not exclusively fine grained"* [1], although the borehole logs in Figure 2.4 demonstrate that the Mesolithic layer of interest consistently appears immediately above alluvial (or river terrace) sands and gravels, which are expected to be in direct hydraulic continuity with the Chalk aquifer. This combined with knowledge that the Amesbury Abbey springs emerge at between around 68m aOD to 68.5m aOD (based on LiDAR data), indicates that the average water levels observed in the trench may well have been representative of a groundwater level in the Chalk aquifer (once excavated down to the Mesolithic layer).

2.5.3 This conjectured range of groundwater levels is shown on the geological section in Figure 2.11. The location of the section and the boreholes are shown on the Drawing in Appendix B.

2.5.4 Figure 2.11 shows the elevation of the A303 and the existing and proposed drainage arrangements from the road. Groundwater levels are lower than the road and neither the existing or proposed drainage interfere with groundwater flow.

2.5.5 The existing road drainage channels are not connected to the saturated ground at Blick Mead although, at times of flood, it is possible that some road runoff finds its way onto the site.

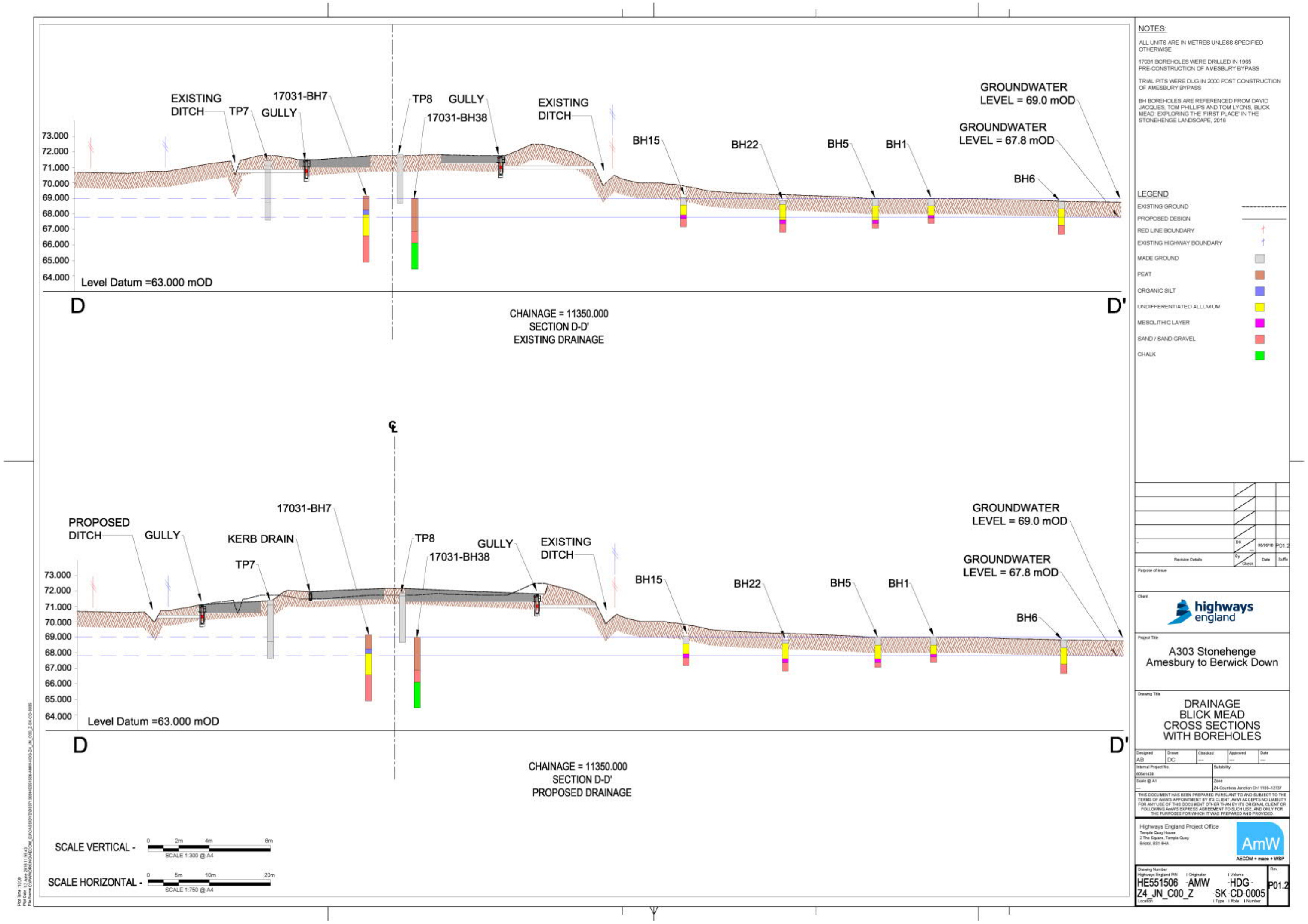

Figure 2.11 Blick Mead Cross Section (for line of Section see Appendix B)

Archaeological evidence of water levels on Blick Mead site

2.5.6 Organic materials are generally better preserved within a waterlogged environment.

2.5.7 A programme of fieldwork incorporating a borehole survey, deposit modelling and environmental archaeological analysis was conducted at Blick Mead between 2014 and 2015 [7]. A multiproxy approach was employed, including the following techniques:

1. Geo-archaeological borehole survey and deposit modelling – to investigate the sediments in the area of the site and the surrounding floodplain, and to provide a record of the sedimentary history and palaeo-environmental potential of these sediments.
2. Plant macrofossil analysis (charred and waterlogged seeds / wood) to enable reconstruction of the vegetation history, as well as to provide an indication of diet and economy on the site (e.g. food, transport, diet).
3. Insect analysis – to provide information on the vegetation history of the site, anthropogenic environments and palaeo-climatic reconstructions.
4. Pollen analysis – to enable reconstruction of the past vegetation of the site and its environs, and the influence of human activity upon it.

2.5.8 In all, twenty-seven boreholes were put down at and near the site [7]. A grid of boreholes (BH1 to BH25) spaced at approximately 10–20 m intervals was put down in the area of the archaeological trenches (Appendix A), with one transect (BH16 to BH19) extending across the floodplain towards the modern course of the River Avon. Two boreholes (BH2 and BH24) were put down to the west of the site where the ground surface rises up from the floodplain, on a feature interpreted as a lynchet and possibly a Late Mesolithic activity area. Borehole BH25 was put down c. 30m to the south of the archaeological trenches, to the south of the artificial causeway. Two further boreholes were put down from the floodplain surface about 0.45km upstream from the archaeological site (in the grounds of Avon House) to investigate peat recorded in British Geological Survey (BGS) archive boreholes (Site 2 of the present investigation).

2.5.9 Of the nine small bulk samples assessed from borehole BH25, three contained low quantities of insects which were preserved as fragments (67.85 to 67.83, 66.17 to 66.15 and 66.15 to 66.13m aOD). These assemblages were too poorly preserved to warrant full analysis. Two samples (66.19 to 66.17 and 66.17 to 66.15 aOD) contained low quantities of waterlogged wood, whilst four (67.83 to 67.81, 66.19 to 66.17, 66.17 to 66.15 and 66.15 to 66.13m aOD) contained low quantities of unidentifiable (<2 mm diameter) charcoal. Six of the nine samples contained low quantities of waterlogged seeds, comprising herbaceous and aquatic taxa including Rumex/Polygonum sp. (dock/sorrel/knotweed), Carex sp. (sedge), Ranunculus cf. repens (creeping buttercup), Bidens sp. (bur-marigold) and Ranunculus cf. fluitans (river water crowfoot). These findings are summarised in Table 1.

Depth (m bgs)	Depth (m aOD)	Charcoal	Wood	Seeds	Insects
0.90 to 0.92	67.85 to 67.83			X	X
0.92 to 0.94	67.83 to 67.81	X			
0.94 to 0.96	67.81 to 67.79				
1.10 to 1.15	67.65 to 67.60			X	
1.15 to 1.20	67.60 to 67.55			X	
1.20 to 1.25	67.55 to 67.50			X	
2.56 to 2.58	66.19 to 66.17	X		X	
2.58 to 2.60	66.17 to 66.15	X	X	X	X
2.60 to 2.62	66.15 to 66.13	X		X	X

Table 1: Levels of macrofossil assessment of samples from borehole BH25

2.5.10 Although limited, the assemblage is consistent with a damp environment dominated by herbaceous and aquatic taxa as might be expected on the margins of a stream, river or pond.

2.5.11 The limited concentration of remains prevents any further interpretation of this assemblage, and it should be noted that the samples are restricted to the top and base of the peat horizon only.

2.5.12 Lithostratigraphic descriptions indicating the presence of waterlogged layers with their elevation and depth from ground surface described in Reference 7 are given in Appendix A.

Off-site

2.5.13 Groundwater levels are monitored by the Environment Agency at Amesbury (NGR SU 15359 41944) via two observation boreholes, located around 350 m east of the Blick Mead archaeological site. The Environment Agency also monitors water levels in the River Avon at the Amesbury Station at NGR SU 15109 41387, located approximately 650m southeast of the Blick Mead archaeological site. The groundwater level and river stage data are presented in Figure 2.12 along with rainfall data from Larkhill rain gauge station (NGR SU13657 44748) for the period 2002 to 2017.

2.5.14 The River Avon stage data demonstrate a range of levels between 67.13 and 68.05m aOD during the period February 1987 to January 2017, with a clear response to rainfall events as expected. These levels are expected to be similar to those that would be experienced in the River Avon adjacent to the Blick Mead site (based on a review of LiDAR data).

2.5.15 The geological log for the Amesbury 'shallow borehole' indicates the base of the superficial deposits is at 63.4m aOD (with a thickness of 5.7 m), with Seaford Chalk Formation underlying the superficial deposits. The shallow borehole extends to 14.5m depth and therefore will be monitoring groundwater levels in the shallow Chalk aquifer. The Amesbury 'deep borehole' is screened from 50 m to 70 m below ground level and therefore monitors groundwater levels in the deeper Chalk aquifer.

2.5.16 Groundwater levels in the deep borehole suggest a typical seasonal fluctuation of around 1.5 m with a range of 67.73m aOD to 69.79m aOD during the period February 2002 to September 2017 (Figure 2.12). The groundwater level in the shallow borehole follows a similar trend to those in the deep borehole, with levels generally 10s of centimetres lower. It is expected that groundwater levels in the Chalk aquifer beneath the Blick Mead site will demonstrate similar fluctuations depending on proximity to the river.

2.5.17 Assuming there are no datum related issues with respect to the boreholes, the data indicate potential for upward flow within the Chalk aquifer, consistent with groundwater discharging into the River Avon (i,e, baseflow). This mechanism is further evidenced by (i) a 0.5 m lower stage in the River Avon compared with groundwater levels in the Chalk (although there is a degree of uncertainty given the distance between the gauging station and the boreholes), and also (ii) groundwater contours from the Environment Agency's Wessex Basin groundwater, which indicate strong convergence of groundwater flow on the River Avon consistent with groundwater discharge from the Chalk to the river (see Figure 2.13).

2.5.18 The modelled groundwater level contours in Figure 2.13 also imply that the groundwater in the Chalk aquifer beneath the Blick Mead site flows from the north. An indicative catchment area to the Blick Mead site is shown on Figure 2.13.

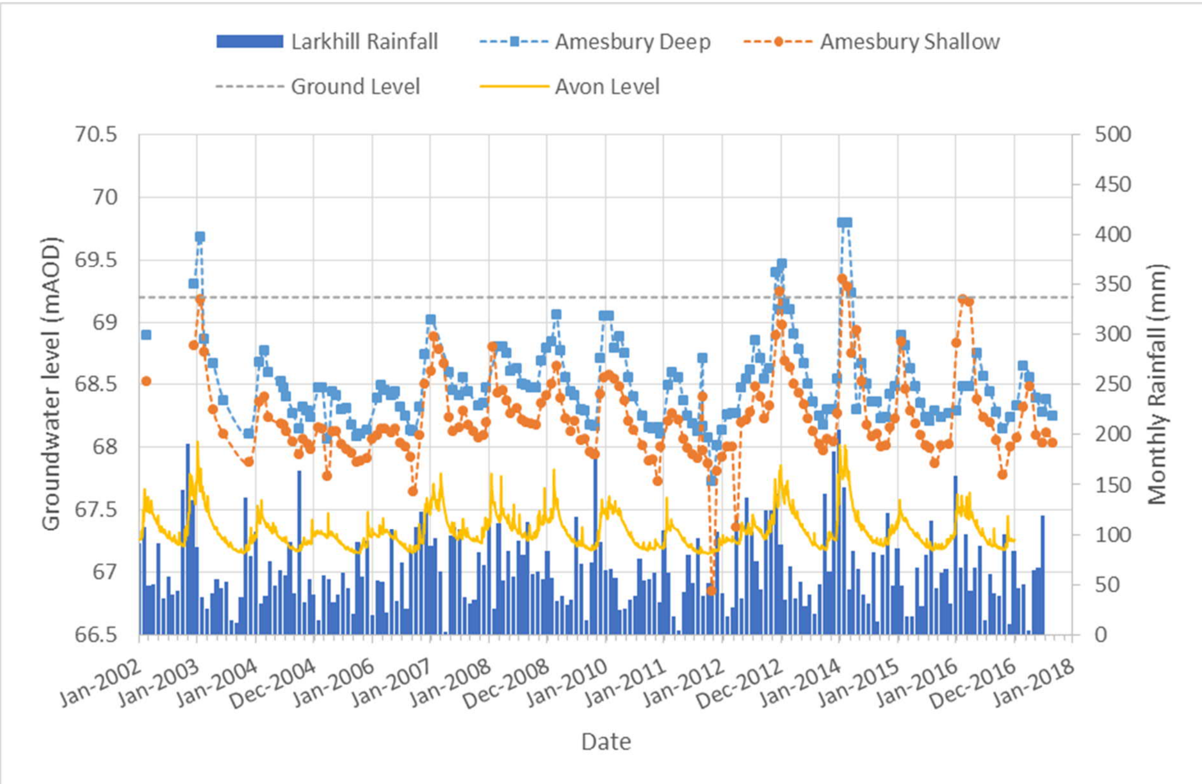

Figure 2.12 Chalk groundwater levels and River Avon stage as monitored by the Environment Agency

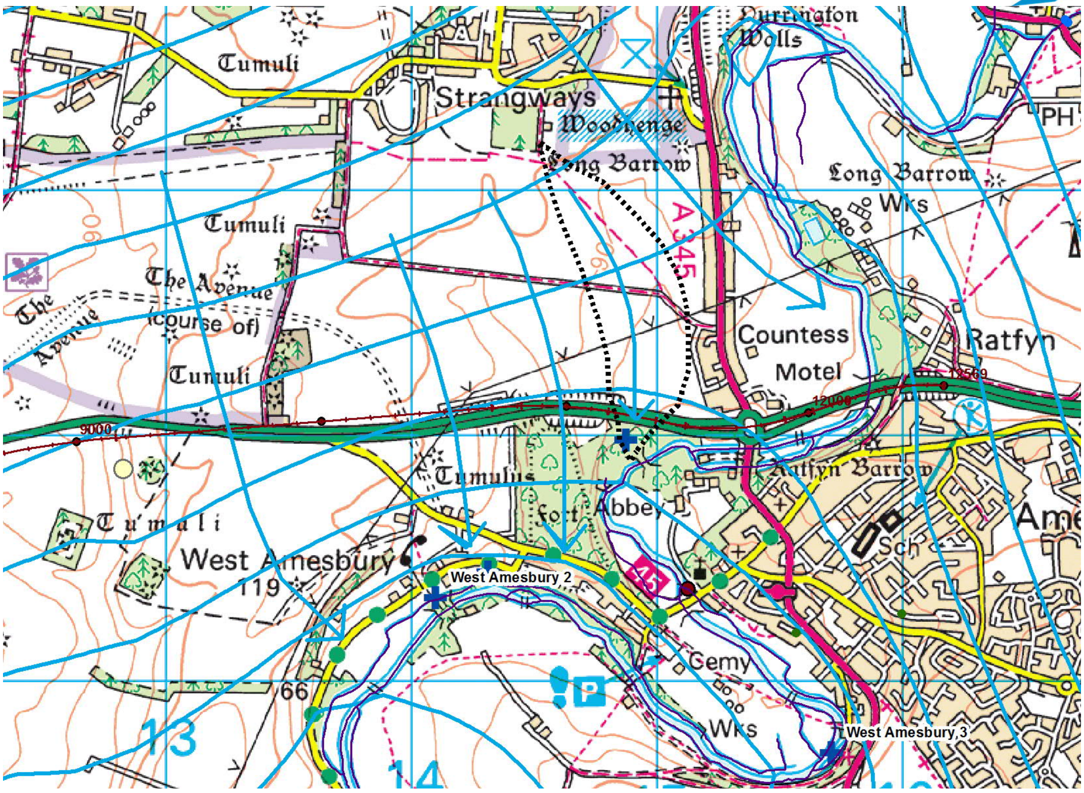

Figure 2.13 Wessex Basin groundwater model showing groundwater contours, interpreted flow direction (blue arrows) and catchment area to Blick Mead (dashed black)

2.6 Conceptual model

2.6.1 The review of the Blick Mead ground investigation data, wider topographical, hydrological, geological and hydrogeological information indicates the following conceptual model for the study area, as illustrated in the schematic in Figure 2.14:

- Groundwater flow in the Chalk aquifer is from north to south towards the Blick Mead archaeological site. The flow will be driven by rainfall recharge higher in the catchment (creating mounding of groundwater) with discharge of groundwater in the topographic lows (the River Avon valley) via springs along the margins of overlying superficial deposits and upward flow via superficial deposits into the River Avon. Based on Environment Agency monitoring data, observations in archaeological trenches, and the elevation of the Amesbury Abbey springs, groundwater levels in the Chalk at the site can range between 67.8m aOD (in drought) and 69m aOD (in flood), but will normally range between 68m aOD and 68.5m aOD.
- The higher permeability superficial deposits (alluvial sands and gravels, river terrace deposits and head deposits) are interpreted as being in hydraulic continuity with the Chalk aquifer i.e. groundwater levels and fluctuations will be very similar to those in the Chalk aquifer. This means that the sands and gravels above the Chalk at the Blick Mead archaeological site and the Chalk effectively behave as a single aquifer.
- The low permeability superficial deposits (peat, alluvial silts and clays, and head deposits) confine the underlying Chalk (and sands and gravels) aquifer, such that groundwater springs (e.g. Amesbury Abbey springs) emerge at the

margins of the superficial deposits. These deposits are also expected to impede upward flow from the Chalk aquifer into the River Avon.

- The Mesolithic deposits of archaeological interest are located at the base of the lower permeability superficial deposits (between 67 and 68m aOD), and immediately above the Chalk and sands and gravels aquifer. The groundwater level in the underlying aquifer is such that there will normally be upward pressure that assists in maintaining the wet conditions in the Mesolithic deposits.
- Rainfall on the low permeability superficial deposits (containing the Mesolithic deposits) is expected to flow over-land to the River Avon (e.g. via the Blick Mead ditch). However, in part, it will infiltrate into the ground, initially overcoming any soil moisture deficit, and then providing a further mechanism for wetting of the Mesolithic deposits.

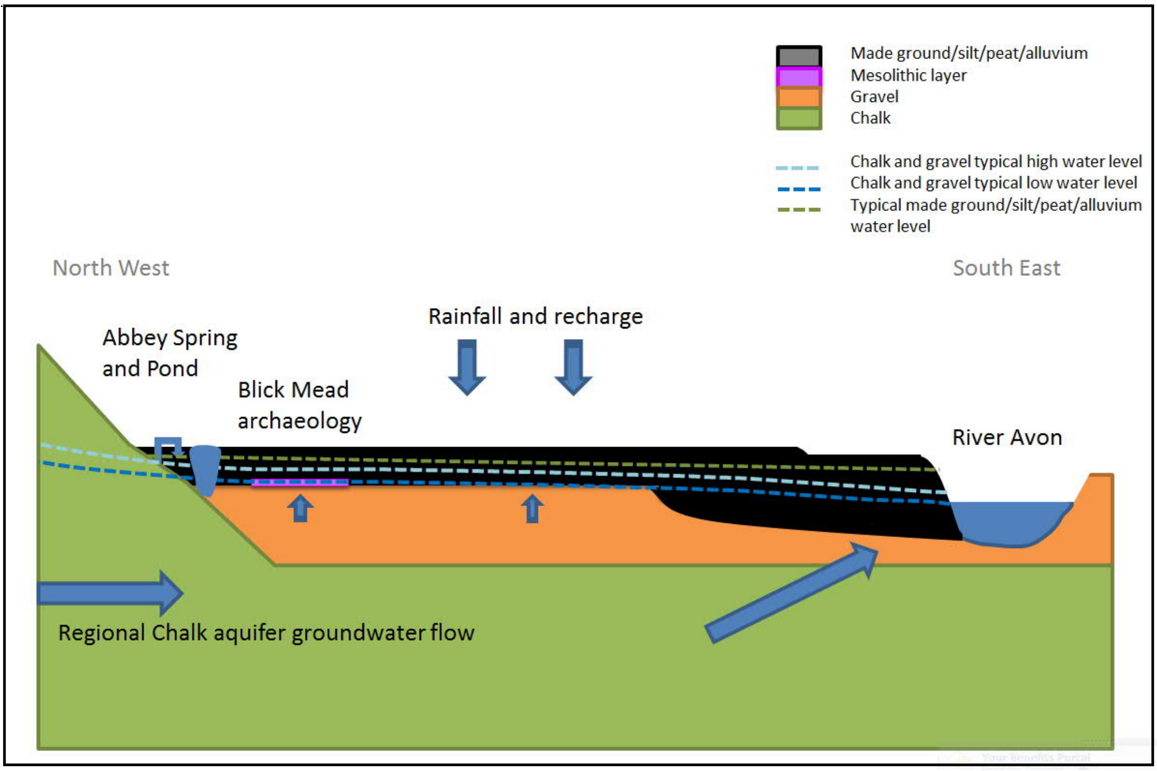

Figure 2.14 Blick Mead Conceptual Hydrogeological Model

2.7 Tier 1 and 2 conclusions

2.7.1 This chapter has developed the conceptual model for the study area. The Tier 1 and 2 questions from source [2] can now be answered:

- Tier 1: *Are the deposits in which significant waterlogged archaeological remains are located, hydraulically connected to the wider groundwater system?* **Yes, although the Mesolithic deposits of interest are within low permeability superficial deposits, they are immediately above the Chalk and sands and gravels aquifer.**

- Tier 1: *Are these remains likely to be located under the water table or have been so in the past?* **Yes, based on the available information they are normally located below the piezometric level in the Chalk (indicating potential for upward flow of groundwater and wetting of the Mesolithic deposits of interest).**

- Tier 2: *Will the deposits in which significant waterlogged archaeological remains are located be underwater all year?* **Yes, in normal years the Mesolithic deposits are expected to be wetted by the underlying aquifer all year. However there is potential for a degree of drying in a drought where (i) a soil moisture deficit develops in the alluvial deposits and (ii) groundwater levels partially drop below the Mesolithic deposits.**

- *Tier 2: If not, what variation can be expected and what is influencing the variation (anthropogenic or natural)? And are these variations short-term or long-term / permanent?* **The Mesolithic deposits occur at an elevation of between 67 and 68m aOD. Groundwater levels in the underlying aquifer are generally above 68m aOD, although could potentially drop below the upper level of the Mesolithic deposits layer (and towards 67.5m aOD) for a number of months in a natural drought. However draining of the Mesolithic deposits layer will not occur immediately following a drop in groundwater level owing to their lower permeability (relative to the underlying aquifer) and a fall to lower than the river level at around 67.5m aOD is unlikely.**

It is important to consider the Tier 2 questions in the context of the Scheme, which has the potential to result in temporary or permanent lowering of ground-water levels. A temporary or permanent lowering of groundwater level in the Chalk and sands and gravels aquifer by a few centimetres is unlikely to result in a significant impact with respect to the Mesolithic deposits of interest.

3 Conclusions and recommendations

3.1 Conclusions

3.1.1 A conceptual model for the Blick Mead archaeological site has been developed and Tier 1 and 2 assessments completed based on Historic England guidance. This indicates that the Mesolithic deposits of interest are likely to remain wetted by the underlying Chalk and sands and gravel aquifer under normal conditions. Groundwater levels in the underlying aquifer are generally above 68m aOD, although could potentially drop below the upper level of the Mesolithic deposits layer towards 67.5m aOD for a number of months in a natural drought. Despite this, draining of the Mesolithic deposits layer will not occur immediately following a drop in groundwater level owing to their low permeability (relative to the underlying aquifer) and a fall to lower than the river level at around 67.5m aOD is unlikely.

3.1.2 It is important to consider the Tier 2 assessment questions in the context of Schemes such as the A303, which have the potential to result in temporary or permanent lowering of groundwater levels. A temporary or permanent lowering of groundwater level in the Chalk and sands and gravels aquifer by a few centimetres is unlikely to result in a significant impact with respect to the Mesolithic deposits of interest.

3.1.3 The existing A303 road drainage may be contributing some overland flow to Blick Mead at times of heavy rainfall.

3.2 Recommendations

It has been agreed that hydrological monitoring at Blick Mead will continue and further investigation and monitoring will be undertaken to include water levels and water quality at shallow depth. The detail of the monitoring and how the data will be used is the subject of ongoing discussion with Historic England, the land owner and other interested stakeholders.

References

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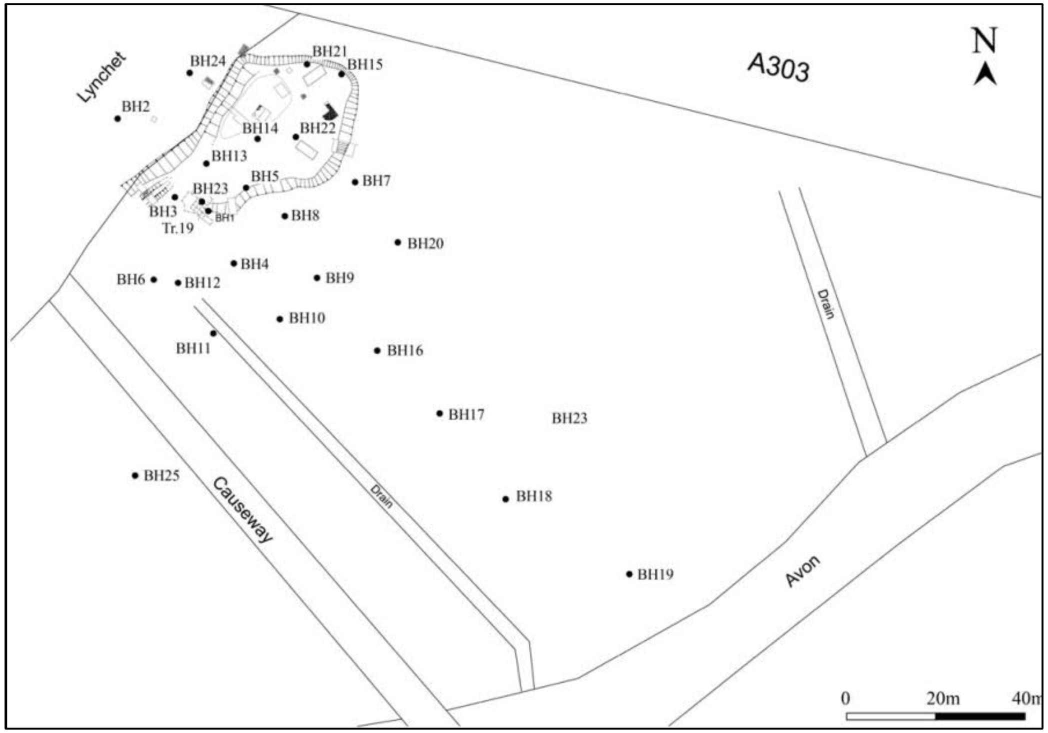
Appendices

Appendix A Archaeological log of waterlogged conditions



Lithostratigraphic descriptions which indicate the presence of waterlogged layers with their OD and depth from ground surface specified (Jacques et al. 2018, pp 200–13).

Borehole	Elevation (maOD)	Depth below surface (m)	Composition
BH3	67.45 to 67.35	1.23 to 1.33	Chalk rubble (very wet)

BH4	67.49 to 67.38	1.64 to 1.75	Compacted plant debris and pieces of roundwood
BH5	68.15 to 68.11	0.71 to 0.75	Dark brown organic clayey silt with a trace of sand.
BH6	68.64 to 68.42	0.08 to 0.30	Dark brown organic clayey silt with a trace of sand (topsoil).
BH7	70.04 to 69.74	0.00 to 0.30	Dark brown organic clayey silt with a trace of sand (topsoil).
BH7	68.04 to 67.77	2.00 to 2.27	Dark brown organic clayey silt with a trace of sand.
BH8	69.48 to 69.33	0.00 to 0.15	Dark brown organic clayey silt with a trace of sand (topsoil).
BH8	68.53 to 68.48	0.05 to 1.00	Dark brown very organic silt and clay.
BH8	68.12 to 68.03	1.36 to 1.45	Dark brown very organic silt and clay.
BH9	68.30 to 68.70	1.22 to 1.45	Dark brown organic clayey silt with a trace of sand.
BH9	67.81 to 67.43	1.71 to 2.09	Grey brown sandy clayey silt with a trace of detrital herbaceous material and a trace of detrital wood.
BH10	68.57 to 68.47	0.72 to 0.82	Dark brown organic clayey silt with a trace of sand.

BH12	68.31 to 68.26	0.55 to 0.60	Dark brown organic clayey silt with a trace of sand.
BH13	68.45 to 68.34	0.56 to 0.67	dark yellowish brown; moderately sorted gritty stoneless silty clay; crumb structure; common root remains; scattered detrital plant remains; scattered broken mollusc shell
BH13	68.34 to 68.16	0.67 0.85	dark brown; moderately to well-sorted slightly sandy stoneless silty clay; massive structure; scattered root and detrital plant remains; worm granules; scattered broken mollusc shell
BH13	68.16 to 67.71	0.85 to 1.30	very dark greyish brown with red mottles; well-sorted slightly sandy silty clay with scattered flint clasts (up to 30 mm); massive structure; small (up to 1 mm) particles of charcoal in upper part (down to c. 68.00 m OD); possible flint flake at 68.03 m OD; several pieces of burnt flint between 67.83 and 67.72 m OD
BH14	68.20 to 67.91	0.58 to 0.87	greyish brown; well-sorted clayey silty fine to medium sand with scattered chalk clasts (up to 10 mm) in upper few cms; massive structure; scattered root and detrital plant remains
BH14	67.91 to 67.33	0.87 to 1.45	olive brown passing down to dark greyish brown; poorly sorted sandy silty clay with flint clasts, small (10–15 mm) with cluster of larger; common root and detrital plant remains; common worm granules; broken and occasional complete mollusc shell; burnt flint at 67.79 m OD

BH16	68.68 to 68.51	0.66 to 0.83	Dark brown organic clayey silt with a trace of sand
BH17	68.32 to 68.17	0.78 to 0.93	Dark brown organic clayey silt with a trace of sand
BH17	67.82 to 67.45	1.28 to 1.65	dark reddish brown well-humified silty peat with a trace of herbaceous material. Seeds of buttercup and bogbean observed.
BH17	67.45 to 66.42	1.65 to 2.68	grey silt and clay with a trace of detrital herbaceous material and occasional gravel clasts. Some possible flint flakes recorded
BH17	66.42 to 66.10	2.68 to 3.00	grey clayey silt with gravel clasts and a trace of detrital herbaceous material. Some possible flint flakes recorded
BH18	67.97 to 67.61	0.64 to 1.00	dark brown; well-sorted stoneless peaty silt; massive and compact; common root and detrital plant remains; worm granules; broken mollusc shell;
BH18	67.61 to 67.17	1.00 to 1.44	very dark brown; peat – humified and compact above, paler and less compact below, no visible mineral content
BH18	67.17 to 67.04	1.44 to 1.57	brown; very well-sorted stoneless silt; massive structure; common root remains; scattered detrital plant remains; worm granules; scattered whole and broken mollusc shell;

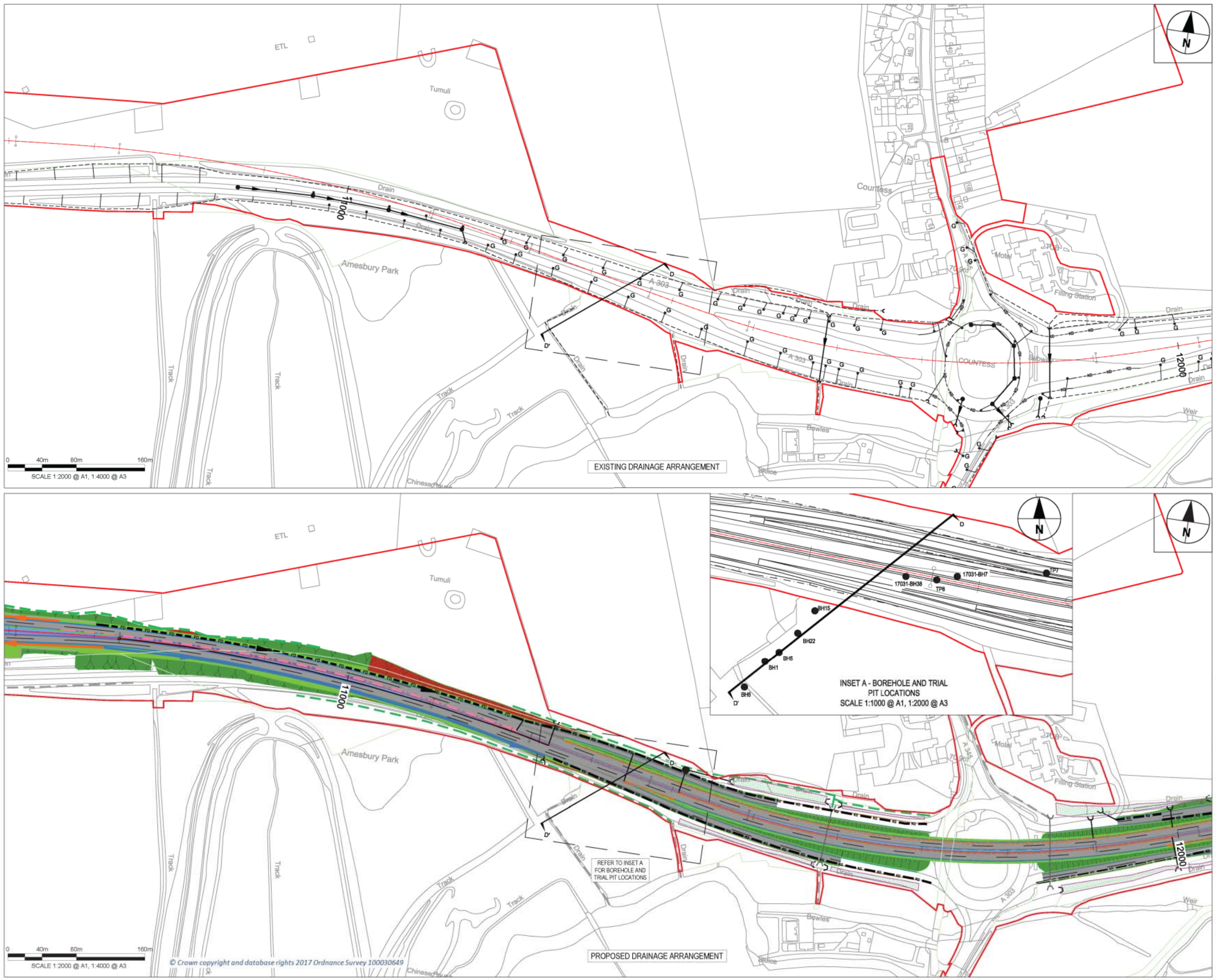
BH18	67.04 to 66.91	1.57 to 1.70	Very dark brown peat
BH18	66.91 to 66.85	1.70 to 1.76	very dark greyish brown; very well-sorted peaty silt passing down to silt; massive structure; common root remains; scattered detrital plant remains
BH18	66.85 to 65.89	1.76 to 2.72	very dark brown; silty peat with scattered sand grains and granules of flint, becoming increasingly silty and clayey downward, scattered larger clasts of flint (up to 40 mm), including clusters at 66.66–66.61 m OD and 65.94–65.89 m OD
BH19	67.42 to 67.10	0.95 to 1.27	dark reddish brown well-humified silty peat with a trace of herbaceous material
BH19	66.97 to 66.75	1.40 to 1.62	grey clayey silt with a trace of detrital herbaceous material and occasional Mollusca fragments
BH19	66.75 to 66.02	1.62 to 2.35	grey clayey silt with a trace of detrital herbaceous material and sand. Frequent Mollusca fragments
BH20	68.49 to 68.39	1.45 to 1.55	dark brown organic clayey silt with a trace of sand

BH21	68.87 to 67.49	0.02 to 1.40	dark greyish brown; moderately sorted slightly gritty/sandy silty clay; with flint clasts (mainly <15 mm but up to 45 mm) and scattered small chalk clasts; massive structure; common root and detrital plant remains; worm granules (mainly below 68.00 m OD); scattered broken mollusc shell (mainly below 68.00 m OD)
BH21	67.47 to 67.34	1.40 to 1.55	olive grey; well-sorted slightly sandy silty clay with scattered sub-angular flint clasts (up to 40 mm); common root remains; scattered detrital plant remains; worm granules
BH22	68.17 to 67.93	0.63 to 0.87	dark greyish brown organic silty clay with traces of gravel. Presence of shell, iron mottling, flint (up to 3 cm).
BH22	67.93 to 67.87	0.87 to 0.93	very dark greyish brown organic, sandy gravelly clay. More iron mottling and extensive charcoal evidence, some small pieces of flint (up to 5 mm).
BH22	67.87 to 67.74	0.93 to 1.06	dark greyish brown sand and clay with occasional gravel clasts. Charcoal and iron traces (though less than overlying unit), some flint clasts.
BH22	67.74 to 67.63	1.06 to 1.17	Very dark grey sandy, silty clay with a trace of organic matter. Increase in iron and charcoal remains from overlying unit, some shell and calcareous material

BH22	67.63 to 67.56	1.17 to 1.24	brown silty sandy clay. Frequent charcoal and iron fragments, possible manganese staining
BH22	67.56 to 67.22	1.24 to 1.58	light yellowish brown silty, clayey sand. Extensive charcoal and iron mottling. Incorporation of calcareous rock, and some large flint, up to 3 cm wide
BH23	68.40 to 67.71	0.43 to 1.12	dark yellowish brown with red mottles passing down to dark greyish brown; moderately to poorly sorted gritty/sandy silty clay/clayey silt with flint clasts (up to 50 mm); massive structure; very scattered root and detrital plant remains; burnt flint present between 67.83 and 67.71 m OD
BH23	67.71 to 67.25	1.12 to 1.58	light olive brown with patchy iron and manganese staining; well-sorted slightly sandy clayey silt with scattered small (<15 mm) clasts of chalk in uppermost few cms; massive structure; scattered detrital plant remains
BH25	68.23 to 67.88	0.57 to 0.87	dark greyish brown; moderately to poorly sorted slightly gritty silty clay; massive; scattered root and detrital plant remains
BH25	67.69 to 66.75	1.06 to 2.00	very dark brown; peat; a few very small (<1 mm) particles of flint, otherwise very little visible mineral content; a very small (c. 1 mm) piece of mollusc shell

BH25	66.10 to 65.88	2.65 to 2.87	light grey to light olive grey, becoming dull green in places; well-sorted slightly sandy silt with beds of well-sorted fine sand; scattered detrital plant remains

Appendix B Drainage



NOTES:

ALL UNITS ARE IN METRES UNLESS SPECIFIED OTHERWISE

17031 BOREHOLES WERE DRILLED IN 1965 PRE-CONSTRUCTION OF AMESBURY BYPASS

TRIAL PITS WERE DUG IN 2000 POST CONSTRUCTION OF AMESBURY BYPASS

BH BOREHOLES ARE REFERENCED FROM DAVID JACQUES, TOM PHILLIPS AND TOM LYONS, BLICK MEAD: EXPLORING THE 'FIRST PLACE' IN THE STONEHENGE LANDSCAPE, 2018

Revision Details	By / Check	Date	Suffix
-	DC	12/06/18	P01.1

Purpose of Issue

Client: highways england

Project Title: A303 Amesbury to Berwick Down

Drawing Title:

DRAINAGE
BLICK MEAD
PLAN
WITH BOREHOLES

Designed	Drawn	Checked	Approved	Date
AB	DC	AT	JS	12/6/18

Internal Project No.	Suitability
60541439	
Scale @ A1	**Zone**
—	Z4-Countess Junction Ch11100-12737

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Highways England Project Office
Temple Quay House
2 The Square, Temple Quay
Bristol. BS1 6HA

AmW
AECOM + mace + WSP

Drawing Number (Highways England PIN | Originator | Volume | Location | Type | Role | Number): HE551506 -AMW -HDG - Z4_JN_C00_Z -SK -CD -0006

Rev: P01.1

A303 Amesbury to Berwick Down

TR010025

6.3 Environmental Statement Appendices

Appendix 11.4 Annex 4 2018 Groundwater Quality Data

Volume 6

APFP Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

October 2018

Exova Jones Environmental

Registered Address : Exova (UK) Ltd, Lochend Industrial Estate, Newbridge, Midlothian, EH28 8PL

Unit 3 Deeside Point
Zone 3
Deeside Industrial Park
Deeside
CH5 2UA

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4225

AECOM
Scott House
Alencon Link
Basingstoke
RG21 7PP

Attention :	
Date :	4th April, 2018
Your reference :	A303
Our reference :	Test Report 18/2914 Batch 1
Location :	A303
Date samples received :	24th February, 2018
Status :	Final report
Issue :	2

Two samples were received for analysis on 24th February, 2018 of which two were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Compiled By:

[redacted]

Simon Gomery BSc
Project Manager

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/2914

Report : Liquid

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16									LOD/LOR	Units	Method No.
Sample ID	RX510A	RX507A											
Depth													
COC No / misc													
Containers	V H HN N P G	V H HN N P G											
Sample Date	23/02/2018 09:25	23/02/2018 12:35											
Sample Type	Ground Water	Ground Water											
Batch Number	1	1											
Date of Receipt	24/02/2018	24/02/2018											
Dissolved Antimony #	<2	4									<2	ug/l	TM30/PM14
Dissolved Arsenic #	<2.5	<2.5									<2.5	ug/l	TM30/PM14
Dissolved Beryllium	<0.5	<0.5									<0.5	ug/l	TM30/PM14
Dissolved Boron	23	19									<12	ug/l	TM30/PM14
Dissolved Cadmium #	<0.5	<0.5									<0.5	ug/l	TM30/PM14
Dissolved Calcium #	114.2	102.3									<0.2	mg/l	TM30/PM14
Total Dissolved Chromium #	<1.5	<1.5									<1.5	ug/l	TM30/PM14
Dissolved Copper #	<7	<7									<7	ug/l	TM30/PM14
Dissolved Lead #	<5	<5									<5	ug/l	TM30/PM14
Dissolved Magnesium #	1.4	1.7									<0.1	mg/l	TM30/PM14
Dissolved Manganese #	<2	<2									<2	ug/l	TM30/PM14
Dissolved Mercury #	<1	<1									<1	ug/l	TM30/PM14
Dissolved Molybdenum #	<2	<2									<2	ug/l	TM30/PM14
Dissolved Nickel #	2	<2									<2	ug/l	TM30/PM14
Dissolved Phosphorus #	<5	<5									<5	ug/l	TM30/PM14
Dissolved Potassium #	0.4	0.3									<0.1	mg/l	TM30/PM14
Dissolved Selenium #	<3	<3									<3	ug/l	TM30/PM14
Dissolved Sodium #	7.8	7.8									<0.1	mg/l	TM30/PM14
Dissolved Zinc #	<3	<3									<3	ug/l	TM30/PM14
Total Cadmium	<0.5	<0.5									<0.5	ug/l	TM30/PM14
Total Copper	<7	37									<7	ug/l	TM30/PM14
Total Iron	1543	12040									<20	ug/l	TM30/PM14
Total Phosphorus	224	1387									<5	ug/l	TM30/PM14
Total Zinc	9	69									<3	ug/l	TM30/PM14

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/2914

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	LOD/LOR	Units	Method No.
Sample ID	RX510A	RX507A			
Depth					
COC No / misc					
Containers	V H HN N P G	V H HN N P G			
Sample Date	23/02/2018 09:25	23/02/2018 12:35			
Sample Type	Ground Water	Ground Water			
Batch Number	1	1			
Date of Receipt	24/02/2018	24/02/2018			
PAH MS					
Naphthalene #	<0.1	<0.1	<0.1	ug/l	TM4/PM30
Acenaphthylene #	<0.013	<0.013	<0.013	ug/l	TM4/PM30
Acenaphthene #	<0.013	<0.013	<0.013	ug/l	TM4/PM30
Fluorene #	<0.014	<0.014	<0.014	ug/l	TM4/PM30
Phenanthrene #	<0.011	<0.011	<0.011	ug/l	TM4/PM30
Anthracene #	<0.013	<0.013	<0.013	ug/l	TM4/PM30
Fluoranthene #	<0.012	<0.012	<0.012	ug/l	TM4/PM30
Pyrene #	<0.013	<0.013	<0.013	ug/l	TM4/PM30
Benzo(a)anthracene #	<0.015	<0.015	<0.015	ug/l	TM4/PM30
Chrysene #	<0.011	<0.011	<0.011	ug/l	TM4/PM30
Benzo(bk)fluoranthene #	<0.018	<0.018	<0.018	ug/l	TM4/PM30
Benzo(a)pyrene #	<0.016	<0.016	<0.016	ug/l	TM4/PM30
Indeno(123cd)pyrene #	<0.011	<0.011	<0.011	ug/l	TM4/PM30
Dibenzo(ah)anthracene #	<0.01	<0.01	<0.01	ug/l	TM4/PM30
Benzo(ghi)perylene #	<0.011	<0.011	<0.011	ug/l	TM4/PM30
PAH 16 Total #	<0.195	<0.195	<0.195	ug/l	TM4/PM30
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	ug/l	TM4/PM30
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	ug/l	TM4/PM30
PAH Surrogate % Recovery	91	72	<0	%	TM4/PM30

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/2914

Report : Liquid

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
$H=H_2SO_4$, Z=ZnAc, N=NaOH, $HN=HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	LOD/LOR	Units	Method No.
Sample ID	RX510A	RX507A			
Depth					
COC No / misc					
Containers	V H HN N P G	V H HN N P G			
Sample Date	23/02/2018 09:25	23/02/2018 12:35			
Sample Type	Ground Water	Ground Water			
Batch Number	1	1			
Date of Receipt	24/02/2018	24/02/2018			
Pesticides					
Organophosphorus Pesticides					
Azinphos ethyl	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Azinphos methyl	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Carbophenothion	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Chlorfenvinphos	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Chlorpyrifos	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Chlorpyrifos-methyl	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Diazinon	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Dichlorvos	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Disulfoton	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Dimethoate	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Ethion	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Ethyl Parathion (Parathion)	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Etrimphos	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Fenitrothion	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Fenthion	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Malathion	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Methyl Parathion	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Mevinphos	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Phosalone	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Pirimiphos Methyl	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Propetamphos	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Triazophos	<0.01	<0.01	<0.01	ug/l	TM149/PM30
TPH CWG					
Aliphatics					
>C5-C6 #	<10	<10	<10	ug/l	TM36/PM12
>C6-C8 #	<10	<10	<10	ug/l	TM36/PM12
>C8-C10 #	<10	<10	<10	ug/l	TM36/PM12
>C10-C12 #	<5	<5	<5	ug/l	TM5/PM16/PM30
>C12-C16 #	<10	<10	<10	ug/l	TM5/PM16/PM30
>C16-C21 #	<10	<10	<10	ug/l	TM5/PM16/PM30
>C21-C35 #	<10	<10	<10	ug/l	TM5/PM16/PM30
Total aliphatics C5-35 #	<10	<10	<10	ug/l	TM5/TM36/PM12/PM16/PM30

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Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/2914

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
$H=H_2SO_4$, Z=ZnAc, N=NaOH, $HN=HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	LOD/LOR	Units	Method No.
Sample ID	RX510A	RX507A			
Depth					
COC No / misc					
Containers	V H HN N P G	V H HN N P G			
Sample Date	23/02/2018 09:25	23/02/2018 12:35			
Sample Type	Ground Water	Ground Water			
Batch Number	1	1			
Date of Receipt	24/02/2018	24/02/2018			
TPH CWG					
Aromatics					
>C5-EC7 #	<10	<10	<10	ug/l	TM36/PM12
>EC7-EC8 #	<10	<10	<10	ug/l	TM36/PM12
>EC8-EC10 #	<10	<10	<10	ug/l	TM36/PM12
>EC10-EC12 #	<5	<5	<5	ug/l	TM5/PM16/PM30
>EC12-EC16 #	<10	<10	<10	ug/l	TM5/PM16/PM30
>EC16-EC21 #	<10	<10	<10	ug/l	TM5/PM16/PM30
>EC21-EC35 #	<10	<10	<10	ug/l	TM5/PM16/PM30
Total aromatics C5-35 #	<10	<10	<10	ug/l	TM5/TM36/PM12/PM16/PM30
Total aliphatics and aromatics(C5-35) #	<10	<10	<10	ug/l	TM5/TM36/PM12/PM16/PM30
MTBE #	<5	<5	<5	ug/l	TM31/PM12
Benzene #	<5	<5	<5	ug/l	TM31/PM12
Toluene #	<5	<5	<5	ug/l	TM31/PM12
Ethylbenzene #	<5	<5	<5	ug/l	TM31/PM12
m/p-Xylene #	<5	<5	<5	ug/l	TM31/PM12
o-Xylene #	<5	<5	<5	ug/l	TM31/PM12
PCB 28	<0.1	<0.1	<0.1	ug/l	TM17/PM30
PCB 52	<0.1	<0.1	<0.1	ug/l	TM17/PM30
PCB 101	<0.1	<0.1	<0.1	ug/l	TM17/PM30
PCB 118	<0.1	<0.1	<0.1	ug/l	TM17/PM30
PCB 138	<0.1	<0.1	<0.1	ug/l	TM17/PM30
PCB 153	<0.1	<0.1	<0.1	ug/l	TM17/PM30
PCB 180	<0.1	<0.1	<0.1	ug/l	TM17/PM30
Total 7 PCBs	<0.7	<0.7	<0.7	ug/l	TM17/PM30
Total Phenols HPLC	<0.1	<0.1	<0.1	mg/l	TM26/PM0
Fluoride	<0.3	<0.3	<0.3	mg/l	TM173/PM0
Sulphate as SO4 #	24.7	28.8	<0.5	mg/l	TM38/PM0
Chloride #	17.5	17.5	<0.3	mg/l	TM38/PM0
Nitrate as NO3 #	40.0	24.0	<0.2	mg/l	TM38/PM0
Nitrite as NO2 #	<0.02	<0.02	<0.02	mg/l	TM38/PM0
MRP Ortho Phosphate as P	<0.03	<0.03	<0.03	mg/l	TM38/PM0
SRP Ortho Phosphate as PO4	<0.06	<0.06	<0.06	mg/l	TM38/PM0
Free Cyanide #	<0.01	<0.01	<0.01	mg/l	TM89/PM0
Total Cyanide #	<0.01	<0.01	<0.01	mg/l	TM89/PM0
Ammoniacal Nitrogen as N #	<0.03	<0.03	<0.03	mg/l	TM38/PM0
Hexavalent Chromium	<6	<6	<6	ug/l	TM38/PM0

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/2914

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16									LOD/LOR	Units	Method No.
Sample ID	RX510A	RX507A											
Depth													
COC No / misc													
Containers	V H HN N P G	V H HN N P G											
Sample Date	23/02/2018 09:25	23/02/2018 12:35											
Sample Type	Ground Water	Ground Water											
Batch Number	1	1											
Date of Receipt	24/02/2018	24/02/2018											
Total Dissolved Chromium III	<6	<6									<6	ug/l	NONE/NONE
Dissolved Alkalinity as CaCO3 #	218	272									<1	mg/l	TM75/PM0
Total Alkalinity as CaCO3 #	536	3026									<1	mg/l	TM75/PM0
Carbonate Alkalinity as CaCO3	<1	<1									<1	mg/l	TM75/PM0
Bicarbonate Alkalinity as CaCO3 (water soluble)	536	3026									<1	mg/l	TM75/PM0
Dissolved Oxygen	10	10									<1	mg/l	TM59/PM0
Dissolved Organic Carbon #	<2	<2									<2	mg/l	TM60/PM0
Electrical Conductivity @25C #	560	602									<2	uS/cm	TM76/PM0
pH #	7.48	7.28									<0.01	pH units	TM73/PM0
Total Dissolved Solids #	432	422									<35	mg/l	TM20/PM0
Turbidity	565.0AA	481.0									<0.1	NTU	TM34/PM0
Total Cations	6.16	5.59									<0.00	mmolc/l	TM30/PM14
Total Anions	12.37	61.98									<0.00	mmolc/l	TM0/PM0
% Cation Excess	-33.51	-83.45										%	TM0/PM0

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/2914

Report : **Misc**

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8												
Sample ID	RX510A												
Depth													
COC No / misc													
Containers	V H HN N P G												
Sample Date	23/02/2018 09:25												
Sample Type	Ground Water												
Batch Number	1										LOD/LOR	Units	Method No.
Date of Receipt	24/02/2018												
Sample Temperature	8.5										<0.1	Degrees C	NONE/NONE

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Client Name: AECOM

Reference: A303

Location: A303

Contact:

Matrix : Liquid

J E Job No.	Batch	Sample ID	Depth	J E Sample No.	Analysis	Reason
18/2914	1	RX510A		1-8	Alkalinity	Sample holding time exceeded
18/2914	1	RX507A		9-16	Alkalinity	Sample holding time exceeded

Please note that only samples that are deviating are mentioned in this report. If no samples are listed it is because none were deviating.

Only analyses which are accredited are recorded as deviating if set criteria are not met.

JE Job No.: 18/2914

SOILS

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

The calculation of Pyrite content assumes that all oxidisable sulphides present in the sample are pyrite. This may not be the case. The calculation may be an overesitimate when other sulphides such as Barite (Barium Sulphate) are present.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 accreditation applies to surface water and groundwater and usually one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

DEVIATING SAMPLES

Samples must be received in a condition appropriate to the requested analyses. All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. If this is not the case you will be informed and any test results that may be compromised highlighted on your deviating samples report.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

BLANKS

Where analytes have been found in the blank, the sample will be treated in accordance with our laboratory procedure for dealing with contaminated blanks.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.
Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

REPORTS FROM THE SOUTH AFRICA LABORATORY

Any method number not prefixed with SA has been undertaken in our UK laboratory unless reported as subcontracted.

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS Ref No. 4225) accredited - UK.
SA	ISO17025 (SANAS Ref No.T0729) accredited - South Africa.
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
++	Result outside calibration range, results should be considered as indicative only and are not accredited.
*	Analysis subcontracted to a Jones Environmental approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range
AA	x2 Dilution

JE Job No: 18/2914

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM0	Not available	PM0	No preparation is required.				
TM4	Modified USEPA 8270 method for the solvent extraction and determination of 16 PAHs by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM4	Modified USEPA 8270 method for the solvent extraction and determination of 16 PAHs by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.	Yes			
TM5	Modified USEPA 8015B method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) with carbon banding within the range C8-C40 GC-FID.	PM16/PM30	Fractionation into aliphatic and aromatic fractions using a Rapid Trace SPE/Water samples are extracted with solvent using a magnetic stirrer to create a vortex.	Yes			
TM5/TM36	please refer to TM5 and TM36 for method details	PM12/PM16/PM30	please refer to PM16/PM30 and PM12 for method details	Yes			
TM17	Modified US EPA method 8270. Determination of specific Polychlorinated Biphenyl congeners by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM20	Modified BS 1377-3: 1990/USEPA 160.3 Gravimetric determination of Total Dissolved Solids/Total Solids	PM0	No preparation is required.	Yes			
TM26	Determination of phenols by Reversed Phased High Performance Liquid Chromatography and Electro-Chemical Detection.	PM0	No preparation is required.				
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM14	Analysis of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for dissolved metals and acidified if required.				
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM14	Analysis of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for dissolved metals and acidified if required.	Yes			

JE Job No: 18/2914

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM31	Modified USEPA 8015B. Determination of Methyltertbutylether, Benzene, Toluene, Ethylbenzene and Xylene by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes			
TM34	Turbidity by 2100P Turbidity Meter	PM0	No preparation is required.				
TM36	Modified US EPA method 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C4-12 by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes			
TM38	Soluble Ion analysis using the Thermo Aquakem Photometric Automatic Analyser. Modified US EPA methods 325.2, 375.4, 365.2, 353.1, 354.1	PM0	No preparation is required.				
TM38	Soluble Ion analysis using the Thermo Aquakem Photometric Automatic Analyser. Modified US EPA methods 325.2, 375.4, 365.2, 353.1, 354.1	PM0	No preparation is required.	Yes			
TM59	Determination of Dissolved Oxygen using the Hach HQ30D Oxygen Meter	PM0	No preparation is required.				
TM60	Modified USEPA 9060. Determination of TOC by calculation from Total Carbon and Inorganic Carbon using a TOC analyser, the carbon in the sample is converted to CO2 and then passed through a non-dispersive infrared gas analyser (NDIR).	PM0	No preparation is required.	Yes			
TM73	Modified US EPA methods 150.1 and 9045D and BS1377:1990. Determination of pH by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			
TM75	Modified US EPA method 310.1. Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.				
TM75	Modified US EPA method 310.1. Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.	Yes			

JE Job No: 18/2914

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM76	Modified US EPA method 120.1. Determination of Specific Conductance by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			
TM89	Modified USEPA method OIA-1667. Determination of cyanide by Flow Injection Analyser. Where WAD cyanides are required a Ligand displacement step is carried out before analysis.	PM0	No preparation is required.	Yes			
TM149	Determination of Pesticides by Large Volume Injection on GC Triple Quad MS, based upon USEPA method 8270	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM173	Analysis of fluoride by ISE (Ion Selective Electrode) using modified ISE method 340.2	PM0	No preparation is required.				
NONE	No Method Code	NONE	No Method Code				

Exova Jones Environmental

Registered Address : Exova (UK) Ltd, Lochend Industrial Estate, Newbridge, Midlothian, EH28 8PL

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Fax: +44 (0) 1244 833781

4225

AECOM
Scott House
Alencon Link
Basingstoke
RG21 7PP

Attention :	
Date :	4th April, 2018
Your reference :	A303
Our reference :	Test Report 18/2915 Batch 1 Schedule A
Location :	A303
Date samples received :	24th February, 2018
Status :	Final report
Issue :	2

Three samples were received for analysis on 24th February, 2018 of which three were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Compiled By:

[redacted]

Simon Gomery BSc
Project Manager

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/2915

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-23	LOD/LOR	Units	Method No.
Sample ID	R158	R507A	RX511B			
Depth						
COC No / misc						
Containers	V H HN N P G	V H HN N P G	V H HN N P G			
Sample Date	22/02/2018 10:00	22/02/2018 11:50	22/02/2018 15:45			
Sample Type	Ground Water	Ground Water	Ground Water			
Batch Number	1	1	1			
Date of Receipt	24/02/2018	24/02/2018	24/02/2018			
Dissolved Antimony #	<2	<2	2	<2	ug/l	TM30/PM14
Dissolved Arsenic #	<2.5	<2.5	<2.5	<2.5	ug/l	TM30/PM14
Dissolved Beryllium	<0.5	<0.5	<0.5	<0.5	ug/l	TM30/PM14
Dissolved Boron	19	21	21	<12	ug/l	TM30/PM14
Dissolved Cadmium #	<0.5	<0.5	<0.5	<0.5	ug/l	TM30/PM14
Dissolved Calcium #	101.5	92.8	98.4	<0.2	mg/l	TM30/PM14
Total Dissolved Chromium #	<1.5	<1.5	<1.5	<1.5	ug/l	TM30/PM14
Dissolved Copper #	<7	<7	<7	<7	ug/l	TM30/PM14
Dissolved Lead #	<5	<5	<5	<5	ug/l	TM30/PM14
Dissolved Magnesium #	2.3	1.4	1.6	<0.1	mg/l	TM30/PM14
Dissolved Manganese #	<2	<2	<2	<2	ug/l	TM30/PM14
Dissolved Mercury #	<1	<1	<1	<1	ug/l	TM30/PM14
Dissolved Molybdenum #	<2	<2	<2	<2	ug/l	TM30/PM14
Dissolved Nickel #	<2	<2	<2	<2	ug/l	TM30/PM14
Dissolved Phosphorus #	7	6	10	<5	ug/l	TM30/PM14
Dissolved Potassium #	0.3	0.7	0.9	<0.1	mg/l	TM30/PM14
Dissolved Selenium #	<3	<3	<3	<3	ug/l	TM30/PM14
Dissolved Sodium #	7.1	6.9	7.0	<0.1	mg/l	TM30/PM14
Dissolved Zinc #	4	<3	<3	<3	ug/l	TM30/PM14
Total Cadmium	<0.5	<0.5	<0.5	<0.5	ug/l	TM30/PM14
Total Copper	<7	16	<7	<7	ug/l	TM30/PM14
Total Iron	65	5055	113	<20	ug/l	TM30/PM14
Total Phosphorus	29	234	38	<5	ug/l	TM30/PM14
Total Zinc	5	22	<3	<3	ug/l	TM30/PM14

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/2915

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
$H=H_2SO_4$, Z=ZnAc, N=NaOH, $HN=HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-23	LOD/LOR	Units	Method No.
Sample ID	R158	R507A	RX511B			
Depth						
COC No / misc						
Containers	V H HN N P G	V H HN N P G	V H HN N P G			
Sample Date	22/02/2018 10:00	22/02/2018 11:50	22/02/2018 15:45			
Sample Type	Ground Water	Ground Water	Ground Water			
Batch Number	1	1	1			
Date of Receipt	24/02/2018	24/02/2018	24/02/2018			
PAH MS						
Naphthalene #	<0.1	<0.1	<0.1	<0.1	ug/l	TM4/PM30
Acenaphthylene #	<0.013	<0.013	<0.013	<0.013	ug/l	TM4/PM30
Acenaphthene #	<0.013	<0.013	<0.013	<0.013	ug/l	TM4/PM30
Fluorene #	<0.014	<0.014	<0.014	<0.014	ug/l	TM4/PM30
Phenanthrene #	<0.011	<0.011	<0.011	<0.011	ug/l	TM4/PM30
Anthracene #	<0.013	<0.013	<0.013	<0.013	ug/l	TM4/PM30
Fluoranthene #	<0.012	<0.012	<0.012	<0.012	ug/l	TM4/PM30
Pyrene #	<0.013	<0.013	<0.013	<0.013	ug/l	TM4/PM30
Benzo(a)anthracene #	<0.015	<0.015	<0.015	<0.015	ug/l	TM4/PM30
Chrysene #	<0.011	<0.011	<0.011	<0.011	ug/l	TM4/PM30
Benzo(bk)fluoranthene #	<0.018	<0.018	<0.018	<0.018	ug/l	TM4/PM30
Benzo(a)pyrene #	<0.016	<0.016	<0.016	<0.016	ug/l	TM4/PM30
Indeno(123cd)pyrene #	<0.011	<0.011	<0.011	<0.011	ug/l	TM4/PM30
Dibenzo(ah)anthracene #	<0.01	<0.01	<0.01	<0.01	ug/l	TM4/PM30
Benzo(ghi)perylene #	<0.011	<0.011	<0.011	<0.011	ug/l	TM4/PM30
PAH 16 Total #	<0.195	<0.195	<0.195	<0.195	ug/l	TM4/PM30
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	ug/l	TM4/PM30
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	ug/l	TM4/PM30
PAH Surrogate % Recovery	89	85	85	<0	%	TM4/PM30

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/2915

Report : Liquid

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
$H=H_2SO_4$, Z=ZnAc, N=NaOH, $HN=HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-23	LOD/LOR	Units	Method No.
Sample ID	R158	R507A	RX511B			
Depth						
COC No / misc						
Containers	V H HN N P G	V H HN N P G	V H HN N P G			
Sample Date	22/02/2018 10:00	22/02/2018 11:50	22/02/2018 15:45			
Sample Type	Ground Water	Ground Water	Ground Water			
Batch Number	1	1	1			
Date of Receipt	24/02/2018	24/02/2018	24/02/2018			
Pesticides						
Organophosphorus Pesticides						
Azinphos ethyl	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Azinphos methyl	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Carbophenothion	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Chlorfenvinphos	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Chlorpyrifos	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Chlorpyrifos-methyl	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Diazinon	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Dichlorvos	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Disulfoton	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Dimethoate	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Ethion	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Ethyl Parathion (Parathion)	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Etrimphos	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Fenitrothion	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Fenthion	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Malathion	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Methyl Parathion	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Mevinphos	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Phosalone	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Pirimiphos Methyl	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Propetamphos	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Triazophos	<0.01	<0.01	<0.01	<0.01	ug/l	TM149/PM30
TPH CWG						
Aliphatics						
>C5-C6 #	<10	<10	<10	<10	ug/l	TM36/PM12
>C6-C8 #	<10	<10	<10	<10	ug/l	TM36/PM12
>C8-C10 #	<10	<10	<10	<10	ug/l	TM36/PM12
>C10-C12 #	<5	<5	<5	<5	ug/l	TM5/PM16/PM30
>C12-C16 #	<10	<10	<10	<10	ug/l	TM5/PM16/PM30
>C16-C21 #	<10	<10	<10	<10	ug/l	TM5/PM16/PM30
>C21-C35 #	<10	<10	<10	<10	ug/l	TM5/PM16/PM30
Total aliphatics C5-35 #	<10	<10	<10	<10	ug/l	TM5/TM36/PM12/PM16/PM30

Exova Jones Environmental

Client Name:	AECOM	**Report :**	**Liquid**
Reference:	A303		
Location:	A303		
Contact:		**Liquids/products:**	V=40ml vial, G=glass bottle, P=plastic bottle
JE Job No.:	18/2915		$H=H_2SO_4$, Z=ZnAc, N=NaOH, $HN=HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-23								LOD/LOR	Units	Method No.
Sample ID	R158	R507A	RX511B										
Depth													
COC No / misc													
Containers	V H HN N P G	V H HN N P G	V H HN N P G										
Sample Date	22/02/2018 10:00	22/02/2018 11:50	22/02/2018 15:45										
Sample Type	Ground Water	Ground Water	Ground Water										
Batch Number	1	1	1										
Date of Receipt	24/02/2018	24/02/2018	24/02/2018										
TPH CWG													
Aromatics													
>C5-EC7 #	<10	<10	<10								<10	ug/l	TM36/PM12
>EC7-EC8 #	<10	<10	<10								<10	ug/l	TM36/PM12
>EC8-EC10 #	<10	<10	<10								<10	ug/l	TM36/PM12
>EC10-EC12 #	<5	<5	<5								<5	ug/l	TM5/PM16/PM30
>EC12-EC16 #	<10	<10	<10								<10	ug/l	TM5/PM16/PM30
>EC16-EC21 #	<10	<10	<10								<10	ug/l	TM5/PM16/PM30
>EC21-EC35 #	<10	<10	<10								<10	ug/l	TM5/PM16/PM30
Total aromatics C5-35 #	<10	<10	<10								<10	ug/l	TM5/TM36/PM12/PM16/PM30
Total aliphatics and aromatics(C5-35) #	<10	<10	<10								<10	ug/l	TM5/TM36/PM12/PM16/PM30
MTBE #	<5	<5	<5								<5	ug/l	TM31/PM12
Benzene #	<5	<5	<5								<5	ug/l	TM31/PM12
Toluene #	<5	<5	<5								<5	ug/l	TM31/PM12
Ethylbenzene #	<5	<5	<5								<5	ug/l	TM31/PM12
m/p-Xylene #	<5	<5	<5								<5	ug/l	TM31/PM12
o-Xylene #	<5	<5	<5								<5	ug/l	TM31/PM12
PCB 28	<0.1	<0.1	<0.1								<0.1	ug/l	TM17/PM30
PCB 52	<0.1	<0.1	<0.1								<0.1	ug/l	TM17/PM30
PCB 101	<0.1	<0.1	<0.1								<0.1	ug/l	TM17/PM30
PCB 118	<0.1	<0.1	<0.1								<0.1	ug/l	TM17/PM30
PCB 138	<0.1	<0.1	<0.1								<0.1	ug/l	TM17/PM30
PCB 153	<0.1	<0.1	<0.1								<0.1	ug/l	TM17/PM30
PCB 180	<0.1	<0.1	<0.1								<0.1	ug/l	TM17/PM30
Total 7 PCBs	<0.7	<0.7	<0.7								<0.7	ug/l	TM17/PM30
Total Phenols HPLC	<0.1	<0.1	<0.1								<0.1	mg/l	TM26/PM0
Fluoride	<0.3	<0.3	<0.3								<0.3	mg/l	TM173/PM0
Sulphate as SO4 #	18.5	17.3	21.0								<0.5	mg/l	TM38/PM0
Chloride #	20.4	12.6	14.4								<0.3	mg/l	TM38/PM0
Nitrate as NO3 #	51.5	24.0	23.7								<0.2	mg/l	TM38/PM0
Nitrite as NO2 #	<0.02	<0.02	<0.02								<0.02	mg/l	TM38/PM0
MRP Ortho Phosphate as P	<0.03	<0.03	<0.03								<0.03	mg/l	TM38/PM0
SRP Ortho Phosphate as PO4	<0.06	<0.06	<0.06								<0.06	mg/l	TM38/PM0
Free Cyanide #	<0.01	<0.01	<0.01								<0.01	mg/l	TM89/PM0
Total Cyanide #	<0.01	<0.01	<0.01								<0.01	mg/l	TM89/PM0
Ammoniacal Nitrogen as N #	<0.03	<0.03	<0.03								<0.03	mg/l	TM38/PM0
Hexavalent Chromium	<6	<6	<6								<6	ug/l	TM38/PM0

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/2915

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-23								LOD/LOR	Units	Method No.
Sample ID	R158	R507A	RX511B										
Depth													
COC No / misc													
Containers	V H HN N P G	V H HN N P G	V H HN N P G										
Sample Date	22/02/2018 10:00	22/02/2018 11:50	22/02/2018 15:45										
Sample Type	Ground Water	Ground Water	Ground Water										
Batch Number	1	1	1										
Date of Receipt	24/02/2018	24/02/2018	24/02/2018										
Total Dissolved Chromium III	<6	<6	<6								<6	ug/l	NONE/NONE
Total Alkalinity as CaCO3 #	258	244	260								<1	mg/l	TM75/PM0
Carbonate Alkalinity as CaCO3	<1	<1	<1								<1	mg/l	TM75/PM0
Bicarbonate Alkalinity as CaCO3 (water soluble)	258	244	260								<1	mg/l	TM75/PM0
Dissolved Oxygen	11	10	10								<1	mg/l	TM59/PM0
Dissolved Organic Carbon #	<2	<2	<2								<2	mg/l	TM60/PM0
Electrical Conductivity @25C #	537	464	502								<2	uS/cm	TM76/PM0
pH #	7.58	7.65	7.59								<0.01	pH units	TM73/PM0
Total Dissolved Solids #	375	305	391								<35	mg/l	TM20/PM0
Turbidity	51.1	92.1	6.5								<0.1	NTU	TM34/PM0
Total Cations	5.57	5.06	5.37								<0.00	mmolc/l	TM30/PM14
Total Anions	6.95	5.98	6.42								<0.00	mmolc/l	TM0/PM0
% Cation Excess	-11.02	-8.33	-8.91									%	TM0/PM0

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/2915

Report : **Misc**

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8											
Sample ID	R158											
Depth												
COC No / misc												
Containers	V H HN N P G											
Sample Date	22/02/2018 10:00											
Sample Type	Ground Water											
Batch Number	1											
Date of Receipt	24/02/2018									LOD/LOR	Units	Method No.
Sample Temperature	8.5									<0.1	Degrees C	NONE/NONE

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Client Name: AECOM
Reference: A303
Location: A303
Contact:

J E Job No.	Batch	Sample ID	Depth	J E Sample No.	Analysis	Reason
No deviating sample report results for job 18/2915						

Please note that only samples that are deviating are mentioned in this report. If no samples are listed it is because none were deviating.
Only analyses which are accredited are recorded as deviating if set criteria are not met.

NOTES TO ACCOMPANY ALL SCHEDULES AND REPORTS

JE Job No.: 18/2915

SOILS

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

The calculation of Pyrite content assumes that all oxidisable sulphides present in the sample are pyrite. This may not be the case. The calculation may be an overesitimate when other sulphides such as Barite (Barium Sulphate) are present.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 accreditation applies to surface water and groundwater and usually one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

DEVIATING SAMPLES

Samples must be received in a condition appropriate to the requested analyses. All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. If this is not the case you will be informed and any test results that may be compromised highlighted on your deviating samples report.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

BLANKS

Where analytes have been found in the blank, the sample will be treated in accordance with our laboratory procedure for dealing with contaminated blanks.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.
Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

REPORTS FROM THE SOUTH AFRICA LABORATORY

Any method number not prefixed with SA has been undertaken in our UK laboratory unless reported as subcontracted.

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS Ref No. 4225) accredited - UK.
SA	ISO17025 (SANAS Ref No.T0729) accredited - South Africa.
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
++	Result outside calibration range, results should be considered as indicative only and are not accredited.
*	Analysis subcontracted to a Jones Environmental approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range

JE Job No: 18/2915

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM0	Not available	PM0	No preparation is required.				
TM4	Modified USEPA 8270 method for the solvent extraction and determination of 16 PAHs by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM4	Modified USEPA 8270 method for the solvent extraction and determination of 16 PAHs by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.	Yes			
TM5	Modified USEPA 8015B method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) with carbon banding within the range C8-C40 GC-FID.	PM16/PM30	Fractionation into aliphatic and aromatic fractions using a Rapid Trace SPE/Water samples are extracted with solvent using a magnetic stirrer to create a vortex.	Yes			
TM5/TM36	please refer to TM5 and TM36 for method details	PM12/PM16/PM30	please refer to PM16/PM30 and PM12 for method details	Yes			
TM17	Modified US EPA method 8270. Determination of specific Polychlorinated Biphenyl congeners by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM20	Modified BS 1377-3: 1990/USEPA 160.3 Gravimetric determination of Total Dissolved Solids/Total Solids	PM0	No preparation is required.	Yes			
TM26	Determination of phenols by Reversed Phased High Performance Liquid Chromatography and Electro-Chemical Detection.	PM0	No preparation is required.				
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM14	Analysis of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for dissolved metals and acidified if required.				
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM14	Analysis of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for dissolved metals and acidified if required.	Yes			

JE Job No: 18/2915

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM31	Modified USEPA 8015B. Determination of Methyltertbutylether, Benzene, Toluene, Ethylbenzene and Xylene by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes			
TM34	Turbidity by 2100P Turbidity Meter	PM0	No preparation is required.				
TM36	Modified US EPA method 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C4-12 by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes			
TM38	Soluble Ion analysis using the Thermo Aquakem Photometric Automatic Analyser. Modified US EPA methods 325.2, 375.4, 365.2, 353.1, 354.1	PM0	No preparation is required.				
TM38	Soluble Ion analysis using the Thermo Aquakem Photometric Automatic Analyser. Modified US EPA methods 325.2, 375.4, 365.2, 353.1, 354.1	PM0	No preparation is required.	Yes			
TM59	Determination of Dissolved Oxygen using the Hach HQ30D Oxygen Meter	PM0	No preparation is required.				
TM60	Modified USEPA 9060. Determination of TOC by calculation from Total Carbon and Inorganic Carbon using a TOC analyser, the carbon in the sample is converted to CO2 and then passed through a non-dispersive infrared gas analyser (NDIR).	PM0	No preparation is required.	Yes			
TM73	Modified US EPA methods 150.1 and 9045D and BS1377:1990. Determination of pH by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			
TM75	Modified US EPA method 310.1. Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.				
TM75	Modified US EPA method 310.1. Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.	Yes			

JE Job No: 18/2915

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM76	Modified US EPA method 120.1. Determination of Specific Conductance by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			
TM89	Modified USEPA method OIA-1667. Determination of cyanide by Flow Injection Analyser. Where WAD cyanides are required a Ligand displacement step is carried out before analysis.	PM0	No preparation is required.	Yes			
TM149	Determination of Pesticides by Large Volume Injection on GC Triple Quad MS, based upon USEPA method 8270	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM173	Analysis of fluoride by ISE (Ion Selective Electrode) using modified ISE method 340.2	PM0	No preparation is required.				
NONE	No Method Code	NONE	No Method Code				

Exova Jones Environmental

Registered Address : Exova (UK) Ltd, Lochend Industrial Estate, Newbridge, Midlothian, EH28 8PL

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AECOM
Scott House
Alencon Link
Basingstoke
RG21 7PP

Attention :	
Date :	24th April, 2018
Your reference :	A303
Our reference :	Test Report 18/5587 Batch 1
Location :	A303
Date samples received :	14th April, 2018
Status :	Final report
Issue :	1

Nine samples were received for analysis on 14th April, 2018 of which nine were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Compiled By:

[redacted]

Paul Boden BSc
Project Manager

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/5587

Report : Liquid

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-24	25-32	33-40	41-48	49-56	57-64	65-72				
Sample ID	RX513A	R507A	R158	R503 B	R503-D	RX511B	RX506	RX507A	RX510A				
Depth													
COC No / misc													
Containers	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G				
Sample Date	12/04/2018 09:40	12/04/2018 12:30	11/04/2018 09:35	11/04/2018 11:40	11/04/2018 11:40	11/04/2018 15:45	13/04/2018 09:15	13/04/2018 11:55	13/04/2018 14:35				
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water				
Batch Number	1	1	1	1	1	1	1	1	1		LOD/LOR	Units	Method No.
Date of Receipt	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018				
Dissolved Antimony #	<2	2	<2	2	<2	<2	<2	<2	<2		<2	ug/l	TM30/PM14
Dissolved Arsenic #	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	2.6	<2.5		<2.5	ug/l	TM30/PM14
Dissolved Beryllium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	ug/l	TM30/PM14
Dissolved Boron	<12	12	<12	<12	<12	14	<12	<12	<12		<12	ug/l	TM30/PM14
Dissolved Cadmium #	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	ug/l	TM30/PM14
Dissolved Calcium #	107.6	100.8	110.9	107.9	107.9	107.4	118.9	106.3	120.7		<0.2	mg/l	TM30/PM14
Total Dissolved Chromium #	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5		<1.5	ug/l	TM30/PM14
Dissolved Copper #	<7	<7	<7	<7	<7	<7	<7	<7	<7		<7	ug/l	TM30/PM14
Total Dissolved Iron #	<20	<20	<20	<20	<20	<20	<20	<20	<20		<20	ug/l	TM30/PM14
Dissolved Lead #	<5	<5	<5	<5	<5	<5	<5	<5	<5		<5	ug/l	TM30/PM14
Dissolved Magnesium #	1.2	1.5	2.4	3.8	3.8	1.7	3.0	3.6	1.5		<0.1	mg/l	TM30/PM14
Dissolved Manganese #	<2	<2	<2	<2	<2	<2	<2	<2	<2		<2	ug/l	TM30/PM14
Dissolved Mercury #	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	ug/l	TM30/PM14
Dissolved Molybdenum #	<2	<2	<2	<2	<2	<2	<2	<2	<2		<2	ug/l	TM30/PM14
Dissolved Nickel #	<2	<2	<2	<2	<2	<2	<2	<2	<2		<2	ug/l	TM30/PM14
Dissolved Phosphorus #	8	10	9	8	<5	9	6	<5	9		<5	ug/l	TM30/PM14
Dissolved Potassium #	0.3	0.7	0.4	0.7	0.7	0.9	0.5	0.5	0.4		<0.1	mg/l	TM30/PM14
Dissolved Selenium #	<3	<3	<3	<3	<3	<3	<3	<3	<3		<3	ug/l	TM30/PM14
Dissolved Sodium #	6.3	6.9	7.9	13.7	13.7	8.3	8.2	12.0	7.7		<0.1	mg/l	TM30/PM14
Dissolved Zinc #	5	<3	4	<3	<3	<3	<3	<3	<3		<3	ug/l	TM30/PM14
Total Cadmium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	ug/l	TM30/PM14
Total Copper	<7	<7	<7	15	15	<7	90	21	10		<7	ug/l	TM30/PM14
Total Iron	2421	518	1696	4903	6106	144	32850_{AD}	9009	6708		<20	ug/l	TM30/PM14
Total Phosphorus	485	58	193	266	318	38	2274	1186	1286		<5	ug/l	TM30/PM14
Total Zinc	23	7	38	21	27	4	170	57	43		<3	ug/l	TM30/PM14

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/5587

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
$H=H_2SO_4$, Z=ZnAc, N=NaOH, $HN=HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-24	25-32	33-40	41-48	49-56	57-64	65-72		LOD/LOR	Units	Method No.
Sample ID	RX513A	R507A	R158	R503 B	R503-D	RX511B	RX506	RX507A	RX510A				
Depth													
COC No / misc													
Containers	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G				
Sample Date	12/04/2018 09:40	12/04/2018 12:30	11/04/2018 09:35	11/04/2018 11:40	11/04/2018 11:40	11/04/2018 15:45	13/04/2018 09:15	13/04/2018 11:55	13/04/2018 14:35				
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water				
Batch Number	1	1	1	1	1	1	1	1	1				
Date of Receipt	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018				
PAH MS													
Naphthalene #	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	ug/l	TM4/PM30
Acenaphthylene #	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013		<0.013	ug/l	TM4/PM30
Acenaphthene #	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013		<0.013	ug/l	TM4/PM30
Fluorene #	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014		<0.014	ug/l	TM4/PM30
Phenanthrene #	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011		<0.011	ug/l	TM4/PM30
Anthracene #	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013		<0.013	ug/l	TM4/PM30
Fluoranthene #	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012		<0.012	ug/l	TM4/PM30
Pyrene #	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013		<0.013	ug/l	TM4/PM30
Benzo(a)anthracene #	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015		<0.015	ug/l	TM4/PM30
Chrysene #	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011		<0.011	ug/l	TM4/PM30
Benzo(bk)fluoranthene #	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018		<0.018	ug/l	TM4/PM30
Benzo(a)pyrene #	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016		<0.016	ug/l	TM4/PM30
Indeno(123cd)pyrene #	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011		<0.011	ug/l	TM4/PM30
Dibenzo(ah)anthracene #	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM4/PM30
Benzo(ghi)perylene #	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011		<0.011	ug/l	TM4/PM30
PAH 16 Total #	<0.195	<0.195	<0.195	<0.195	<0.195	<0.195	<0.195	<0.195	<0.195		<0.195	ug/l	TM4/PM30
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM4/PM30
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM4/PM30
PAH Surrogate % Recovery	93	91	94	84	90	183	91	90	89		<0	%	TM4/PM30

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Client Name:	AECOM	**Report :**	**Liquid**
Reference:	A303		
Location:	A303		
Contact:		**Liquids/products:**	V=40ml vial, G=glass bottle, P=plastic bottle
JE Job No.:	18/5587		$H=H_2SO_4$, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-24	25-32	33-40	41-48	49-56	57-64	65-72				
Sample ID	RX513A	R507A	R158	R503 B	R503-D	RX511B	RX506	RX507A	RX510A				
Depth													
COC No / misc													
Containers	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G				
Sample Date	12/04/2018 09:40	12/04/2018 12:30	11/04/2018 09:35	11/04/2018 11:40	11/04/2018 11:40	11/04/2018 15:45	13/04/2018 09:15	13/04/2018 11:55	13/04/2018 14:35				
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water				
Batch Number	1	1	1	1	1	1	1	1	1				
Date of Receipt	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018		LOD/LOR	Units	Method No.
Pesticides													
Organophosphorus Pesticides													
Azinphos ethyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Azinphos methyl	$<0.02_{AA}$	$<0.02_{AA}$	$<0.02_{AA}$	$<0.02_{AA}$	$<0.02_{AA}$	$<0.02_{AA}$	$<0.02_{AA}$	$<0.02_{AA}$	$<0.02_{AA}$		<0.01	ug/l	TM149/PM30
Carbophenothion	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Chlorfenvinphos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Chlorpyrifos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Chlorpyrifos-methyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Diazinon	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Dichlorvos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Disulfoton	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Dimethoate	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Ethion	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Ethyl Parathion (Parathion)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Etrimphos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Fenitrothion	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Fenthion	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Malathion	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Methyl Parathion	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Mevinphos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Phosalone	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Pirimiphos Methyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Propetamphos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
Triazophos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	ug/l	TM149/PM30
TPH CWG													
Aliphatics													
>C5-C6 #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM36/PM12
>C6-C8 #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM36/PM12
>C8-C10 #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM36/PM12
>C10-C12 #	<5	<5	<5	<5	<5	<5	<5	<5	<5		<5	ug/l	TM5/PM16/PM30
>C12-C16 #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM5/PM16/PM30
>C16-C21 #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM5/PM16/PM30
>C21-C35 #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM5/PM16/PM30
Total aliphatics C5-35 #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM5/TM36/PM12/PM16/PM30

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All solid results are expressed on a dry weight basis unless stated otherwise.

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/5587

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-24	25-32	33-40	41-48	49-56	57-64	65-72		LOD/LOR	Units	Method No.
Sample ID	RX513A	R507A	R158	R503 B	R503-D	RX511B	RX506	RX507A	RX510A				
Depth													
COC No / misc													
Containers	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G				
Sample Date	12/04/2018 09:40	12/04/2018 12:30	11/04/2018 09:35	11/04/2018 11:40	11/04/2018 11:40	11/04/2018 15:45	13/04/2018 09:15	13/04/2018 11:55	13/04/2018 14:35				
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water				
Batch Number	1	1	1	1	1	1	1	1	1				
Date of Receipt	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018				
TPH CWG													
Aromatics													
>C5-EC7 #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM36/PM12
>EC7-EC8 #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM36/PM12
>EC8-EC10 #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM36/PM12
>EC10-EC12 #	<5	<5	<5	<5	<5	<5	<5	<5	<5		<5	ug/l	TM5/PM16/PM30
>EC12-EC16 #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM5/PM16/PM30
>EC16-EC21 #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM5/PM16/PM30
>EC21-EC35 #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM5/PM16/PM30
Total aromatics C5-35 #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM5/TM36/PM12/PM16/PM30
Total aliphatics and aromatics(C5-35) #	<10	<10	<10	<10	<10	<10	<10	<10	<10		<10	ug/l	TM5/TM36/PM12/PM16/PM30
MTBE #	<5	<5	<5	<5	<5	<5	<5	<5	<5		<5	ug/l	TM31/PM12
Benzene #	<5	<5	<5	<5	<5	<5	<5	<5	<5		<5	ug/l	TM31/PM12
Toluene #	<5	<5	<5	<5	<5	<5	<5	<5	<5		<5	ug/l	TM31/PM12
Ethylbenzene #	<5	<5	<5	<5	<5	<5	<5	<5	<5		<5	ug/l	TM31/PM12
m/p-Xylene #	<5	<5	<5	<5	<5	<5	<5	<5	<5		<5	ug/l	TM31/PM12
o-Xylene #	<5	<5	<5	<5	<5	<5	<5	<5	<5		<5	ug/l	TM31/PM12
PCB 28	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	ug/l	TM17/PM30
PCB 52	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	ug/l	TM17/PM30
PCB 101	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	ug/l	TM17/PM30
PCB 118	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	ug/l	TM17/PM30
PCB 138	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	ug/l	TM17/PM30
PCB 153	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	ug/l	TM17/PM30
PCB 180	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	ug/l	TM17/PM30
Total 7 PCBs	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7		<0.7	ug/l	TM17/PM30
Total Phenols HPLC	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15		<0.15	mg/l	TM26/PM0
Fluoride	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3		<0.3	mg/l	TM173/PM0
Sulphate as SO4 #	23.3	21.1	20.2	24.7	22.6	20.8	19.6	44.1	24.0		<0.5	mg/l	TM38/PM0
Chloride #	19.5	20.3	24.1	32.1	32.6	16.9	23.4	24.6	16.6		<0.3	mg/l	TM38/PM0
Nitrate as NO3 #	59.1	31.3	57.0	61.9	63.2	24.9	119.1	12.3	37.6		<0.2	mg/l	TM38/PM0
Nitrite as NO2 #	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02		<0.02	mg/l	TM38/PM0
MRP Ortho Phosphate as P	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03		<0.03	mg/l	TM38/PM0
SRP Ortho Phosphate as PO4	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06		<0.06	mg/l	TM38/PM0
Free Cyanide #	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	mg/l	TM89/PM0
Total Cyanide #	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	mg/l	TM89/PM0
Ammoniacal Nitrogen as N #	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03		<0.03	mg/l	TM38/PM0
Hexavalent Chromium	<6	<6	<6	<6	<6	<6	<6	<6	<6		<6	ug/l	TM38/PM0

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/5587

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-24	25-32	33-40	41-48	49-56	57-64	65-72				
Sample ID	RX513A	R507A	R158	R503 B	R503-D	RX511B	RX506	RX507A	RX510A				
Depth													
COC No / misc													
Containers	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G				
Sample Date	12/04/2018 09:40	12/04/2018 12:30	11/04/2018 09:35	11/04/2018 11:40	11/04/2018 11:40	11/04/2018 15:45	13/04/2018 09:15	13/04/2018 11:55	13/04/2018 14:35				
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water				
Batch Number	1	1	1	1	1	1	1	1	1		LOD/LOR	Units	Method No.
Date of Receipt	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018	14/04/2018				
Total Dissolved Chromium III	<6	<6	<6	<6	<6	<6	<6	<6	<6		<6	ug/l	NONE/NONE
Dissolved Alkalinity as CaCO3 #	219	205	205	204	224	217	227	242	256		<1	mg/l	TM75/PM0
Total Alkalinity as CaCO3 #	824	224	380	465	380	254	3394	1422	763		<1	mg/l	TM75/PM0
Carbonate Alkalinity as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	mg/l	TM75/PM0
Bicarbonate Alkalinity as CaCO3 (water soluble)	824	224	380	465	380	254	3394	1422	763		<1	mg/l	TM75/PM0
Dissolved Oxygen	12	11	11	11	11	11	12	12	12		<1	mg/l	TM59/PM0
Dissolved Organic Carbon #	<2	<2	<2	<2	<2	<2	<2	<2	<2		<2	mg/l	TM60/PM0
Electrical Conductivity @25C #	520	373	475	548	546	503	519	479	486		<2	uS/cm	TM76/PM0
pH #	6.99	7.04	7.05	7.72	7.01	7.10	6.93	7.01	6.97		<0.01	pH units	TM73/PM0
Total Dissolved Solids #	479	330	427	480	490	350	1111	372	3488		<35	mg/l	TM20/PM0
Turbidity	2372.0_{AB}	42.1	925.0	433.0	884.0_{AA}	18.9	16800.0_{AE}	4720.0_{AC}	4740.0_{AC}		<0.1	NTU	TM34/PM0
Total Cations	5.75	5.47	6.09	6.31	6.31	5.88	6.55	6.14	6.49		<0.00	mmolc/l	TM30/PM14
Total Anions	18.46	6.00	9.62	11.72	10.01	6.39	70.85	30.24	16.83		<0.00	mmolc/l	TM0/PM0
% Cation Excess	-52.50	-4.62	-22.47	-30.01	-22.67	-4.16	-83.07	-66.25	-44.34			%	TM0/PM0

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/5587

Report : **Misc**

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

J E Sample No.	1-8											
Sample ID	RX513A											
Depth										Please see attached notes for all abbreviations and acronyms		
COC No / misc												
Containers	V H HN N P G											
Sample Date	12/04/2018 09:40											
Sample Type	Ground Water											
Batch Number	1									LOD/LOR	Units	Method No.
Date of Receipt	14/04/2018											
Sample Temperature	7.0									<0.1	Degrees C	NONE/NONE

Client Name: AECOM
Reference: A303
Location: A303
Contact:

J E Job No.	Batch	Sample ID	Depth	J E Sample No.	Analysis	Reason
No deviating sample report results for job 18/5587						

Please note that only samples that are deviating are mentioned in this report. If no samples are listed it is because none were deviating.
Only analyses which are accredited are recorded as deviating if set criteria are not met.

JE Job No.: 18/5587

SOILS

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

The calculation of Pyrite content assumes that all oxidisable sulphides present in the sample are pyrite. This may not be the case. The calculation may be an overesitimate when other sulphides such as Barite (Barium Sulphate) are present.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 accreditation applies to surface water and groundwater and usually one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

DEVIATING SAMPLES

Samples must be received in a condition appropriate to the requested analyses. All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. If this is not the case you will be informed and any test results that may be compromised highlighted on your deviating samples report.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

BLANKS

Where analytes have been found in the blank, the sample will be treated in accordance with our laboratory procedure for dealing with contaminated blanks.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.
Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

REPORTS FROM THE SOUTH AFRICA LABORATORY

Any method number not prefixed with SA has been undertaken in our UK laboratory unless reported as subcontracted.

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS Ref No. 4225) accredited - UK.
SA	ISO17025 (SANAS Ref No.T0729) accredited - South Africa.
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
++	Result outside calibration range, results should be considered as indicative only and are not accredited.
*	Analysis subcontracted to a Jones Environmental approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range
AA	x2 Dilution
AB	x4 Dilution
AC	x5 Dilution
AD	x10 Dilution
AE	x20 Dilution

JE Job No: 18/5587

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM0	Not available	PM0	No preparation is required.				
TM4	Modified USEPA 8270 method for the solvent extraction and determination of 16 PAHs by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM4	Modified USEPA 8270 method for the solvent extraction and determination of 16 PAHs by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.	Yes			
TM5	Modified USEPA 8015B method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) with carbon banding within the range C8-C40 GC-FID.	PM16/PM30	Fractionation into aliphatic and aromatic fractions using a Rapid Trace SPE/Water samples are extracted with solvent using a magnetic stirrer to create a vortex.	Yes			
TM5/TM36	please refer to TM5 and TM36 for method details	PM12/PM16/PM30	please refer to PM16/PM30 and PM12 for method details	Yes			
TM17	Modified US EPA method 8270. Determination of specific Polychlorinated Biphenyl congeners by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM20	Modified BS 1377-3: 1990/USEPA 160.3 Gravimetric determination of Total Dissolved Solids/Total Solids	PM0	No preparation is required.	Yes			
TM26	Determination of phenols by Reversed Phased High Performance Liquid Chromatography and Electro-Chemical Detection.	PM0	No preparation is required.				
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM14	Analysis of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for dissolved metals and acidified if required.				
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM14	Analysis of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for dissolved metals and acidified if required.	Yes			

JE Job No: 18/5587

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM31	Modified USEPA 8015B. Determination of Methyltertbutylether, Benzene, Toluene, Ethylbenzene and Xylene by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes			
TM34	Turbidity by 2100P Turbidity Meter	PM0	No preparation is required.				
TM36	Modified US EPA method 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C4-12 by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes			
TM38	Soluble Ion analysis using the Thermo Aquakem Photometric Automatic Analyser. Modified US EPA methods 325.2, 375.4, 365.2, 353.1, 354.1	PM0	No preparation is required.				
TM38	Soluble Ion analysis using the Thermo Aquakem Photometric Automatic Analyser. Modified US EPA methods 325.2, 375.4, 365.2, 353.1, 354.1	PM0	No preparation is required.	Yes			
TM59	Determination of Dissolved Oxygen using the Hach HQ30D Oxygen Meter	PM0	No preparation is required.				
TM60	Modified USEPA 9060. Determination of TOC by calculation from Total Carbon and Inorganic Carbon using a TOC analyser, the carbon in the sample is converted to CO2 and then passed through a non-dispersive infrared gas analyser (NDIR).	PM0	No preparation is required.	Yes			
TM73	Modified US EPA methods 150.1 and 9045D and BS1377:1990. Determination of pH by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			
TM75	Modified US EPA method 310.1. Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.				
TM75	Modified US EPA method 310.1. Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.	Yes			

JE Job No: 18/5587

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM76	Modified US EPA method 120.1. Determination of Specific Conductance by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			
TM89	Modified USEPA method OIA-1667. Determination of cyanide by Flow Injection Analyser. Where WAD cyanides are required a Ligand displacement step is carried out before analysis.	PM0	No preparation is required.	Yes			
TM149	Determination of Pesticides by Large Volume Injection on GC Triple Quad MS, based upon USEPA method 8270	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM173	Analysis of fluoride by ISE (Ion Selective Electrode) using modified ISE method 340.2	PM0	No preparation is required.				
NONE	No Method Code	NONE	No Method Code				

Exova Jones Environmental

Registered Address : Exova (UK) Ltd, Lochend Industrial Estate, Newbridge, Midlothian, EH28 8PL

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Deeside
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4225

AECOM
Scott House
Alencon Link
Basingstoke
RG21 7PP

Attention :	
Date :	27th April, 2018
Your reference :	A303
Our reference :	Test Report 18/5875 Batch 1
Location :	A303
Date samples received :	19th April, 2018
Status :	Final report
Issue :	1

Five samples were received for analysis on 19th April, 2018 of which five were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Compiled By:

[redacted]

Paul Boden BSc
Project Manager

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/5875

Report : Liquid

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
$H=H_2SO_4$, Z=ZnAc, N=NaOH, $HN=HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-24	25-32	33-40			
Sample ID	RX508A	R509A	RX512A	PX506	PX505A			
Depth								
COC No / misc								
Containers	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G			
Sample Date	17/04/2018 09:45	17/04/2018 11:35	17/04/2018 14:00	18/04/2018 10:13	18/04/2018 12:20			
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water			
Batch Number	1	1	1	1	1	LOD/LOR	Units	Method No.
Date of Receipt	19/04/2018	19/04/2018	19/04/2018	19/04/2018	19/04/2018			
Dissolved Antimony #	<2	<2	5	<2	<2	<2	ug/l	TM30/PM14
Dissolved Arsenic #	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	ug/l	TM30/PM14
Dissolved Beryllium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ug/l	TM30/PM14
Dissolved Boron	28	<12	15	<12	<12	<12	ug/l	TM30/PM14
Dissolved Cadmium #	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ug/l	TM30/PM14
Dissolved Calcium #	109.3	111.4	112.7	96.1	114.2	<0.2	mg/l	TM30/PM14
Total Dissolved Chromium #	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	ug/l	TM30/PM14
Dissolved Copper #	<7	<7	<7	<7	<7	<7	ug/l	TM30/PM14
Total Dissolved Iron #	<20	<20	<20	<20	<20	<20	ug/l	TM30/PM14
Dissolved Lead #	<5	<5	<5	<5	<5	<5	ug/l	TM30/PM14
Dissolved Magnesium #	2.7	1.4	1.6	1.8	3.0	<0.1	mg/l	TM30/PM14
Dissolved Manganese #	<2	<2	<2	<2	4	<2	ug/l	TM30/PM14
Dissolved Mercury #	<1	<1	<1	<1	<1	<1	ug/l	TM30/PM14
Dissolved Molybdenum #	<2	<2	<2	<2	<2	<2	ug/l	TM30/PM14
Dissolved Nickel #	<2	<2	<2	<2	<2	<2	ug/l	TM30/PM14
Dissolved Phosphorus #	11	7	8	7	10	<5	ug/l	TM30/PM14
Dissolved Potassium #	0.8	0.2	0.6	0.5	0.5	<0.1	mg/l	TM30/PM14
Dissolved Selenium #	<3	<3	<3	<3	<3	<3	ug/l	TM30/PM14
Dissolved Sodium #	6.0	7.4	8.5	7.6	6.2	<0.1	mg/l	TM30/PM14
Dissolved Zinc #	<3	<3	3	3	<3	<3	ug/l	TM30/PM14
Total Cadmium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ug/l	TM30/PM14
Total Copper	19	16	<7	40	123	<7	ug/l	TM30/PM14
Total Iron	28940_{AD}	33180_{AD}	4759	18360_{AD}	61910_{AE}	<20	ug/l	TM30/PM14
Total Phosphorus	1607	1949	342	1287	3925	<5	ug/l	TM30/PM14
Total Zinc	98	87	18	73	238	<3	ug/l	TM30/PM14

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/5875

Report : Liquid

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
$H=H_2SO_4$, Z=ZnAc, N=NaOH, $HN=HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-24	25-32	33-40	LOD/LOR	Units	Method No.
Sample ID	RX508A	R509A	RX512A	PX506	PX505A			
Depth								
COC No / misc								
Containers	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G			
Sample Date	17/04/2018 09:45	17/04/2018 11:35	17/04/2018 14:00	18/04/2018 10:13	18/04/2018 12:20			
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water			
Batch Number	1	1	1	1	1			
Date of Receipt	19/04/2018	19/04/2018	19/04/2018	19/04/2018	19/04/2018			
PAH MS								
Naphthalene #	<0.3$_{AB}$	<0.3$_{AB}$	<0.3$_{AB}$	<0.3$_{AB}$	<0.3$_{AB}$	<0.1	ug/l	TM4/PM30
Acenaphthylene #	<0.039$_{AB}$	<0.039$_{AB}$	<0.039$_{AB}$	<0.039$_{AB}$	<0.039$_{AB}$	<0.013	ug/l	TM4/PM30
Acenaphthene #	<0.039$_{AB}$	<0.039$_{AB}$	<0.039$_{AB}$	<0.039$_{AB}$	<0.039$_{AB}$	<0.013	ug/l	TM4/PM30
Fluorene #	<0.042$_{AB}$	<0.042$_{AB}$	<0.042$_{AB}$	<0.042$_{AB}$	<0.042$_{AB}$	<0.014	ug/l	TM4/PM30
Phenanthrene #	<0.033$_{AB}$	<0.033$_{AB}$	<0.033$_{AB}$	<0.033$_{AB}$	<0.033$_{AB}$	<0.011	ug/l	TM4/PM30
Anthracene #	<0.039$_{AB}$	<0.039$_{AB}$	<0.039$_{AB}$	<0.039$_{AB}$	<0.039$_{AB}$	<0.013	ug/l	TM4/PM30
Fluoranthene #	<0.036$_{AB}$	<0.036$_{AB}$	<0.036$_{AB}$	<0.036$_{AB}$	<0.036$_{AB}$	<0.012	ug/l	TM4/PM30
Pyrene #	<0.039$_{AB}$	<0.039$_{AB}$	<0.039$_{AB}$	<0.039$_{AB}$	<0.039$_{AB}$	<0.013	ug/l	TM4/PM30
Benzo(a)anthracene #	<0.045$_{AB}$	<0.045$_{AB}$	<0.045$_{AB}$	<0.045$_{AB}$	<0.045$_{AB}$	<0.015	ug/l	TM4/PM30
Chrysene #	<0.033$_{AB}$	<0.033$_{AB}$	<0.033$_{AB}$	<0.033$_{AB}$	<0.033$_{AB}$	<0.011	ug/l	TM4/PM30
Benzo(bk)fluoranthene #	<0.054$_{AB}$	<0.054$_{AB}$	<0.054$_{AB}$	<0.054$_{AB}$	<0.054$_{AB}$	<0.018	ug/l	TM4/PM30
Benzo(a)pyrene #	<0.048$_{AB}$	<0.048$_{AB}$	<0.048$_{AB}$	<0.048$_{AB}$	<0.048$_{AB}$	<0.016	ug/l	TM4/PM30
Indeno(123cd)pyrene #	<0.033$_{AB}$	<0.033$_{AB}$	<0.033$_{AB}$	<0.033$_{AB}$	<0.033$_{AB}$	<0.011	ug/l	TM4/PM30
Dibenzo(ah)anthracene #	<0.03$_{AB}$	<0.03$_{AB}$	<0.03$_{AB}$	<0.03$_{AB}$	<0.03$_{AB}$	<0.01	ug/l	TM4/PM30
Benzo(ghi)perylene #	<0.033$_{AB}$	<0.033$_{AB}$	<0.033$_{AB}$	<0.033$_{AB}$	<0.033$_{AB}$	<0.011	ug/l	TM4/PM30
PAH 16 Total #	<0.585$_{AB}$	<0.585$_{AB}$	<0.585$_{AB}$	<0.585$_{AB}$	<0.585$_{AB}$	<0.195	ug/l	TM4/PM30
Benzo(b)fluoranthene	<0.03$_{AB}$	<0.03$_{AB}$	<0.03$_{AB}$	<0.03$_{AB}$	<0.03$_{AB}$	<0.01	ug/l	TM4/PM30
Benzo(k)fluoranthene	<0.03$_{AB}$	<0.03$_{AB}$	<0.03$_{AB}$	<0.03$_{AB}$	<0.03$_{AB}$	<0.01	ug/l	TM4/PM30
PAH Surrogate % Recovery	87$_{AB}$	89$_{AB}$	87$_{AB}$	87$_{AB}$	86$_{AB}$	<0	%	TM4/PM30

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/5875

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-24	25-32	33-40	LOD/LOR	Units	Method No.
Sample ID	RX508A	R509A	RX512A	PX506	PX505A			
Depth								
COC No / misc								
Containers	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G			
Sample Date	17/04/2018 09:45	17/04/2018 11:35	17/04/2018 14:00	18/04/2018 10:13	18/04/2018 12:20			
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water			
Batch Number	1	1	1	1	1			
Date of Receipt	19/04/2018	19/04/2018	19/04/2018	19/04/2018	19/04/2018			
Pesticides								
Organophosphorus Pesticides								
Azinphos ethyl	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Azinphos methyl	<0.05$_{AD}$	<0.05$_{AD}$	<0.05$_{AD}$	<0.05$_{AD}$	<0.05$_{AD}$	<0.01	ug/l	TM149/PM30
Carbophenothion	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Chlorfenvinphos	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Chlorpyrifos	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Chlorpyrifos-methyl	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Diazinon	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Dichlorvos	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Disulfoton	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Dimethoate	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Ethion	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Ethyl Parathion (Parathion)	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Etrimphos	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Fenitrothion	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Fenthion	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Malathion	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Methyl Parathion	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Mevinphos	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Phosalone	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Pirimiphos Methyl	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Propetamphos	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
Triazophos	<0.01	<0.01	<0.01	<0.01	<0.01^{SV}	<0.01	ug/l	TM149/PM30
TPH CWG								
Aliphatics								
>C5-C6#	<10	<10	<10	<10	<10	<10	ug/l	TM36/PM12
>C6-C8#	<10	<10	<10	<10	<10	<10	ug/l	TM36/PM12
>C8-C10#	<10	<10	<10	<10	<10	<10	ug/l	TM36/PM12
>C10-C12#	<5	<5	<5	<5	<5	<5	ug/l	TM5/PM16/PM30
>C12-C16#	<10	<10	<10	<10	<10	<10	ug/l	TM5/PM16/PM30
>C16-C21#	<10	<10	<10	<10	<10	<10	ug/l	TM5/PM16/PM30
>C21-C35#	<10	<10	<10	<10	<10	<10	ug/l	TM5/PM16/PM30
Total aliphatics C5-35#	<10	<10	<10	<10	<10	<10	ug/l	TM5/TM36/PM12/PM16/PM30

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/5875

Report : Liquid

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=HNO_3

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-24	25-32	33-40						LOD/LOR	Units	Method No.
Sample ID	RX508A	R509A	RX512A	PX506	PX505A								
Depth													
COC No / misc													
Containers	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G								
Sample Date	17/04/2018 09:45	17/04/2018 11:35	17/04/2018 14:00	18/04/2018 10:13	18/04/2018 12:20								
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water								
Batch Number	1	1	1	1	1								
Date of Receipt	19/04/2018	19/04/2018	19/04/2018	19/04/2018	19/04/2018								
TPH CWG													
Aromatics													
>C5-EC7 #	<10	<10	<10	<10	<10						<10	ug/l	TM36/PM12
>EC7-EC8 #	<10	<10	<10	<10	<10						<10	ug/l	TM36/PM12
>EC8-EC10 #	<10	<10	<10	<10	<10						<10	ug/l	TM36/PM12
>EC10-EC12 #	<5	<5	<5	<5	<5						<5	ug/l	TM5/PM16/PM30
>EC12-EC16 #	<10	<10	<10	<10	<10						<10	ug/l	TM5/PM16/PM30
>EC16-EC21 #	<10	<10	<10	<10	<10						<10	ug/l	TM5/PM16/PM30
>EC21-EC35 #	<10	<10	<10	<10	<10						<10	ug/l	TM5/PM16/PM30
Total aromatics C5-35 #	<10	<10	<10	<10	<10						<10	ug/l	TM5/TM36/PM12/PM16/PM30
Total aliphatics and aromatics(C5-35) #	<10	<10	<10	<10	<10						<10	ug/l	TM5/TM36/PM12/PM16/PM30
MTBE #	<5	<5	<5	<5	<5						<5	ug/l	TM31/PM12
Benzene #	<5	<5	<5	<5	<5						<5	ug/l	TM31/PM12
Toluene #	<5	<5	<5	<5	<5						<5	ug/l	TM31/PM12
Ethylbenzene #	<5	<5	<5	<5	<5						<5	ug/l	TM31/PM12
m/p-Xylene #	<5	<5	<5	<5	<5						<5	ug/l	TM31/PM12
o-Xylene #	<5	<5	<5	<5	<5						<5	ug/l	TM31/PM12
PCB 28	<0.1	<0.1	<0.1	<0.1	<0.1						<0.1	ug/l	TM17/PM30
PCB 52	<0.1	<0.1	<0.1	<0.1	<0.1						<0.1	ug/l	TM17/PM30
PCB 101	<0.1	<0.1	<0.1	<0.1	<0.1						<0.1	ug/l	TM17/PM30
PCB 118	<0.1	<0.1	<0.1	<0.1	<0.1						<0.1	ug/l	TM17/PM30
PCB 138	<0.1	<0.1	<0.1	<0.1	<0.1						<0.1	ug/l	TM17/PM30
PCB 153	<0.1	<0.1	<0.1	<0.1	<0.1						<0.1	ug/l	TM17/PM30
PCB 180	<0.1	<0.1	<0.1	<0.1	<0.1						<0.1	ug/l	TM17/PM30
Total 7 PCBs	<0.7	<0.7	<0.7	<0.7	<0.7						<0.7	ug/l	TM17/PM30
Total Phenols HPLC	<0.15	<0.15	<0.15	<0.15	<0.15						<0.15	mg/l	TM26/PM0
Fluoride	<0.3	<0.3	<0.3	<0.3	<0.3						<0.3	mg/l	TM173/PM0
Sulphate as SO4 #	23.8	28.4	22.3	16.2	32.5						<0.5	mg/l	TM38/PM0
Chloride #	8.2	18.4	20.6	17.9	21.6						<0.3	mg/l	TM38/PM0
Nitrate as NO3 #	22.1	68.0	52.4	38.2	63.8						<0.2	mg/l	TM38/PM0
Nitrite as NO2 #	<0.02	<0.02	<0.02	<0.02	<0.02						<0.02	mg/l	TM38/PM0
MRP Ortho Phosphate as P	<0.03	<0.03	<0.03	<0.03	<0.03						<0.03	mg/l	TM38/PM0
SRP Ortho Phosphate as PO4	<0.06	<0.06	<0.06	<0.06	<0.06						<0.06	mg/l	TM38/PM0
Free Cyanide #	<0.01	<0.01	<0.01	<0.01	<0.01						<0.01	mg/l	TM89/PM0
Total Cyanide #	<0.01	<0.01	<0.01	<0.01	<0.01						<0.01	mg/l	TM89/PM0
Ammoniacal Nitrogen as N #	0.07	<0.03	<0.03	<0.03	<0.03						<0.03	mg/l	TM38/PM0
Hexavalent Chromium	<6	<6	<6	<6	<6						<6	ug/l	TM38/PM0

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/5875

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	17-24	25-32	33-40	LOD/LOR	Units	Method No.
Sample ID	RX508A	R509A	RX512A	PX506	PX505A			
Depth								
COC No / misc								
Containers	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G	V H HN N P G			
Sample Date	17/04/2018 09:45	17/04/2018 11:35	17/04/2018 14:00	18/04/2018 10:13	18/04/2018 12:20			
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water			
Batch Number	1	1	1	1	1			
Date of Receipt	19/04/2018	19/04/2018	19/04/2018	19/04/2018	19/04/2018			
Total Dissolved Chromium III	<6	<6	<6	<6	<6	<6	ug/l	NONE/NONE
Dissolved Alkalinity as CaCO3 #	228	202	212	192	194	<1	mg/l	TM75/PM0
Total Alkalinity as CaCO3 #	2831	3108	552	1004	2549	<1	mg/l	TM75/PM0
Carbonate Alkalinity as CaCO3	<1	<1	<1	<1	<1	<1	mg/l	TM75/PM0
Bicarbonate Alkalinity as CaCO3 (water soluble)	2831	3108	552	1004	2549	<1	mg/l	TM75/PM0
Dissolved Oxygen	10	10	10	10	11	<1	mg/l	TM59/PM0
Dissolved Organic Carbon #	<2	<2	<2	<2	<2	<2	mg/l	TM60/PM0
Electrical Conductivity @25C #	572	519	584	491	581	<2	uS/cm	TM76/PM0
pH #	7.21	6.97	7.03	7.01	6.95	<0.01	pH units	TM73/PM0
Total Dissolved Solids #	357	465	462	362	569	<35	mg/l	TM20/PM0
Turbidity	8860.0_{AE}	11120.0_{AF}	1484.0_{AA}	2980.0_{AC}	10060.0_{AF}	<0.1	NTU	TM34/PM0
Total Cations	5.96	6.00	6.14	5.29	6.23	<0.00	mmolc/l	TM30/PM14
Total Anions	57.68	64.35	12.93	21.53	53.28	<0.00	mmolc/l	TM0/PM0
% Cation Excess	-81.27	-82.94	-35.61	-60.55	-79.06		%	TM0/PM0

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/5875

Report : **Misc**

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8											
Sample ID	RX508A											
Depth												
COC No / misc												
Containers	V H HN N P G											
Sample Date	17/04/2018 09:45											
Sample Type	Ground Water											
Batch Number	1											
Date of Receipt	19/04/2018									LOD/LOR	Units	Method No.
Sample Temperature	7.0									<0.1	Degrees C	NONE/NONE

Client Name: AECOM
Reference: A303
Location: A303
Contact:

J E Job No.	Batch	Sample ID	Depth	J E Sample No.	Analysis	Reason
No deviating sample report results for job 18/5875						

Please note that only samples that are deviating are mentioned in this report. If no samples are listed it is because none were deviating.
Only analyses which are accredited are recorded as deviating if set criteria are not met.

JE Job No.: 18/5875

SOILS

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

The calculation of Pyrite content assumes that all oxidisable sulphides present in the sample are pyrite. This may not be the case. The calculation may be an overesitimate when other sulphides such as Barite (Barium Sulphate) are present.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 accreditation applies to surface water and groundwater and usually one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

DEVIATING SAMPLES

Samples must be received in a condition appropriate to the requested analyses. All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. If this is not the case you will be informed and any test results that may be compromised highlighted on your deviating samples report.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

BLANKS

Where analytes have been found in the blank, the sample will be treated in accordance with our laboratory procedure for dealing with contaminated blanks.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.
Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

REPORTS FROM THE SOUTH AFRICA LABORATORY

Any method number not prefixed with SA has been undertaken in our UK laboratory unless reported as subcontracted.

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS Ref No. 4225) accredited - UK.
SA	ISO17025 (SANAS Ref No.T0729) accredited - South Africa.
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
++	Result outside calibration range, results should be considered as indicative only and are not accredited.
*	Analysis subcontracted to an Exova Jones Environmental approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range
AA	x2 Dilution
AB	x3 Dilution
AC	x4 Dilution
AD	x5 Dilution
AE	x10 Dilution
AF	x20 Dilution

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

JE Job No: 18/5875

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM0	Not available	PM0	No preparation is required.				
TM4	Modified USEPA 8270 method for the solvent extraction and determination of 16 PAHs by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM4	Modified USEPA 8270 method for the solvent extraction and determination of 16 PAHs by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.	Yes			
TM5	Modified USEPA 8015B method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) with carbon banding within the range C8-C40 GC-FID.	PM16/PM30	Fractionation into aliphatic and aromatic fractions using a Rapid Trace SPE/Water samples are extracted with solvent using a magnetic stirrer to create a vortex.	Yes			
TM5/TM36	please refer to TM5 and TM36 for method details	PM12/PM16/PM30	please refer to PM16/PM30 and PM12 for method details	Yes			
TM17	Modified US EPA method 8270. Determination of specific Polychlorinated Biphenyl congeners by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM20	Modified BS 1377-3: 1990/USEPA 160.3 Gravimetric determination of Total Dissolved Solids/Total Solids	PM0	No preparation is required.	Yes			
TM26	Determination of phenols by Reversed Phased High Performance Liquid Chromatography and Electro-Chemical Detection.	PM0	No preparation is required.				
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM14	Analysis of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for dissolved metals and acidified if required.				
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM14	Analysis of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for dissolved metals and acidified if required.	Yes			

JE Job No: 18/5875

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM31	Modified USEPA 8015B. Determination of Methyltertbutylether, Benzene, Toluene, Ethylbenzene and Xylene by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes			
TM34	Turbidity by 2100P Turbidity Meter	PM0	No preparation is required.				
TM36	Modified US EPA method 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C4-12 by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes			
TM38	Soluble Ion analysis using the Thermo Aquakem Photometric Automatic Analyser. Modified US EPA methods 325.2, 375.4, 365.2, 353.1, 354.1	PM0	No preparation is required.				
TM38	Soluble Ion analysis using the Thermo Aquakem Photometric Automatic Analyser. Modified US EPA methods 325.2, 375.4, 365.2, 353.1, 354.1	PM0	No preparation is required.	Yes			
TM59	Determination of Dissolved Oxygen using the Hach HQ30D Oxygen Meter	PM0	No preparation is required.				
TM60	Modified USEPA 9060. Determination of TOC by calculation from Total Carbon and Inorganic Carbon using a TOC analyser, the carbon in the sample is converted to CO2 and then passed through a non-dispersive infrared gas analyser (NDIR).	PM0	No preparation is required.	Yes			
TM73	Modified US EPA methods 150.1 and 9045D and BS1377:1990. Determination of pH by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			
TM75	Modified US EPA method 310.1. Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.				
TM75	Modified US EPA method 310.1. Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.	Yes			

JE Job No: 18/5875

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM76	Modified US EPA method 120.1. Determination of Specific Conductance by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			
TM89	Modified USEPA method OIA-1667. Determination of cyanide by Flow Injection Analyser. Where WAD cyanides are required a Ligand displacement step is carried out before analysis.	PM0	No preparation is required.	Yes			
TM149	Determination of Pesticides by Large Volume Injection on GC Triple Quad MS, based upon USEPA method 8270	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM173	Analysis of fluoride by ISE (Ion Selective Electrode) using modified ISE method 340.2	PM0	No preparation is required.				
NONE	No Method Code	NONE	No Method Code				

Exova Jones Environmental

Registered Address : Exova (UK) Ltd, Lochend Industrial Estate, Newbridge, Midlothian, EH28 8PL

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AECOM
Scott House
Alencon Link
Basingstoke
RG21 7PP

Attention :	
Date :	16th March, 2018
Your reference :	A303
Our reference :	Test Report 18/3587 Batch 1
Location :	A303
Date samples received :	10th March, 2018
Status :	Final report
Issue :	1

Two samples were received for analysis on 10th March, 2018 of which two were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Compiled By:

[redacted]

Simon Gomery BSc
Project Manager

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/3587

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16			
Sample ID	RX513A	RX514A			
Depth					
COC No / misc					
Containers	V H HN N P G	V H HN N P G			
Sample Date	08/03/2018 11:45	08/03/2018 14:35			
Sample Type	Effluent	Effluent			
Batch Number	1	1	LOD/LOR	Units	Method No.
Date of Receipt	10/03/2018	10/03/2018			
Dissolved Antimony	<2	<2	<2	ug/l	TM30/PM14
Dissolved Arsenic	<2.5	<2.5	<2.5	ug/l	TM30/PM14
Dissolved Beryllium	<0.5	<0.5	<0.5	ug/l	TM30/PM14
Dissolved Boron	16	<12	<12	ug/l	TM30/PM14
Dissolved Cadmium	<0.5	<0.5	<0.5	ug/l	TM30/PM14
Dissolved Calcium	108.6	105.4	<0.2	mg/l	TM30/PM14
Total Dissolved Chromium	<1.5	<1.5	<1.5	ug/l	TM30/PM14
Dissolved Copper	<7	<7	<7	ug/l	TM30/PM14
Dissolved Lead	<5	<5	<5	ug/l	TM30/PM14
Dissolved Magnesium	1.3	1.9	<0.1	mg/l	TM30/PM14
Dissolved Manganese	<2	<2	<2	ug/l	TM30/PM14
Dissolved Mercury	<1	<1	<1	ug/l	TM30/PM14
Dissolved Molybdenum	<2	<2	<2	ug/l	TM30/PM14
Dissolved Nickel	<2	<2	<2	ug/l	TM30/PM14
Dissolved Phosphorus	6	7	<5	ug/l	TM30/PM14
Dissolved Potassium	0.3	0.3	<0.1	mg/l	TM30/PM14
Dissolved Selenium	<3	<3	<3	ug/l	TM30/PM14
Dissolved Sodium	6.3	6.1	<0.1	mg/l	TM30/PM14
Dissolved Zinc	3	<3	<3	ug/l	TM30/PM14
Total Cadmium	<0.5	<0.5	<0.5	ug/l	TM30/PM14
Total Copper	<7	<7	<7	ug/l	TM30/PM14
Total Iron	571	7436	<20	ug/l	TM30/PM14
Total Phosphorus	124	909	<5	ug/l	TM30/PM14
Total Zinc	6	32	<3	ug/l	TM30/PM14

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/3587

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=HNO_3

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16			
Sample ID	RX513A	RX514A			
Depth					
COC No / misc					
Containers	V H HN N P G	V H HN N P G			
Sample Date	08/03/2018 11:45	08/03/2018 14:35			
Sample Type	Effluent	Effluent			
Batch Number	1	1	LOD/LOR	Units	Method No.
Date of Receipt	10/03/2018	10/03/2018			
PAH MS					
Naphthalene	<0.1	<0.1	<0.1	ug/l	TM4/PM30
Acenaphthylene	<0.013	<0.013	<0.013	ug/l	TM4/PM30
Acenaphthene	<0.013	<0.013	<0.013	ug/l	TM4/PM30
Fluorene	<0.014	<0.014	<0.014	ug/l	TM4/PM30
Phenanthrene	<0.011	<0.011	<0.011	ug/l	TM4/PM30
Anthracene	<0.013	<0.013	<0.013	ug/l	TM4/PM30
Fluoranthene	<0.012	<0.012	<0.012	ug/l	TM4/PM30
Pyrene	<0.013	<0.013	<0.013	ug/l	TM4/PM30
Benzo(a)anthracene	<0.015	<0.015	<0.015	ug/l	TM4/PM30
Chrysene	<0.011	<0.011	<0.011	ug/l	TM4/PM30
Benzo(bk)fluoranthene	<0.018	<0.018	<0.018	ug/l	TM4/PM30
Benzo(a)pyrene	<0.016	<0.016	<0.016	ug/l	TM4/PM30
Indeno(123cd)pyrene	<0.011	<0.011	<0.011	ug/l	TM4/PM30
Dibenzo(ah)anthracene	<0.01	<0.01	<0.01	ug/l	TM4/PM30
Benzo(ghi)perylene	<0.011	<0.011	<0.011	ug/l	TM4/PM30
PAH 16 Total	<0.195	<0.195	<0.195	ug/l	TM4/PM30
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	ug/l	TM4/PM30
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	ug/l	TM4/PM30
PAH Surrogate % Recovery	79	88	<0	%	TM4/PM30

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/3587

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
$H=H_2SO_4$, Z=ZnAc, N=NaOH, $HN=HNO_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16			
Sample ID	RX513A	RX514A			
Depth					
COC No / misc					
Containers	V H HN N P G	V H HN N P G			
Sample Date	08/03/2018 11:45	08/03/2018 14:35			
Sample Type	Effluent	Effluent			
Batch Number	1	1	LOD/LOR	Units	Method No.
Date of Receipt	10/03/2018	10/03/2018			
Pesticides					
Organophosphorus Pesticides					
Azinphos ethyl	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Azinphos methyl	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Carbophenothion	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Chlorfenvinphos	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Chlorpyrifos	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Chlorpyrifos-methyl	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Diazinon	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Dichlorvos	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Disulfoton	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Dimethoate	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Ethion	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Ethyl Parathion (Parathion)	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Etrimphos	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Fenitrothion	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Fenthion	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Malathion	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Methyl Parathion	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Mevinphos	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Phosalone	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Pirimiphos Methyl	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Propetamphos	<0.01	<0.01	<0.01	ug/l	TM149/PM30
Triazophos	<0.01	<0.01	<0.01	ug/l	TM149/PM30
TPH CWG					
Aliphatics					
>C5-C6	<10	<10	<10	ug/l	TM36/PM12
>C6-C8	<10	<10	<10	ug/l	TM36/PM12
>C8-C10	<10	<10	<10	ug/l	TM36/PM12
>C10-C12	<5	<5	<5	ug/l	TM5/PM30
>C12-C16	<10	<10	<10	ug/l	TM5/PM30
>C16-C21	<10	<10	<10	ug/l	TM5/PM30
>C21-C35	<10	<10	<10	ug/l	TM5/PM30
Total aliphatics C5-35	<10	<10	<10	ug/l	TM5/TM36/PM30/PM12

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/3587

Report : Liquid

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16	LOD/LOR	Units	Method No.
Sample ID	RX513A	RX514A			
Depth					
COC No / misc					
Containers	V H HN N P G	V H HN N P G			
Sample Date	08/03/2018 11:45	08/03/2018 14:35			
Sample Type	Effluent	Effluent			
Batch Number	1	1			
Date of Receipt	10/03/2018	10/03/2018			
TPH CWG					
Aromatics					
>C5-EC7	<10	<10	<10	ug/l	TM36/PM12
>EC7-EC8	<10	<10	<10	ug/l	TM36/PM12
>EC8-EC10	<10	<10	<10	ug/l	TM36/PM12
>EC10-EC12	<5	<5	<5	ug/l	TM5/PM30
>EC12-EC16	<10	<10	<10	ug/l	TM5/PM30
>EC16-EC21	<10	<10	<10	ug/l	TM5/PM30
>EC21-EC35	<10	<10	<10	ug/l	TM5/PM30
Total aromatics C5-35	<10	<10	<10	ug/l	TM5/TM36/PM30/PM12
Total aliphatics and aromatics(C5-35)	<10	<10	<10	ug/l	TM5/TM36/PM30/PM12
MTBE	<5	<5	<5	ug/l	TM31/PM12
Benzene	<5	<5	<5	ug/l	TM31/PM12
Toluene	<5	<5	<5	ug/l	TM31/PM12
Ethylbenzene	<5	<5	<5	ug/l	TM31/PM12
m/p-Xylene	<5	<5	<5	ug/l	TM31/PM12
o-Xylene	<5	<5	<5	ug/l	TM31/PM12
PCB 28	<0.1	<0.1	<0.1	ug/l	TM17/PM30
PCB 52	<0.1	<0.1	<0.1	ug/l	TM17/PM30
PCB 101	<0.1	<0.1	<0.1	ug/l	TM17/PM30
PCB 118	<0.1	<0.1	<0.1	ug/l	TM17/PM30
PCB 138	<0.1	<0.1	<0.1	ug/l	TM17/PM30
PCB 153	<0.1	<0.1	<0.1	ug/l	TM17/PM30
PCB 180	<0.1	<0.1	<0.1	ug/l	TM17/PM30
Total 7 PCBs	<0.7	<0.7	<0.7	ug/l	TM17/PM30
Total Phenols HPLC	<0.15	<0.15	<0.15	mg/l	TM26/PM0
Fluoride	<0.3	<0.3	<0.3	mg/l	TM173/PM0
Sulphate as SO4	23.8	22.0	<0.5	mg/l	TM38/PM0
Chloride	20.5	19.6	<0.3	mg/l	TM38/PM0
Nitrate as NO3	75.1	50.1	<0.2	mg/l	TM38/PM0
Nitrite as NO2	<0.02	<0.02	<0.02	mg/l	TM38/PM0
MRP Ortho Phosphate as P	<0.03	0.56	<0.03	mg/l	TM38/PM0
SRP Ortho Phosphate as PO4	<0.06	<0.06	<0.06	mg/l	TM38/PM0
Free Cyanide	<0.01	<0.01	<0.01	mg/l	TM89/PM0
Total Cyanide	<0.01	<0.01	<0.01	mg/l	TM89/PM0
Ammoniacal Nitrogen as N	0.03	0.04	<0.03	mg/l	TM38/PM0
Hexavalent Chromium	<6	<6	<6	ug/l	TM38/PM0

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/3587

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
$H=H_2SO_4$, Z=ZnAc, N=NaOH, $HN=HN0_3$

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8	9-16									LOD/LOR	Units	Method No.
Sample ID	RX513A	RX514A											
Depth													
COC No / misc													
Containers	V H HN N P G	V H HN N P G											
Sample Date	08/03/2018 11:45	08/03/2018 14:35											
Sample Type	Effluent	Effluent											
Batch Number	1	1											
Date of Receipt	10/03/2018	10/03/2018											
Total Dissolved Chromium III	<6	<6									<6	ug/l	NONE/NONE
Total Alkalinity as CaCO3	302	410									<1	mg/l	TM75/PM0
Carbonate Alkalinity as CaCO3	<1	<1									<1	mg/l	TM75/PM0
Bicarbonate Alkalinity as CaCO3 (water soluble)	302	410									<1	mg/l	TM75/PM0
Dissolved Oxygen	10	10									<1	mg/l	TM59/PM0
Dissolved Organic Carbon	<2	<2									<2	mg/l	TM60/PM0
Electrical Conductivity @25C	567	520									<2	uS/cm	TM76/PM0
pH	7.05	7.18									<0.01	pH units	TM73/PM0
Total Dissolved Solids	337	396									<35	mg/l	TM20/PM0
Turbidity	814.0	4230.0$_{AA}$									<0.1	NTU	TM34/PM0

Exova Jones Environmental

Client Name: AECOM
Reference: A303
Location: A303
Contact:
JE Job No.: 18/3587

Report : **Misc**

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-8										LOD/LOR	Units	Method No.
Sample ID	RX513A												
Depth													
COC No / misc													
Containers	V H HN N P G												
Sample Date	08/03/2018 11:45												
Sample Type	Effluent												
Batch Number	1												
Date of Receipt	10/03/2018												
Sample Temperature	7.5										<0.1	Degrees C	NONE/NONE

Client Name: AECOM
Reference: A303
Location: A303
Contact:

J E Job No.	Batch	Sample ID	Depth	J E Sample No.	Analysis	Reason
No deviating sample report results for job 18/3587						

Please note that only samples that are deviating are mentioned in this report. If no samples are listed it is because none were deviating.
Only analyses which are accredited are recorded as deviating if set criteria are not met.

NOTES TO ACCOMPANY ALL SCHEDULES AND REPORTS

JE Job No.: 18/3587

SOILS

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

The calculation of Pyrite content assumes that all oxidisable sulphides present in the sample are pyrite. This may not be the case. The calculation may be an overesitimate when other sulphides such as Barite (Barium Sulphate) are present.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 accreditation applies to surface water and groundwater and usually one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

DEVIATING SAMPLES

Samples must be received in a condition appropriate to the requested analyses. All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. If this is not the case you will be informed and any test results that may be compromised highlighted on your deviating samples report.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

BLANKS

Where analytes have been found in the blank, the sample will be treated in accordance with our laboratory procedure for dealing with contaminated blanks.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.
Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

REPORTS FROM THE SOUTH AFRICA LABORATORY

Any method number not prefixed with SA has been undertaken in our UK laboratory unless reported as subcontracted.

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS Ref No. 4225) accredited - UK.
SA	ISO17025 (SANAS Ref No.T0729) accredited - South Africa.
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
++	Result outside calibration range, results should be considered as indicative only and are not accredited.
*	Analysis subcontracted to a Jones Environmental approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range
AA	x10 Dilution

JE Job No: 18/3587

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM4	Modified USEPA 8270 method for the solvent extraction and determination of 16 PAHs by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM5	Modified USEPA 8015B method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) with carbon banding within the range C8-C40 GC-FID.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM5/TM36	please refer to TM5 and TM36 for method details	PM30/PM12	CWG GC-FID				
TM17	Modified US EPA method 8270. Determination of specific Polychlorinated Biphenyl congeners by GC-MS.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM20	Modified BS 1377-3: 1990/USEPA 160.3 Gravimetric determination of Total Dissolved Solids/Total Solids	PM0	No preparation is required.				
TM26	Determination of phenols by Reversed Phased High Performance Liquid Chromatography and Electro-Chemical Detection.	PM0	No preparation is required.				
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7, 6010B and BS EN ISO 11885 2009	PM14	Analysis of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for dissolved metals and acidified if required.				
TM31	Modified USEPA 8015B. Determination of Methyltertbutylether, Benzene, Toluene, Ethylbenzene and Xylene by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.				
TM34	Turbidity by 2100P Turbidity Meter	PM0	No preparation is required.				
TM36	Modified US EPA method 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C4-12 by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.				

JE Job No: 18/3587

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM38	Soluble Ion analysis using the Thermo Aquakem Photometric Automatic Analyser. Modified US EPA methods 325.2, 375.4, 365.2, 353.1, 354.1	PM0	No preparation is required.				
TM59	Determination of Dissolved Oxygen using the Hach HQ30D Oxygen Meter	PM0	No preparation is required.				
TM60	Modified USEPA 9060. Determination of TOC by calculation from Total Carbon and Inorganic Carbon using a TOC analyser, the carbon in the sample is converted to CO2 and then passed through a non-dispersive infrared gas analyser (NDIR).	PM0	No preparation is required.				
TM73	Modified US EPA methods 150.1 and 9045D and BS1377:1990. Determination of pH by Metrohm automated probe analyser.	PM0	No preparation is required.				
TM75	Modified US EPA method 310.1. Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.				
TM76	Modified US EPA method 120.1. Determination of Specific Conductance by Metrohm automated probe analyser.	PM0	No preparation is required.				
TM89	Modified USEPA method OIA-1667. Determination of cyanide by Flow Injection Analyser. Where WAD cyanides are required a Ligand displacement step is carried out before analysis.	PM0	No preparation is required.				
TM149	Determination of Pesticides by Large Volume Injection on GC Triple Quad MS, based upon USEPA method 8270	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.				
TM173	Analysis of fluoride by ISE (Ion Selective Electrode) using modified ISE method 340.2	PM0	No preparation is required.				
NONE	No Method Code	NONE	No Method Code				

A303 Amesbury to Berwick Down

Qualitative Risk Assessment

Appendix 11.4: Annex 5

AECOM, Mace, WSP

11 September 2018

Table E - 1 **Qualitative Risk Assessment – Winterbourne Stoke Bypass Section**

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Description of Magnitude	Risk of Impact following Embedded mitigation	Significance of Effect
C01	S1	Excavations and deposition of soils, sediment or other construction materials causing pollution	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Moderately Likely	Use of excavated material will take place for embankments, and new chalk grassland habitats, with Construction compounds and storage of spoil in the area	Negligible	With the use of the 0EMP, and required material testing to confirm concentrations there will be no measureable impact on the receptor quality	Low	Neutral
					R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	The excavation and deposition is not taking place in the vicinity of abstractions with published SPZ.	Negligible	No impact anticipated	Very Low	Neutral
					R4	River Till	Very High	Moderately Likely	Use of excavated material for embankments at Till Viaduct	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	The excavation and deposition is not taking place in the vicinity of communities with reported historical flooding	Negligible	No impact anticipated	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Moderately Likely	Use of excavated material for embankments at Till Viaduct	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Moderately Likely	Use of excavated material will take place for new chalk grassland habitats in vicinity of dry valley.	Negligible	With the use of the OEMP, and required mater-ial testing to confirm concentrations there will be no measureable impact on the receptor quality	Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	Excavations and the deposition of material is not taking place within the SPZ1 (nominal 50 m) of any licensed private abstraction	Negligible	No impact anticipated	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	The excavation and deposition is not taking place in the vicinity of receptor	Negligible	No impact anticipated	Very Low	Neutral
					R14	Environment Agency Monitoring boreholes	Medium	Very unlikely	The excavation and deposition is not taking place in the vicinity of receptor	Negligible	No impact anticipated	Very Low	Neutral
			P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R4	River Till	Very High	Remote	Down hydraulic gradient of use of excavated material for embankments at Till Viaduct, and and new chalk grassland habitats	Negligible no	With the use of the OEMP there will be measureable impact in the receptor quality	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Very unlikely	Down hydraulic gradient of use of excavated material for embankments at Till Viaduct	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	Down hydraulic gradient of use of excavated material for new chalk grassland habitats	Negligible	With the use of the OEMP, and required mater-ial testing to confirm concentrations there will be no measureable impact on the receptor quality	Very Low	Neutral
			P3	Change in groundwater flow direction within the aquifer due to abstraction or dewatering activities	R4	River Till	Very High	Remote	Any dewatering required for the construction of the River Till Viaduct Piers will be localised and temporary, with groundwater returned to the aquifer and as such risk of pollutants reaching River is low	Negligible	With the use of the CEMP there will be no measureable impact on the receptor quality	Very Low	Neutral

C - Construction Impact
O - Operational Impact

S - Source
P - Pathway
R - Receptor

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Description of Magnitude	Risk of Impact following Embedded mitigation	Significance of Effect
C02	S2	Spillage of fuels or other contaminating liquids	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Likely	Construction is occuring into the Chalk unsaturated zone, and saturated zone	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	No construction is occurring within the close vicinity of any published SPZ	Negligible	No impact anticipated	Very Low	Neutral
					R4	River Till	Very High	Moderately Likely	Construction is occurring in the vicinity of the receptor	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	Constuction is not taking place in the vicinity of communities with reported historical flooding	Negligible	No impact anticipated	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Moderately Likely	Construction is occurring in the vicinity of the receptor	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Moderately Likely	Construction is occurring in the vicinity of the receptor	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Likely	No construction is occuring within the SPZ1 of the pending EA licence borehole Manor Farm well 4, which is considered as the nominal SPZ for this abstraction.	Negligible	With the use of the EMP there will be no measureable impact on the receptor quality	Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	No construction is occurring within the close vicinity of any receptor	Negligible	No impact anticipated	Very Low	Neutral
					R14	Environment Agency Monitoring boreholes	Medium	Likely	The road structure close to the Berwick Down A303 monitoring borehole will be adjusted north of the borehole, with landscaping in the vicinity.	Minor Adverse	With the use of the EMP there will be no measureable impact on the receptor quality	Medium	Slight Adverse
			P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R4	River Till	Very High	Remote	Construction is occurring in the vicinity of the receptor	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Remote	Construction is occurring up hydraulic gradient of receptors	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Remote	Construction is occurring up hydraulic gradient of receptors	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	Construction is occurring up hydraulic gradient of receptors but not within nominal SPZ1.	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	Construction is occurring up hydraulic gradient of receptors	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R14	Environment Agency Monitoring boreholes	Medium	Moderately Likely	The road structure close to the Berwick Down A303 monitoring borehole will be adjusted north of the borehole, with landscaping in the vicinity.	Negligible	With the use of the EMP there will be no measureable impact on the receptor quality	Low	Neutral
			P3	Change in groundwater flow direction within the aquifer due to abstraction or dewatering activities	R4	River Till	Very High	Very unlikely	Dewatering undertaken for construction of River Till Viaduct will collect any spills occuring	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
			P4	Preferential flow pathways created by the construction of foundations for structures	R1	Principal Chalk Aquifer	Very High	Likely	Piles are likely to extend below groundwater levels.	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and the use of the OEMP there will be no measureable impact on the re-ceptor quality	Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Likely	Foundations and piles will be present in receptor	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and the use of the OEMP there will be no measureable impact on the re-ceptor quality	Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Very unlikely	Foundations are not proposed in the vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral

C - Construction Impact
O - Operational Impact

S - Source
P - Pathway
R - Receptor

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Description of Magnitude	Risk of Impact following Embedded mitigation	Significance of Effect
C03	S3	Mobilisation of contaminants following disturbance of contaminated ground or groundwater, or through uncontrolled site runoff	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Remote	Construction is occurring in the vicinity of the receptor but no potentially contaminated ground is present	Negligible	No impact anticipated	Very Low	Neutral
					R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	No construction is occurring within the close vicinity of any published SPZ	Negligible	No impact anticipated	Very Low	Neutral
					R4	River Till	Very High	Remote	Construction is occurring in the vicinity of the receptor but no potentially contaminated ground is	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality.	Very Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	No construction is occurring within the close vicinity of any receptor	Negligible	No impact anticipated	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Remote	Construction is occurring in the vicinity of the receptor but no potentially contaminated ground is present	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality.	Very Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Remote	Construction is occurring in the vicinity of the receptor but no potentially contaminated ground is likely to be intercepted	Negligible	With the use of the CEMP there will be no measureable impact on the receptor quality.	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Very unlikely	No construction is occuring within the SPZ1 of the pending EA licence borehole Manor Farm well 4, which is considered as the nominal SPZ for this abstraction.	Negligible	No impact anticipated	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	No construction is occurring in the vincinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R14	Environment Agency Monitoring boreholes	Medium	Remote	Construction is occurring in the vicinity of the receptor but no potentially contaminated ground is likely to be intercepted	Negligible	With the use of the EMP there will be no measureable impact on the receptor quality.	Very Low	Neutral
			P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R4	River Till	Very High	Very unlikely	Construction is occurring in the vicinity of the receptor but no potentially contaminated ground is present	Negligible	No impact anticipated	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Very unlikely	Down hydraulic gradient of construction but no potentially contaminated ground is present	Negligible	No impact anticipated	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	Down hydraulic gradient of construction but no potentially contaminated ground is present	Negligible	No impact anticipated	Very Low	Neutral
			P3	Change in groundwater flow direction within the aquifer due to abstraction or dewatering activities	R4	River Till	Very High	Very unlikely	Construction is occuring in vicinity of the receptor requiring dewatering activities but there are not anticipated to contaminative land uses present	Negligible	No impact anticipated	Very Low	Neutral
			P4	Preferential flow pathways created by the construction of foundations for structures	R1	Principal Chalk Aquifer	Very High	Very unlikely	Construction is occurring in the receptor but but no potentially contaminated ground is likely to be intercepted	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and the use of the OEMP there will be no measureable impact on the re-ceptor quality	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Very unlikely	Construction is occurring in the receptor but but no potentially contaminated ground is likely to be intercepted	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and the use of the OEMP there will be no measureable impact on the re-ceptor quality	Very Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Very unlikely	Construction is occurring in the receptor but but no potentially contaminated ground is likely to be intercepted	Negligible	No impact anticipated	Very Low	Neutral
C04	S5	Temporary dewatering or abstraction reducing groundwater level or flow	P3	Change in groundwater flow direction within the aquifer due to abstraction or dewatering activities	R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	No dewatering activities are occurring within the close vicinity of any published SPZ	Negligible	No impact anticipated	Very Low	Neutral
					R4	River Till	Very High	Moderately Likely	Dewatering activities may be required for construction of the River Till viaduct depending on water levels at time of foundation constuction.	Negligible measureable	use of the OEMP there will be no impact on the receptor.	Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	No dewatering activities are required for construction in the vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	Dewatering activities may be required for construction of the River Till viaduct up hydraulic gradient of a receptor.	Negligible	Influence of dewatering is not anticipated to extend to the receptor.	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	No dewatering activities are required for construction in the vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R14	Environment Agency Monitoring boreholes	Medium	Very unlikely	No dewatering activities are required for construction in the vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
C05	S6	Presence of underground structures (foundations, peirs or cables) that could cause interference to groundwater flow	P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	No structures are proposed within the close vicinity of any published SPZ	Negligible	No impact anticipated	Very Low	Neutral
					R4	River Till	Very High	Moderately Likely	Foundations and piles are present within close vicinity of the receptor that will impede groundwater flow in either superficial deposits or the underlying Chalk aquifer	Negligible	Impact is expected to be localised around structures and no measurable impact observed	Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R14	Environment Agency Monitoring boreholes	Medium	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral

C - Construction Impact
O - Operational Impact

S - Source
P - Pathway
R - Receptor

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Description of Magnitude	Risk of Impact following Embedded mitigation	Significance of Effect
O01	S8	Pollutants from spillages or road maintenance to increases in discharge to ground	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Likely	Receptor underlies existing A303 drainage and proposed drainage system infiltration basins	Negligible	HEWRAT assessment for proposed drainage scheme has shown an improvement in existing spillage risk, but not sufficient to be of minor benefit.	NA	Neutral
					R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	No drainage occurs in vicinity of receptor	Negligible	No impact anticipated	NA	Neutral
					R4	River Till	Very High	Likely	Receptor is close to existing A303 drainage system and down hydraulic gradient of proposed infiltration basins	Negligible	HEWRAT assessment for proposed drainage scheme has shown an improvement in existing spillage risk, but not sufficient to be of minor benefit.	NA	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Likely	Receptor is close to existing A303 drainage system and down hydraulic gradient of proposed infiltration basins	Negligible	HEWRAT assessment for proposed drainage scheme has shown an improvement in existing spillage risk, but not sufficient to be of minor benefit.	NA	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Likely	Receptor is close to existing A303 drainage system and down hydraulic gradient of proposed infiltration basins	Negligible	HEWRAT assessment for proposed drainage scheme has shown an improvement in existing spillage risk, but not sufficient to be of minor benefit.	NA	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Likely	Receptor is close to existing A303 drainage system and down hydraulic gradient of proposed infiltration basins	Negligible	HEWRAT assessment for proposed drainage scheme has shown an improvement in existing spillage risk, but not sufficient to be of minor benefit.	NA	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Likely	Receptor is close to existing A303 drainage system and down hydraulic gradient of proposed infiltration basins	Negligible	HEWRAT assessment for proposed drainage scheme has shown an improvement in existing spillage risk, but not sufficient to be of minor benefit.	NA	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Likely	Receptor is close to existing A303 drainage system	Negligible	No impact anticipated	NA	Neutral
					R14	Environment Agency Monitoring boreholes	Medium	Likely	Receptor is close to existing A303 drainage system	Minor Beneficial	Road drainage is to be improved in this area of the A303 such that spills will not reach this borehole. The road drainage improvement will have a positive impact on this receptor.	NA	Slight Beneficial

C - Construction Impact
O - Operational Impact

S - Source
P - Pathway
R - Receptor

Table E- 2 **Qualitative Risk Assessment – Longbarrow Junction Section**

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Description of Magnitude	Risk of Impact following Embedded mitigation	Significance of Effect
C01	S1	Excavations and deposition of soils, sediment or other construction materials causing pollution	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Moderately Likely	Excavations will be undertaken for the construction of the Longbarrow Junction, with Construction compounds and storage of spoil in the area	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality	Low	Neutral
					R4	River Till	Very High	Very unlikely	The section lies within the catchment of the River Till.	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Very unlikely	The licensed abstraction at the Stonehenge Visitors centre is up hydraulic gradient and the works are distant to the source	Negligible	No impact anticipated	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Very unlikely	The section lies within the catchment of the River Till.	Negligible	No impact anticipated	Very Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Very unlikely	The section lies within the catchment of the River Till.	Negligible	No impact anticipated	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	No excavations or deposition of material is to be carried out within 50m of the pending EA licence borehole Manor Farm well 3, which is considered as the nominal SPZ for this abstraction.	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	Excavation and deposition is not taking place in the vicinity of receptor	Negligible	No impact anticipated	Very Low	Neutral
			P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R4	River Till	Very High	Very unlikely	The section lies within the catchment of the River Till.	Negligible	No impact anticipated	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	No excavations or deposition of material is to be carried out within 50m of the pending EA licence borehole Manor Farm well 3, which is considered as the nominal SPZ for this abstraction.	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality	Very Low	Neutral
			P3	Change in groundwater flow direction within the aquifer due to abstraction or dewatering activities	R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	The pending EA licence borehole Manor Farm well 3 is a local abstraction, and as such is abstracing in the area. No excavations or deposition of material is to be carried out within 50m of the well. No dewatering activities are anticipated but the receptor would need to be considered for any abstraction for water supply at the construction compounds	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality	Very Low	Neutral
C02	S2	Spillage of fuels or other contaminating liquids	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Likely	Construction is occuring into the Chalk unsaturated zone	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R4	River Till	Very High	Very unlikely	The section lies within the catchment of the River Till.	Negligible	No impact anticipated	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Very unlikely	The licensed abstraction at the Stonehenge Visitors centre is up hydraulic gradient and the works are distant to the source	Negligible	No impact anticipated	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Very unlikely	The section lies within the catchment of the River Till.	Negligible	No impact anticipated	Very Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Very unlikely	The section lies within the catchment of the River Till.	Negligible	No impact anticipated	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Likely	The chalk spoil storage at the construction compound area at the new Longbarrow Junction is located within 50m of the pending EA licence borehole Manor Farm well 3, which is considered as the nominal SPZ for this abstraction. As such there is potential for spillage of fuels from vehicles during the storage period to be released to ground.	Minor Adverse	No material will be placed within 50m of the borehole, with an exclusion zone applied during the selection of the area to be utilised. The measures in the OEMP will reduce the risk by collecting any spills within the construction area.	Medium	Slight Adverse
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	No construction is occurring within the close vicinity of any receptor	Negligible	No impact anticipated	Very Low	Neutral
			P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R4	River Till	Very High	Remote	Construction is occurring in the vicinity of the receptor	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Remote	Work to be completed will be outside of the SPZ2 (nominal distance of 250m) for the licensed abstraction at the Stonehenge Visitors centre.	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Moderately Likely	The chalk spoil storage at the construction compound area at the new Longbarrow Junction is located within 50m of the pending EA licence borehole Manor Farm well 3, which is considered as the nominal SPZ for this abstraction. As such there is potential for spillage of fuels from vehicles during the storage period to be released to ground.	Negligible	No material will be placed within 50m of the borehole, with an exclusion zone applied during the selection of the area to be utilised. The measures in the OEMP will reduce the risk by collecting any spills within the construction area.	Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Remote	Work to be completed will be outside of the SPZ2 (nominal distance of 250m) of any receptor.	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
			P3	Change in groundwater flow direction within the aquifer due to abstraction or dewatering activities	R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	The pending EA licence borehole Manor Farm well 3 is a local abstraction, and as such is abstracing in the area. No dewatering activities are anticipated but the receptor would need to be considered for any abstraction for water supply at the construction compounds.	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality	Very Low	Neutral
			P4	Preferential flow pathways created by the construction of foundations for structures	R1	Principal Chalk Aquifer	Very High	Moderately Likely	Piles are likely to extend below average high groundwater levels for Bridges.	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and the use of the OEMP there will be no measureable impact on the re-ceptor quality	Low	Neutral

C - Construction Impact
O - Operational Impact

S - Source
P - Pathway
R - Receptor

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Description of Magnitude	Risk of Impact following Embedded mitigation	Significance of Effect
C03	S3	Mobilisation of contaminants following disturbance of contaminated ground or groundwater, or through uncontrolled site runoff	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Moderately Likely	Construction of the Longbarrow junction is occurring in the location of a historical land use with potential for contamination	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality. The cuttings are not predicted to encounter ground-water.	Low	Neutral
					R4	River Till	Very High	Remote	The section lies within the catchment of the River Till.	Negligible	No impact anticipated	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Very unlikely	Work to be completed will be outside of the SPZ2 (nominal distance of 250m) for the licensed abstraction at the Stonehenge Visitors centre, and no land use with potential for contamination identified.	Negligible	No impact anticipated	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Very unlikely	The section lies within the catchment of the River Till.	Negligible	No impact anticipated	Very Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Very unlikely	The section lies within the catchment of the River Till.	Negligible	No impact anticipated	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Very unlikely	No construction likely to disturb contaminated ground to be undertaken within SPZ1 of receptor, no land use with potential for contamination identified	Negligible	No impact anticipated	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	No construction is occurring in the vincinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
			P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R4	River Till	Very High	Very unlikely	The section lies within the catchment of the River Till.	Negligible	No impact anticipated	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Very unlikely	Receptor is located up hydraulic gradient of any construction likely to encounter contaminated ground.	Negligible	No impact anticipated	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Very unlikely	No groundwater is expected to be encountered by construction works	Negligible	No impact anticipated	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	No groundwater is expected to be encountered by construction works	Negligible	No impact anticipated	Very Low	Neutral
			P3	Change in groundwater flow direction within the aquifer due to abstraction or dewatering activities	R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	The pending EA licence borehole Manor Farm well 3 is a local abstraction, and as such is abstracting in the area. No dewatering activities are anticipated but the receptor would need to be considered for any abstraction for water supply at the construction compounds.	Negligible	No impact anticipated	Very Low	Neutral
			P4	Preferential flow pathways created by the construction of foundations for structures	R1	Principal Chalk Aquifer	Very High	Moderately Likely	Piles are likely to extend below average high groundwater levels for Bridges in an area of potentially contaminated land..	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and the use of the OEMP there will be no measureable impact on the re-ceptor quality	Low	Neutral
C06	S6	Presence of underground structures (foundations, peirs or cables) that could cause interference to groundwater flow	P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R4	River Till	Very High	Very unlikely	The section lies within the catchment of the River Till, but no structures are proposed within close proximity.	Negligible	No impact anticipated	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	The Green Bridge at Longbarrow Junction is at the edge of the nominal SPZ2 for the receptor. It will have pile structures extending below average high groundwater levels therefore could cause interferrence with flow, but will be localised.	Negligible	No impact anticipated	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
O01	S8	Pollutants from spillages or road maintenance to increases in discharge to ground	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Likely	Receptor underlies existing A303 drainage and proposed drainage system infiltration basins	Negligible	HEWRAT assessment for proposed drainage scheme has shown an improvement in existing spillage risk, but not sufficient to be of minor benefit.	NA	Neutral
					R4	River Till	Very High	Very unlikely	No drainage occurs in vicinity of receptor from section	Negligible	No impact anticipated	NA	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Moderately Likely	Receptor is close to existing A360 drainage system, but up or cross hydraulic gradient.	Negligible	The drainage scheme upgrade may bring some potential improvements but unlikely to be of minor benefit	NA	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Remote	No drainage occurs in vicinity of receptor from section	Negligible	No impact anticipated	NA	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Remote	No drainage occurs in vicinity of receptor from section	Negligible	No impact anticipated	NA	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Likely	Receptor is close to exisitng A303 and A360 drainage system. Receptor is located within 250 m of proposed Longbarrow roundabout	Negligible	Road drainage is to be improved in this area of the A303 to reduce impact from road drainage in the vicnity of the receptor. Drainage from roundabout is to be routed to DTA5, located down hydraulic gradient of the receptor. An improvement is expected, but this will not be of a significant nature. The HEWRAT assessment does not provide a minor benefit level improvement.	NA	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Likely	Receptor is down hydraulic gradient of exisitng A303 drainage system.	Negligible	Road drainage is to be improved in this area of the A303 to reduce impact from road drainage in the vicnity of the receptor. Drainage from roundabout is to be routed to DTA5, located up hydraulic gradient of the receptor. An improvement is expected, but this will not be of a significant nature. The HEWRAT assessment does not provide a minor benefit level improvement.	NA	Neutral

C - Construction Impact
O - Operational Impact

S - Source
P - Pathway
R - Receptor

Table E- 3 Qualitative Risk Assessment – Approaches to Portals and Twin-bore Tunnel Section

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Description of Magnitude	Risk of Impact following Embedded mitigation	Significance of Effect
C01	S1	Excavations and deposition of soils, sediment or other construction materials causing pollution	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Likely	Excavation of material is occurring in the unsaturated and saturated zones of the Chalk	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	The excavation is not taking place in the vicinity of any abstractions with published SPZ	Negligible	No impact anticipated	Very Low	Neutral
					R3	River Avon	Very High	Very unlikely	No construction is occurring in the vicinity of the receptor in this section	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R4	River Till	Very High	Very unlikely	No construction is occurring in the vicinity of the receptor in this section	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Very unlikely	No construction is occurring in the vicinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	No excavation is taking place in the vicinity of the receptors in this section	Negligible	No impact anticipated	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Very unlikely	No excavation is occurring in the vicinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R8	Springs near River Avon	High	Very unlikely	No excavation or deposition is taking place in the vicinity of the springs	Negligible	No impact anticipated	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Very unlikely	No excavation is occurring in the vicinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Moderately Likely	The excavation of material at Amesbury cutting may intercept the superficial deposits	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Very unlikely	No excavation is occurring in the vicinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	No excavation is occurring in the vicinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R13	Seasonal Springs	Medium	Very unlikely	No excavation is occurring in the vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
			P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R3	River Avon	Very High	Remote	The receptor is down hydraulic gradient of the Amesbury Cutting and approaches to Portals.	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R4	River Till	Very High	Very unlikely	The section is not located in the Till catchment	Negligible	No impact anticipated	Very Low	Neutral
					R5	Blick Mead Archaeological SitO	Very High	Remote	The receptor is down hydraulic gradient of the Amesbury Cutting.	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	The receptors are remote from the excavations	Negligible	No impact anticipated	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Remote	Receptors are located significant distance down hydraulic gradient of the approach to Western Portal	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R8	Springs near River Avon	High	Remote	The receptors are located down hydraulic gradient of the Amesbury Cutting and the approach to Eastern portal	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	Receptors are located significant distance down hydraulic gradient of the approach to Western Portal	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Remote	Receptors are located significant distance down hydraulic gradient of the approach to Western Portal	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R13	Seasonal Springs	Medium	Remote	The receptors are remote from the excavations	Negligible	No impact anticipated	Very Low	Neutral

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Description of Magnitude	Risk of Impact following Embedded mitigation	Significance of Effect
C02	S2	Spillage of fuels or other contaminating liquids	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Likely	Construction is occurring in the unsaturated and saturated zones of the Chalk	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	Construction is not taking place in the vicinity of any abstractions with published SPZ	Negligible	No impact anticipated	Very Low	Neutral
					R3	River Avon	Very High	Very unlikely	No construction is occurring in the vicinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R4	River Till	Very High	Very unlikely	No construction is occurring in the vicinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Very unlikely	No construction is occurring in the vicinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	No construction is taking place in the vicinity of the receptors in this section	Negligible	No impact anticipated	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Very unlikely	The receptor is a significant distance (1.9km) from any construction in this section	Negligible	No impact anticipated	Very Low	Neutral
					R8	Springs near River Avon	High	Very unlikely	The receptor is a significant distance from any construction in this section	Negligible	No impact anticipated	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Very unlikely	No construction is occurring in the vicinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Moderately Likely	The excavation of material at Amesbury cutting may intercept the superficial deposits	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	The receptor is a significant distance (2.5km) from any construction	Negligible	No impact anticipated	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Remote	The receptor is a significant distance (2.5km) from any construction	Negligible	No impact anticipated	Very Low	Neutral
					R13	Seasonal Springs	Medium	Remote	The receptor is a significant distance (1.9km) from any construction	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
			P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R3	River Avon	Very High	Remote	The receptor is down hydraulic gradient of the Amesbury Cutting and approaches to Portals.	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R4	River Till	Very High	Very unlikely	The section is not located in the Till catchment	Negligible	No impact anticipated	Very Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Remote	The receptor is down hydraulic gradient of the Amesbury Cutting.	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	The receptors are remote from construction	Negligible	No impact anticipated	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Remote	Receptors are located significant distance (Wilsford-Cum-Lake Borehole B is closest at 1.9km) down hydraulic gradient of the approach to Western Portal	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality	Very Low	Neutral
					R8	Springs near River Avon	High	Remote	The receptors are located down hydraulic gradient of the Amesbury Cutting and the approach to Eastern portal	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	Receptors are located a significant distance down hydraulic gradient of the approach to Western Portal	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Remote	Receptors are located a significant distance down hydraulic gradient of the approach to Western Portal	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R13	Seasonal Springs	Medium	Remote	The receptor (spring at Spring Bottom Farm) is a significant distance (1.9km) from any construction	Negligible	No impact anticipated	Very Low	Neutral
			P4	Preferential flow pathways created by the construction of foundations for structures	R1	Principal Chalk Aquifer	Very High	Remote	Piles for Green Bridge are likely to extend below average high groundwater levels.	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral

C - Construction Impact
O - Operational Impact

S - Source
P - Pathway
R - Receptor

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Description of Magnitude	Risk of Impact following Embedded mitigation	Significance of Effect
C03	S3	Mobilisation of contaminants following disturbance of contaminated ground or groundwater, or through uncontrolled site runoff	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Moderately Likely	Construction of the Green bridge 4, and the western portal are occurring in the location of a historical land use with potential for contamination	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality. No evidence of contaminated ground or groundwater in the area has been observed.	Low	Neutral
					R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	No construction is occurring within the close vicinity of any published SPZ	Negligible	No impact anticipated	Very Low	Neutral
					R3	River Avon	Very High	Moderately Likely	No construction is occurring in the vincinity of the receptor in this section	Negligible	No impact anticipated	Low	Neutral
					R4	River Till	Very High	Remote	No construction is occurring in the vincinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Very unlikely	No construction is occurring in the vincinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	No construction is occurring in the vincinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Very unlikely	No construction is occurring in the vincinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R8	Springs near River Avon	High	Very unlikely	No construction is occurring in the vincinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Very unlikely	No construction is occurring in the vicinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Remote	Construction is occurring in the vicinity of the receptor but no potentially contaminated ground is likely to be intercepted	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality.	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Very unlikely	No construction is occurring in the vicinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	No construction is occurring in the vicinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
					R13	Seasonal Springs	Medium	Very unlikely	No construction is occurring in the vicinity of the receptor in this section	Negligible	No impact anticipated	Very Low	Neutral
			P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R3	River Avon	Very High	Very unlikely	The receptor is down hydraulic gradient of the Amesbury Cutting and approaches to Portals, but no impact from potentially contaminated land use is anticipated.	Negligible	No impact anticipated	Very Low	Neutral
					R4	River Till	Very High	Very unlikely	The section is not located in the Till catchment	Negligible	No impact anticipated	Very Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Very unlikely	The receptor is down hydraulic gradient of the Amesbury Cutting, but no impact from potentially contaminated land use is anticipated.	Negligible	No impact anticipated	Very Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	The receptors are remote from the excavations likely to intercept contamination	Negligible	No impact anticipated	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Very unlikely	Receptors are located significant distance down hydraulic gradient of the approach to Western Portal	Negligible	No impact anticipated	Very Low	Neutral
					R8	Springs near River Avon	High	Very unlikely	The receptors are located down hydraulic gradient of the Amesbury Cutting and the approach to Eastern portal, but no impact from potentially contaminated land use is anticipated.	Negligible	No impact anticipated	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	Receptors are located significant distance (Wilsford-Cum-Lake, Borehole #A is closest at 2.5km) down hydraulic gradient of the approach to Western Portal	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality.	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Remote	Receptors are located significant distance (Wilsford-Cum-Lake, Borehole #A is closest at 2.5km) down hydraulic gradient of the approach to Western Portal	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality.	Very Low	Neutral
					R13	Seasonal Springs	Medium	Very unlikely	The receptors are remote from the excavations likely to intercept contamination	Negligible	No impact anticipated	Very Low	Neutral
			P4	Preferential flow pathways created by the construction of foundations for structures	R1	Principal Chalk Aquifer	Very High	Moderately Likely	Piles for Green Bridge four are likely to extend below average high groundwater levels, in an area of potentially contaminated land	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
C04	S4	Release or leaching of substances (cement, grout) used in tunnelling process	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Likely	Construction is occurring in receptor	Negligible	Construction methods and use of the OEMP there will be no measureable impact on the re-ceptor quality.	Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Moderately Likely	Construction could occur close to the receptor	Negligible	Construction methods and use of the OEMP there will be no measureable impact on the re-ceptor quality.	Low	Neutral
			P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	No construction is occurring within the close vicinity of any published SPZ	Negligible	No impact anticipated	Very Low	Neutral
					R3	River Avon	Very High	Very unlikely	The receptor is a significant distance from the source	Negligible	No impact anticipated	Very Low	Neutral
					R4	River Till	Very High	Very unlikely	The receptor is a significant distance from the source	Negligible	No impact anticipated	Very Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Very unlikely	The receptor is a significant distance from the source	Negligible	No impact anticipated	Very Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	The receptor is a significant distance from the source	Negligible	No impact anticipated	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Remote	Nearest down gradient receptor is 1.9km from tunnel	Negligible	Construction methods and use of the OEMP there will be no measureable impact on the receptor	Very Low	Neutral
					R8	Springs near River Avon	High	Very unlikely	The receptor is a significant distance from the source	Negligible	No impact anticipated	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	Nearest down gradient receptor (Wilsford-Cum-Lake, Borehole #A) is 2.5km from tunnel	Negligible	Construction methods and use of the OEMP there will be no measureable impact on the re-ceptor quality.	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Remote	Nearest down gradient receptor (Wilsford-Cum-Lake, Borehole #A) is 2.5km from tunnel	Negligible	Construction methods and use of the OEMP there will be no measureable impact on the receptor	Very Low	Neutral
					R13	Seasonal Springs	Medium	Remote	Nearest down gradient receptor is 1.9km from tunnel	Negligible	Construction methods and use of the OEMP there will be no measureable impact on the receptor	Very Low	Neutral

C - Construction Impact
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S - Source
P - Pathway
R - Receptor

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Description of Magnitude	Risk of Impact following Embedded mitigation	Significance of Effect
C05	S5	Temporary dewatering or abstraction reducing groundwater level or flow	P3	Change in groundwater flow direction within the aquifer due to abstraction or dewatering activities	R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	The receptors are a significant distance from the proposed tunnel. Any groundwater control required for cross passages will have localised effects only	Negligible	No impact anticipated	Very Low	Neutral
					R3	River Avon	Very High	Very unlikely	The receptor is a significant distance from the proposed tunnel, no groundwater is anticipated to be intercepted by the Amesbury cutting. Any groundwater control required for cross passages will have localised effects only	Negligible	No impact anticipated	Very Low	Neutral
					R4	River Till	Very High	Very unlikely	The receptor is a significant distance from the proposed tunnel. Any groundwater control required for cross passages will have localised effects only	Negligible	No impact anticipated	Very Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Very unlikely	The receptor is a significant distance from the proposed tunnel, no groundwater is anticipated to be intercepted by the Amesbury cutting. Any groundwater control required for cross passages will have localised effects only	Negligible	No impact anticipated	Very Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	The receptor is a significant distance from the proposed tunnel. Any groundwater control required for cross passages will have localised effects only	Negligible	No impact anticipated	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Remote	The receptor is a significant distance (1.9km) from the proposed tunnel. Any groundwater control required for cross passages will have localised effects only	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality	Very Low	Neutral
					R8	Springs near River Avon	High	Very unlikely	The receptor is a significant distance from the proposed tunnel, no groundwater is anticipated to be intercepted by the Amesbury cutting. Any groundwater control required for cross passages will have localised effects only	Negligible	No impact anticipated	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	The receptor is a significant distance (2.5km) from the proposed tunnel. Any groundwater control required for cross passages will have localised effects only	Negligible	No impact anticipated	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Remote	The receptor is a significant distance (2.5km) from the proposed tunnel. Any groundwater control required for cross passages will have localised effects only	Negligible	No impact anticipated	Very Low	Neutral
					R13	Seasonal Springs	Medium	Remote	The receptor (spring at Spring Bottom Farm) is a significant distance (1.9km) from the proposed tunnel. Any groundwater control required for cross passages will have localised effects only	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality	Very Low	Neutral
C05	S6	Presence of underground structures (foundations, peirs or cables) that could cause interference to groundwater flow	P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	No structures are proposed within the close vicinity of any published SPZ	Negligible	No impact anticipated	Very Low	Neutral
					R3	River Avon	Very High	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R4	River Till	Very High	Moderately Likely	The Green Bridge four will have pile structures extending below average high groundwater levels therefore could cause interference with flow, but this will be localised.	Negligible	No impact anticipated	Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R8	Springs near River Avon	High	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Very unlikely	The Green Bridge four will have pile structures extending below average high groundwater levels therefore could cause interference with flow, but this will be localised.	Negligible	No impact anticipated	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R13	Seasonal Springs	Medium	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral

C - Construction Impact
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S - Source
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ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Description of Magnitude	Risk of Impact following Embedded mitigation	Significance of Effect
C06	S7	Presence of the tunnel below groundwater level interfering with groundwater flow	P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Remote	Receptors within predicted zone of influence are up hydraulic gradient of tunnel	Negligible	The predicted increase in groundwater level up hydraulic gradient is not predicted to have a measurable impact on the operation of the abstraction during drought periods.	Very Low	Neutral
					R3	River Avon	Very High	Very unlikely	Receptors is not present in predicted zone of influence	Negligible	No measurable impact on flow is predicted	Very Low	Neutral
					R4	River Till	Very High	Very unlikely	Receptors is not present in predicted zone of influence	Negligible	No measurable impact on flow is predicted	Very Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Remote	Receptor is at outskirts of predicted zone of influence	Negligible	No measurable impact is predicted	Very Low	Neutral
					R6	Communities that have reported historical groundwater flooding	Very High	Very unlikely	No receptors are present in predicted zone of influence	Negligible	No impact anticipated	Very Low	Neutral
					R7	Licensed Private Drinking Water abstractions	High	Moderately Likely	Receptors are present in the predicted zone of influence	Negligible	The predicted increase in groundwater level up hydraulic gradient, and decrease in level down hydraulic gradient is not predicted to have a measurable impact on the operation of the abstraction during drought periods.	Low	Neutral
					R8	Springs near River Avon	High	Remote	Receptors are present in the predicted zone of influence	Negligible	The predicted decrease in level down hydraulic gradient is not predicted to have a measurable impact on the receptor during drought periods.	Very Low	Neutral
					R11	Licensed groundwater abstractions for energy, industrial or commercial or agricultural requirements	Medium	Remote	Receptors are present in the predicted zone of influence	Negligible	The predicted increase in groundwater level up hydraulic gradient, and decrease in level down hydraulic gradient is not predicted to have a measurable impact on the operation of the abstraction during drought periods.	Very Low	Neutral
					R12	Unlicensed abstractions for domestic and other uses	Medium	Remote	Receptors are present in the predicted zone of influence	Negligible	The predicted increase in groundwater level up hydraulic gradient is not predicted to have a measurable impact on the operation of the abstraction during drought periods.	Very Low	Neutral
					R13	Seasonal Springs	Medium	Remote	Receptors are present in the predicted zone of influence	Negligible	The predicted decrease in level down hydraulic gradient is not predicted to have a measurable impact on the receptor during drought periods.	Very Low	Neutral
O01	S8	Pollutants from spillages or road maintenance to increases in discharge to ground	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Likely	Receptor underlies existing A303 drainage and proposed drainage system	Negligible	Road drainage is to be improved in this area of the A303 to reduce impact from road drainage in the vicnity of the receptor, with tunnel drainage collected and disposed of. An improvement is expected, but this will not be of a significant nature. The HEWRAT assessment does not provide a minor benefit level improvement.	NA	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Likely	Receptor underlies existing A303 drainage and proposed drainage system	Negligible	Road drainage is to be improved in this area of the A303 to reduce impact from road drainage in the vicnity of the receptor, with tunnel drainage collected and disposed of. An improvement is expected, but this will not be of a significant nature. The HEWRAT assessment does not provide a minor benefit level improvement.	NA	Neutral

C - Construction Impact
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Table E - 4 **Qualitative Risk Assessment – Countess Junction Section**

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Description of Magnitude	Risk of Impact following Embedded mitigation	Significance of Effect
C01	S1	Excavations and deposition of soils, sediment or other construction materials causing pollution	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Moderately Likely	Use of excavated material will take place for embankments	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	The excavation and deposition is not taking place in the vicinity of any abstractions with published SPZ	Negligible	No impact anticipated	Very Low	Neutral
					R3	River Avon	Very High	Moderately Likely	Use of excavated material for embankments at Countess Junction	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Very unlikely	The excavation and deposition is not taking place in the vicinity of the site	Negligible	No impact anticipated	Very Low	Neutral
					R8	Springs near River Avon	High	Very unlikely	The excavation and deposition is not taking place in the vicinity of the springs	Negligible	No impact anticipated	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Moderately Likely	Use of excavated material for embankments at Countess Junction	Negligible	With the use of the CEMP there will be no measureable impact n the receptor quality	Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Moderately Likely	Use of excavated material for embankments at Countess Junction	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
			P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R3	River Avon	Very High	Remote	Use of excavated material for embankments at Countess Junction	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Remote	The site may extent to an area down hydraulic gradient of the area where excavated material will be used for embankments at Countess Junction	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality	Very Low	Neutral
C02	S2	Spillage of fuels or other contaminating liquids	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Likely	Construction is occuring into the Chalk unsaturated zone	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	No construction is occurring within the close vicinity of any published SPZ	Negligible	No impact anticipated	Very Low	Neutral
					R3	River Avon	Very High	Moderately Likely	Construction is occurring in the vicinity of the receptor	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Very unlikely	No construction is occurring in the vincinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R8	Springs near River Avon	High	Very unlikely	No construction is occurring in the vincinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Moderately Likely	Construction is occurring in the vicinity of the receptor	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Moderately Likely	Construction is occurring in the vicinity of the receptor	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Low	Neutral
			P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R3	River Avon	Very High	Remote	Construction is occurring in the vicinity of the receptor	Negligible	With the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Remote	The site may extend to an area down hydraulic gradient of the area for construction at Countess Junction	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality	Very Low	Neutral
			P4	Preferential flow pathways created by the construction of foundations for structures	R1	Principal Chalk Aquifer	Very High	Remote	Piles for flyover and columns for embankment are likely to extend below average high groundwater levels.	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R3	River Avon	Very High	Very unlikely	No construction is to occur directly to the River	Negligible	No impact anticipated	Very Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Very unlikely	No construction is to occur directly to the site	Negligible	No impact anticipated	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Moderately Likely	Construction at the existing River Avon bridge to support te road may extend into the superficial deposits	Negligible	With the use of the CEMP there will be no measureable impact on the receptor quality	Low	Neutral

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S - Source
P - Pathway
R - Receptor

ID	[S#]	Source	[P#]	Pathway	[R#]	Receptor	Sensitivity	Likelihood	Description of Likelihood	Magnitude of Impact	Description of Magnitude	Risk of Impact following Embedded mitigation	Significance of Effect
C03	S3	Mobilisation of contaminants following disturbance of contaminated ground or groundwater, or through uncontrolled site runoff	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Moderately Likely	Construction is occuring into the Chalk unsaturated zone in a location with land use with potential for contamination	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality.	Low	Neutral
					R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	No construction is occurring within the close vicinity of any published SPZ	Negligible	No impact anticipated	Very Low	Neutral
					R3	River Avon	Very High	Moderately Likely	Construction is occurring in the vicinity of the receptor where there are potential contaminative land uses present	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality.	Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Very unlikely	No construction is occurring within the close vicinity of any receptor	Negligible	No impact anticipated	Very Low	Neutral
					R8	Springs near River Avon	High	Very unlikely	No construction is occurring in the vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Moderately Likely	Construction is occurring in the vicinity of the receptor where there are potential contaminative land uses present	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality.	Low	Neutral
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Moderately Likely	Construction is occurring in the vicinity of the receptor where there are potential contaminative land uses present	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality.	Low	Neutral
			P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R3	River Avon	Very High	Remote	Construction is occurring in the vicinity of the receptor where there are potential contaminative land uses present	Negligible no	With the use of the OEMP there will be measureable impact on the receptor quality.	Very Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Very unlikely	No construction is occurring in the vincinity of the receptor likely to intercept any contaminated ground	Negligible	No impact anticipated	Very Low	Neutral
			P4	Preferential flow pathways created by the construction of foundations for structures	R1	Principal Chalk Aquifer	Very High	Very unlikely	Piles for flyover and columns for embankment are likely to extend below average high groundwater levels, in an area where contaminated ground/groundwater may be present.	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R3	River Avon	Very High	Remote	Construction is occurring in the vicinity of the receptor where there are potential contaminative land uses present	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Very unlikely	No foundation construction is occurring in the vincinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Remote	Construction is occurring in the vicinity of the receptor where there are potential contaminative land uses present	Negligible	Pile construction methods will limit creation of flow pathways to the aquifer, and the use of the OEMP there will be no measureable impact on the receptor quality	Very Low	Neutral
C06	S6	Presence of underground structures (foundations, peirs or cables) that could cause interference to groundwater flow	P2	Flow of groundwater through the Principal Chalk aquifer, and Secondary superficial deposit aquifers	R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	No structures are proposed within the close vicinity of any published SPZ	Negligible	No impact anticipated	Very Low	Neutral
					R3	River Avon	Very High	Moderately Likely	Foundations, piles and cables are present within close vicinity of the receptor that would impede groundwater flow in either superficial deposits or the underlying Chalk aquifer	Negligible	Impact is expected to be localised around structures and no measurable impact observed in receptor	Low	Neutral
					R5	Blick Mead Archaeological Site	Very High	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
					R8	Springs near River Avon	High	Very unlikely	No structures are proposed within the close vicinity of the receptor	Negligible	No impact anticipated	Very Low	Neutral
O01	S8	Pollutants from spillages or road maintenance to increases in discharge to ground	P1	Infiltration and leaching of pollutants through the unsaturated zone of the Chalk and superficial deposits	R1	Principal Chalk Aquifer	Very High	Moderately Likely	Receptor underlies existing A303 drainage and proposed drainage system ponds	Minor Beneficial	The installation of Re-medi8 within the existing A303 drainage ditches that are to be maintained for infiltration purposes will enable a slight benefit in the groundwater quality in this area. Where the lined drainage ponds are to be used, the HEWRAT assessment has shown an improvement in existing spillage risk of a minor benefit.	NA	Moderate/Large Beneficial
					R2	Licensed Public Drinking Water Abstractions with published SPZ	Very High	Very unlikely	No drainage occurs in vicinity of receptor	Negligible	No impact anticipated	NA	Neutral
					R3	River Avon	Very High	Remote	Receptor underlies existing A303 drainage, proposed drainage is to be via lined ponds, with treatment direct to receptor	Minor Beneficial	Where the lined drainage ponds are to be used, the HEWRAT assessment has shown an improvement in existing spillage risk of a minor benefit.	NA	Moderate/Large Beneficial
					R5	Blick Mead Archaeological Site	Very High	Moderately Likely	Receptor is in close vicinity of existing A303 drainage, and environment may be supported by infiltration from drainage	Negligible	The installation of Re-medi8 within the existing A303 drainage ditches that are to be maintained for infiltration purposes will enable a slight benefit in the groundwater quality in this area, but not of a minor benefit	NA	Neutral
					R8	Springs near River Avon	High	Very unlikely	No drainage occurs in vicinity of receptor	Negligible	No impact anticipated	NA	Neutral
					R9	Secondary A Superficial deposits aquifers	Medium	Remote	Receptor is close to existing A303 drainage system and proposed drainage ponds	Minor Beneficial	Where the lined drainage ponds are to be used, the HEWRAT assessment has shown an improvement in existing spillage risk of a minor benefit.	NA	Slight Beneficial
					R10	Secondary undifferentiated Superficial deposits aquifers	Medium	Remote	Receptor is close to existing A303 drainage system and proposed infiltration basins	Minor Beneficial	Where the lined drainage ponds are to be used, the HEWRAT assessment has shown an improvement in existing spillage risk of a minor benefit.	NA	Slight Beneficial

C - Construction Impact
O - Operational Impact

S - Source
P - Pathway
R - Receptor

Magnitude of Impact

Magnitude of Impact	Criteria	Examples	Risk Score
Major Adverse	Results in impact on integrity of attribute or loss of part of attribute	1. Loss of, or extensive change to, an aquifer 2. Loss of regionally important water supply 3. Potential high risk of pollution to groundwater from routine runoff - risk score >250 4. Calculated risk of pollution from spillages ≥2% annually 5. Loss of, or extensive change to, groundwater supported designated wetlands or baseflow contribution to protected surface water bodies 6. Reduction in water body WFD classification	4
Moderate Adverse	Results in effect on integrity of attribute, or loss of part of attribute	1. Partial loss or change to an aquifer. 2. Degradation of regionally important public water supply or loss of significant commercial/ industrial/ agricultural supplies 3. Potential medium risk of pollution to groundwater from routine runoff - risk score 150-250 4. Calculated risk of pollution from spillages ≥1% annually and <2% annually 5. Partial loss of the integrity of groundwater supported terrestrial ecosystem (wetland) 6. Contribution to reduction in water body WFD classification	3
Minor Adverse	Results in some measurable change in attributes, quality or vulnerability	1. Potential low risk of pollution to groundwater from routine runoff - risk score <150 2. Calculated risk of pollution from spillages ≥0.5% annually and <1% annually 3. Minor effects on an aquifer, groundwater supported wetlands, abstractions and structures	2

Negligible	Results in an impact on attribute but of insignificant magnitude to affect the use / integrity	1. No measurable impact upon an aquifer and/or groundwater receptors	1
Minor Beneficial	Results in some beneficial effect on attribute or a reduced risk of negative effect occurring	1. Calculated reduction in existing spillage risk by 50% or more to an aquifer (when existing spillage risk <1% annually) 2. Reduction of groundwater hazards to existing structures 3. Reductions in waterlogging and groundwater flooding	NA
Moderate Beneficial	Results in moderate improvement of attribute quality	1. Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is >1% annually) 2. Contribution to improvement in water body WFD classification 3. Improvement in water body CAMS classification 4. Support to significant improvements in damaged GWDTE	NA
Major Beneficial	Results in major improvement of attribute quality	1. Removal of existing polluting discharge to an aquifer or removing the likelihood of polluting discharges occurring 2. Recharge of an aquifer 3. Improvement in water body WFD classification	NA

Significance of effect

Receptor Sensitivity	Magnitude of Impact			
	Negligible	Minor	Moderate	Major
Very High	Neutral	Moderate/Large	Large/Very Large	Very Large
High	Neutral	Slight/Moderate	Moderate/Large	Large/Very Large
Medium	Neutral	Slight	Moderate	Large
Low	Neutral	Neutral	Slight	Slight/Moderate

Likelihood of a S-P-R Mechanism occurring

Score	Likelihood	Description	Example
1	Very unlikely	Very unlikely to occur	Extreme set of circumstances required
2	Remote	Unlikely to occur	Site underlain by low permeability strata
3	Moderately Likely	Equally likely or unlikely to occur	Controllable activity
4	Likely	More likely to occur than not	Failure of equipment is likely to lead to a release of pollutants
5	Almost Certain	Highly likely to occur	Uncontrolled activity

Risk Rating Table

X		Magnitude					
		1	2	3	4	Score	Risk Rating
Likelihood	1	1	2	3	4	1-2	Very Low
	2	2	4	6	8	3-5	Low
	3	3	6	9	12	6-12	Medium
	4	4	8	12	16	15-20	High
	5	5	10	15	20		

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