Southampton to London Pipeline Project

Volume 6

Environmental Statement (Volume D)
Appendix 8.1: Groundwater Baseline

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Appendix 8.1 Groundwater Baseline

1.1 Introduction

1.1.1 This appendix details the groundwater baseline within and in the vicinity of the Order Limits. This includes a desk study of available information, including data published or held by regulators such as the Environment Agency (EA), local authorities and public organisations including the British Geological Survey (BGS). Ground investigations have been undertaken to expand the historical dataset and collect further information on groundwater levels.

1.1.2 The groundwater topic has close alignment with the following subject areas, which are subject to separate baseline reports:

- Appendix 11.1 Soils and Geology Supporting Information
- Appendix 8.5 Water Framework Directive Compliance Assessment; and
- Chapter 7 Biodiversity and its associated appendices.

1.1.3 To provide greater detail on key groundwater receptors, separate appendices have been produced for the following:

- potential hydrogeological impacts at trenchless crossings on receptors of relevance (Appendix 8.2 Detailed Trenchless and Targeted Trench Assessments);
- groundwater dependent terrestrial ecosystems (GWDTEs) (Appendix 8.3 Groundwater Dependent Terrestrial Ecosystems); and
- groundwater abstractions (Appendix 8.4 Groundwater Abstraction Conceptual Site Models).

1.1.4 It is not the purpose of this groundwater baseline appendix to reproduce the data and assessments in these appendices, although where necessary the appendices are referred to.

Groundwater Study Area

1.1.5 The groundwater study area is defined as the Order Limits with a 1km buffer on either side. This buffer allows for the identification of receptors outside the location of the physical works. These could be impacted by activities such as change in groundwater levels caused by dewatering or disturbance (in flow and/or quality) of groundwater flows. These in turn may support receptors such as GWDTEs or provide baseflow to watercourses.

1.1.6 This groundwater study area is split further based on the geology and associated groundwater environment. Figure A8.1.1 shows the bedrock geology and Figure A8.1.2 shows the superficial deposits. The study areas are as follows.

- Groundwater Study Area A (GWSA-A): Order Limits from Boorley Green in Hampshire to the southern boundary of the Chalk Principal aquifer at Bishop's

Waltham covering part of Section A. This area passes over Palaeogene bedrock geological deposits which mostly form Secondary A aquifers.

- GWSA-B: Order Limits that cross the Chalk Principal aquifer from Bishop's Waltham to Crondall. This covers part of Section A and all of Sections B and C and a very small part of Section D.
- GWSA-C: Order Limits from Crondall to Chertsey South, around 500m west of the M25. This covers most of Section D, all of Section E and most of Section F. This area passes over Palaeogene geological deposits which mostly form Secondary A aquifers, including the Bracklesham Group.
- GWSA-D: Order Limits from Chertsey South to the Esso West London Terminal storage facility covering a small part of Section F and all of Sections G and H. This area passes over Principal aquifers associated with superficial sand and gravel deposits.

Aims and Objectives

1.1.7 The objective of this groundwater baseline appendix is to characterise the groundwater environment and collect baseline data to inform the Environmental Impact Assessment (EIA) and other assessments required to construct and operate the pipeline, which include a Habitats Regulations Assessment and a Water Framework Directive (WFD) Compliance Assessment (Appendix 8.5).

1.1.8 This appendix presents the findings of groundwater surveys undertaken in 2018 by hydrogeologists as well as desk study and review of earlier site investigation data collected within the study area and a new phase of ground investigation. Ongoing data collection will continue into 2019.

1.1.9 The specific aims of this work are to:

- provide an understanding of the baseline groundwater conditions within the pipeline Order Limits and their vicinity;
- identify key groundwater receptors;
- provide a report that can be referred to throughout the EIA process for key groundwater information for the project;
- inform the relevant EIA chapters; and
- inform a WFD Compliance Assessment (Appendix 8.5) and Habitats Regulations Assessment.

1.1.10 This baseline assessment presents the available data for:

- **Groundwater Resource**, which identifies groundwater levels and flow mechanisms and groundwater abstractions within the study area, and whether the Order Limits cross designated aquifers. This section also identifies whether there are any groundwater source protection zones (SPZs), licensed and/or unlicensed abstractions, groundwater level monitoring data and any groundwater catchment models previously developed by the EA or water utilities within the study area. This section concludes by bringing all information available together and highlighting which sections of the Order Limits are expected to have shallow groundwater conditions within the context of shallow trenches being required along the majority of the length of the project.

- **Groundwater Quality**, which identifies the likely groundwater quality within each study area based on available EA monitoring data and published information on the generic quality of groundwater for each identified aquifer unit. This section also provides data on known groundwater pollution incidents within the Order Limits.
- **GWDTE**, which identifies the potential GWDTE within each study area and how reliant on groundwater each is assessed to be.

1.2 Methodology

Introduction

1.2.1 This baseline appendix is based on a combination of a desk study, which reviews the existing information from the study area, and hydrogeological surveys to further develop the key baseline observations. The following steps were undertaken.

- Review of desk-based information on the groundwater study area, including data held by the EA, BGS, local authorities and water companies.
- Site walkovers for GWDTEs which were identified as having the potential to be impacted by the project. For three of these GWDTEs, soil coring was undertaken to identify shallow ground conditions.
- Ground investigations to record groundwater levels in a small number of boreholes installed specifically for the project.

Desk Study

1.2.2 The desk study comprised the analysis of available information, including maps, geological data, soils data, data collected from historical investigations and publicly available data provided by the EA and local authorities. The following is a list of the key documentation/data used to inform the desk study.

- EA data obtained from their website (EA, 2018) or via an information request. These comprise data relating to:
  - licensed groundwater abstractions;
  - pollution incidents which may have affected groundwater;
  - groundwater quality monitoring points; and
  - groundwater levels measured in boreholes monitored by the EA.
- MAGIC website (Department for Environment, Food and Rural Affairs (Defra), 2019); including groundwater SPZs and aquifer designations.
- Ordnance Survey 1:10,000, 1:25,000 and 1:50,000 maps.
- Geological maps and borehole logs available at the BGS's Geoindex website (BGS, 2018a).

- BGS map data identifying the vertical permeability of bedrock and superficial deposits ("Permeability Index") (Lewis et.al., 2006).
- BGS map data identifying areas susceptible to groundwater flooding (BGS, 2017).
- BGS map data identifying where karst features may be present and rock solubility (Farrant and Cooper, 2008).
- Data on unlicensed private water supplies (PWSs) provided by local authorities. These PWSs relate to groundwater abstractions which abstract less than 20m^3/day of groundwater.

1.2.3 The EA also provided groundwater model output data for three groundwater models as shown in Table 8.1.1. The output from the models has been used to plot groundwater contours at a time of high groundwater levels in the winter of 2001 and to assess groundwater levels at individual points, such as at trenchless crossings or where the pipeline runs adjacent to rivers (Appendix 8.2, Detailed Trenchless and Targeted Trench Assessments). The areas covered by the models are shown in Figure A8.1.3. The models do not provide groundwater level data for all the geological strata crossed by the groundwater study area. Of particular note, no model data are available for the Bracklesham Group deposits in GWSA-C.

Table 8.1.1: EA Groundwater Models

Groundwater Model	Geological Layers Modelled	Model Grid Spacing	Modelled Period	Reference^
East Hampshire and Chichester Chalk (EHCC)	Paleogene and superficials* Chalk and Upper Greensand	Uniform 200m x 200m	1965 to 2011	Environment Agency, 2007
Test and Itchen	Chalk and Upper Greensand	Uniform 250m x 250m	1965 to 2011	Environment Agency, 2005
Mole	Chalk** Upper Greensand** Folkestone Formation Lower Greensand Group	Uniform 250m x 250m	1970 to 2012	Environment Agency, 2011

** The model area for these deposits is outside of the Order Limits*

*** Only the unconfined Chalk and Upper Greensand layers are of interest to the project*

^ For each model, following issue of the initial model referred to in the reference, the model has been updated with additional data to cover the modelled period shown

1.2.4 Discussions and meetings have been held with the water companies whose area the Order Limits cover, including Portsmouth Water, Southern Water, South East Water and Affinity Water. Data on specific groundwater abstractions which have the potential to be impacted by the project have been provided by these water companies. The abstractions which have the potential to be affected are considered further in Appendix 8.4 Groundwater Abstraction Conceptual Site Models.

1.2.5 In addition to the discussions with the water companies, consultation has taken place with the EA. This has involved meetings to discuss the scope of the EIA and the methodologies to be used for the groundwater assessment and land quality and groundwater issues due to the presence of landfills.

1.2.6 As part of the desk study, for each groundwater study area, maps produced by the EA have been studied to identify the aquifer designations for the bedrock and superficial deposits that the Order Limits cross over (Figure A8.1.4 and Figure A8.1.5 respectively). These designations are as follows:

- **Principal aquifer**: geology that exhibits high permeability and/or provides a high level of water storage. They may support water supply and/or river baseflow on a strategic scale.
- **Secondary A aquifer**: permeable strata capable of supporting water supplies at a local rather than strategic scale and in some cases forming an important source of baseflow to rivers.
- **Secondary B aquifer**: predominantly lower permeability strata which may in part have the ability to store and yield limited amounts of groundwater by virtue of localised features such as fissures, thin permeable horizons and weathering.
- **Secondary Undifferentiated aquifer**: designation used in cases where it has not been possible to attribute either category A or B to a rock type.
- **Unproductive Strata**: these are geological strata with low permeability that have negligible significance for water supply or river base flow.

1.2.7 Data on SPZs (Defra, 2019) (Figure A8.1.6) have been used to assess potential for impacts on public water supplies and groundwater abstractions used for food or drink production. For each source, three zones are defined as follows, with Zone 1 being closest to the abstraction point and therefore the most sensitive:

- **Zone 1 (Inner Protection Zone)**: this zone is defined by a travel time of 50 days or less from any point within the zone at, or below, the water table. Additionally, the zone has, as a minimum, a 50-metre radius. It is based principally on biological decay criteria and is designed to protect against the transmission of toxic chemicals and water-borne disease.
- **Zone 2 (Outer Protection Zone)**: this zone is defined by the 400-day travel time from a point below the water table. Additionally, this zone has a minimum radius of 250 or 500 metres, depending on the size of the abstraction. The travel time is derived from consideration of the minimum time required to provide delay, dilution and attenuation of slowly degrading pollutants.
- **Zone 3 (Total catchment)**: this zone is defined as the total area needed to support the abstraction or discharge from the protected groundwater source.

1.2.8 Data on groundwater flooding susceptibility have been obtained from the BGS (Figure A8.1.7) (BGS, 2017). These data have been used to assist in determining where groundwater may be shallow and the pipe may be laid below the groundwater table. The BGS define three groundwater flooding susceptibility zones for aquifers as follows:

- areas with potential for groundwater flooding to occur at surface;
- areas with potential for groundwater flooding of property situated below ground level; and

- areas with limited potential for groundwater flooding to occur – in these areas it can be assumed that groundwater levels are relatively deep.

1.2.9 Groundwater flooding susceptibility is not shown for Unproductive strata.

1.2.10 The BGS Permeability Index is a qualitative classification based on expert judgement of estimated rates of vertical movement of water from the ground surface through the unsaturated zone (Lewis et. al., 2006). This is established for both bedrock and superficial deposits and is based on a regional (rather than site-specific) assessment. The index identifies whether groundwater movement is predominantly in fissures or by intergranular flow and determines the maximum and minimum qualitative rate of movement on a five-point scale from very low to very high.

1.2.11 Ground dissolution occurs when water passing through soluble rocks produces underground cavities and cave systems. These cavities reduce support to the ground above and can cause localised collapse of the overlying rocks and deposits and lead to damage to infrastructure, including pipelines. The potential for dissolution to be a hazard has been assessed by BGS (BGS, 2019) using 1:50,000 scale digital maps of superficial and bedrock deposits. These maps have been combined with information from the BGS Superficial Drift Thickness dataset and scientific and engineering reports with five classes of solubility defined by the BGS as follows:

> ***‘A****: Soluble rocks are either not thought to be present or are not prone to dissolution. Dissolution features are unlikely to be present.*
>
> ***B****: Soluble rocks are present but unlikely to cause problems except under exceptional conditions.*
>
> ***C****: Significant soluble rocks are present. Low possibility of localised subsidence or dissolution-related degradation of bedrock occurring naturally, but may be possible in adverse conditions such as high surface or subsurface water flow.*
>
> ***D****: Very significant soluble rocks are present with a moderate possibility of localised natural subsidence or dissolution-related degradation of bedrock, especially in adverse conditions such as concentrated surface or subsurface water flow.*
>
> ***E****: Very significant soluble rocks are present with a high possibility of localised subsidence or dissolution-related degradation of bedrock occurring naturally, especially in adverse conditions such as concentrated surface or subsurface water flow’.*

Hydrogeological Surveys

1.2.12 Hydrogeological reconnaissance surveys comprised site walkovers of a number of potential GWDTEs. For three of the GWDTEs (Chobham Common Site of Special Scientific Interest (SSSI), Folly Bog (part of Colony Bog and Bagshot Heath SSSI) and Ewshot Meadows), a shallow soil survey was undertaken to identify potential shallow groundwater pathways. Further details of these surveys are provided in Appendix 8.3, Groundwater Dependent Terrestrial Ecosystems.

1.2.13 Data have also been collected as part of ongoing ground investigations. The ground investigation included the installation of groundwater monitoring standpipes to allow groundwater levels to be measured and samples of groundwater to be collected for chemical analysis.

1.2.14 Borehole locations were chosen to assess the ground and groundwater conditions at selected trenchless crossings and where there was potential for contaminated land and groundwater. Permeability measurements have been undertaken in the majority of the boreholes. Groundwater data loggers have been installed in the majority of the boreholes so that changes in groundwater level over time can be recorded. Data collected from these investigations up until 23 November 2018 have been used in this appendix and have herein been referred to as the 2018 ground investigation (GI).

Limitations

1.2.15 Where data have been supplied by third parties, these have been accepted at face value without further verification. Any inaccuracies in third party data have the potential to reduce the accuracy of the assessment in Chapter 8 Water which relies on that data.

1.2.16 All reasonable efforts have been made to obtain the required data from these third parties, and in most cases, data have been received. However, in the case of obtaining the information on unlicensed groundwater abstractions, not all of the local authorities supplied the requested information. As such, for private unlicensed groundwater abstractions, there are likely to be further abstractions within the study area which have not been identified. This has been considered in the assessment presented in Chapter 8 Water.

1.2.17 GI data are still currently being collected, and therefore not all scheduled information is available at the time of writing. Data available from the 2018 GI up to 21 February 2019 have been used. This may not capture the highest winter groundwater levels. As such, shallower groundwater conditions may be present than reported in this appendix with the potential that areas not considered as having shallow groundwater could be present. Groundwater in these areas could be intercepted by the installation of the pipeline. However, the 2018 GI water level data are one of several sources of information relating to groundwater levels. As such, the relatively small data set from the 2018 GI is unlikely to substantially affect the assessment presented in Chapter 8 Water.

1.3 Groundwater Study Area A

Groundwater Resource and Groundwater Levels

1.3.1 The superficial Secondary A aquifers in this study area are formed by River Terrace Deposits and alluvium associated with watercourses to the north of Boorley Green (Figure A8.1.5, Sheet 1 of 4). The River Terrace Deposits are shown to have an intergranular Permeability Index of very high to high. The alluvium has an intergranular Permeability Index of high to very low.

1.3.2 The Order Limits in GWSA-A cross the bedrock formations as shown in Table 8.1.2. Figure A8.1.4 (Sheet 1 of 4) and Table 8.1.2 show the aquifer designations for these deposits and the table also shows the Permeability Index as defined by the BGS.

Table 8.1.2: Bedrock Geology and Aquifers within GWSA-A

Geological Unit	Description	Aquifer Designation	Permeability Index
Wittering Formation (part of the Bracklesham Group)	These sedimentary rocks are detrital (formed from previous rock formations), comprising sand, silt and clay forming interbedded sequences.	Secondary A aquifer	Intergranular, high to low permeability
Whitecliff Sand Member (part of the London Clay Formation)	These sedimentary rocks are detrital, ranging from coarse- to fine-grained sand forming interbedded sequences. These are sandy horizons of the London Clay Formation.	Secondary A aquifer	Intergranular, high permeability
Durley Sand Member (part of the London Clay Formation)			
London Clay Formation	These sedimentary rocks are detrital and dominantly comprise clay, with silt and sand forming distinctively graded beds.	Unproductive strata	Mixed moderate to very low permeability
Lambeth Group	These sedimentary rocks are detrital, forming sand, silt and clay deposits.	Secondary A aquifer	Mixed moderate to very low permeability

1.3.3 The majority of the London Clay Formation is of little significance as an aquifer, due to its mainly clay nature. However, the sandier upper part of the formation, especially the Whitecliff Sand Member, provides permeable horizons and the increased chance of a successful abstraction borehole with reported yields of around 500m^3/day (Neumann et. al., 2004).

1.3.4 Within this study area, the Chalk is present beneath the overlying lower permeability London Clay and Lambeth Group bedrock (this section of the Chalk aquifer is known as the confined Chalk). At the northern edge of GWSA-A, the Chalk is overlain only by the Lambeth Group deposits (rather than the Lambeth group and London Clay). As such, if the Lambeth Group deposits are sufficiently permeable, there may be hydraulic connection of groundwater in the Lambeth Group and Chalk. Two BGS borehole logs at Wintershill to the west of Bishop's Waltham, located 300m south of the boundary of the Chalk and Lambeth Group, show the Lambeth Group to comprise 2.5m of stony clay, over 5.5m of fine to coarse sand with an 8m-thick hard red mudstone overlying the Chalk. These deposits will provide protection to, and confine the groundwater in, the Chalk.

1.3.5 There are no surface SPZs within GWSA-A, although at the northeastern end of the study area part of the SPZ for Northbrook where the Chalk is confined is within the study area (Figure A8.1.6, Sheet 1 of 4).

1.3.6 No licensed groundwater abstractions have been identified within GWSA-A. However, five unlicensed PWS groundwater abstractions have been identified as shown in Table 8.1.3 and shown on Figure A8.1.6, Sheet 1 of 4.

Table 8.1.3: Identified Unlicensed Groundwater Abstractions within GWSA-A

Local Authority Area	Reference Number	Name	National Grid Reference (NGR)	Primary Use of Abstraction*
Winchester City Council	PW000033	Greywood	SU5184214709	Unknown
Winchester City Council	PW000034	Netherhills	SU5207815448	Unknown
Winchester City Council	PW000035	Netherhills	SU5205615471	Unknown
Winchester City Council	PW000036	Netherhills	SU5199215391	Unknown
Winchester City Council	PW000037	Netherhills	SU5210015426	Unknown

** Although the use of the abstractions has not been identified, the location of the abstractions identifies these to be at residential properties*

1.3.7 EA data on groundwater levels for GWSA-A show that there are two groundwater monitoring boreholes within the study area (Figure A8.1.7, Sheet 1 of 4). These are in the north of the study area to the west of Bishop's Waltham where the Chalk becomes confined by the Lambeth Group (it is likely that the boreholes are the same as those mentioned above in relation to the Lambeth Group geology). The measured water levels (Table 8.1.4) do show that the Chalk is confined by the overlying Lambeth Group deposits and artesian pressures can be encountered. There is a relatively large variability in groundwater levels in the Chalk borehole as expected given its confined nature. However, water levels are more frequently lower than in the overlying deposits.

Table 8.1.4: Groundwater Levels Recorded by the EA within GWSA-A

Borehole Name	NGR	Aquifer Monitored	Period of Record	Maximum Groundwater Level Recorded	
				mbgl*	mAOD**
Wintershill (Chalk)	SU5384818214	Chalk	2001 to 2017	0.0	42.0
Wintershill (Tertiary)	SU5385418218	Lambeth Group	2005 to 2017	0.0	42.0

** metres below ground level*

*** metres above Ordnance Datum*

1.3.8 For the Wintershill (Tertiary) borehole, water levels are generally higher than in the underlying Chalk aquifer, except during the highest levels. For this borehole, groundwater levels are very close to the ground surface and annual cyclicity in groundwater levels is in the order of 0.5m.

1.3.9 Generally, it would be anticipated that groundwater levels are shallowest in the watercourse valleys, particularly for the tributary of the River Hamble near to Ford Lake Valley. This is where the groundwater flood susceptibility map (Figure A8.1.7, Sheet 1 of 4) shows there is the potential for groundwater flooding at the surface. A further smaller area where there is susceptibility to groundwater flooding at the surface is present at Wintershill to the west of Bishop's Waltham. This area corresponds with the shallow groundwater levels recorded in the EA monitoring boreholes at Wintershill. There are also flood susceptibility areas corresponding to the mapped extents of the superficial deposits (River Terrace Deposits and alluvium), where the London Clay is underlying.

1.3.10 The EA's EHCC and Test and Itchen groundwater modelling studies do model groundwater levels in the confined Chalk in GWSA-A. However, as the pipeline will not reach the Chalk (including at any trenchless crossing points), the water level data from the models are not relevant to the project.

1.3.11 At the time of writing, the 2018 GI has installed two boreholes in GWSA-A as shown in Table 8.1.5. A groundwater level data logger has been installed in BH124.

Table 8.1.5: Groundwater Levels Recorded in 2018 GI boreholes within GWSA-A

Borehole Number	NGR	Horizon Monitored	Groundwater Strike*		Maximum Groundwater Level Recorded	
			mbgl	mAOD	mbgl	mAOD
BH124	453609 117844	Clay	No strike recorded		0.28	32.88
BH126	451487 114768	Clay	No strike recorded		-0.94 (artesian conditions)	15.07

** Groundwater strike is the level at which groundwater is encountered when drilling the borehole*

1.3.12 In BH124, once the borehole had been drilled to 10m, a rest water level of 1.7mbgl was recorded. After drilling of the borehole had progressed to 16mbgl, groundwater was rising over the casing with the level recorded at least 2.75m above ground level (i.e. artesian conditions). The borehole was terminated at 16.42mbgl and a bentonite seal was put in place prior to borehole installation. The completed borehole monitors a horizon down to 4mbgl.

1.3.13 In BH126, which was completed between 6.0mbgl and 20.0mbgl, artesian groundwater conditions have been recorded since the borehole was completed. The maximum height of water above the ground level has been recorded as 0.94m.

1.3.14 Based on the above groundwater level information, within GWSA-A, shallow groundwater levels which may be intercepted by the trench excavated to install the pipeline are most likely to occur at the following locations:

- Ford Lake Valley, although a trenchless crossing would be used here for much of the area where the shallowest groundwater levels are likely to be present (see Appendix 8.2 Detailed Trenchless and Targeted Trench Assessments); and
- Wintershill to the west of Bishop's Waltham.

1.3.15 In terms of WFD groundwater bodies, much of GWSA-A lies within the South East Hants Bracklesham Group groundwater body. This is shown to have good quantitative status and poor chemical, and therefore poor overall, status. A small length of GWSA-A in the extreme north crosses the East Hants Lambeth Group groundwater body which is shown to have poor quantitative status and good chemical status, with overall poor status. Further details, including a map showing the extent of the waterbodies, is available in Appendix 8.5 WFD Compliance Assessment.

Groundwater Quality

1.3.16 Neumann et. al. (2004) indicates the most common water type encountered in the Palaeogene aquifer in the region is calcium bicarbonate type groundwater. These waters are generally fresh with low sodium and chloride concentrations but frequently with high iron and manganese concentrations and slightly acidic conditions with a pH between 6.2 and 7.3. Given the rural nature of the study area, human influence on groundwater quality is likely to be slight, although elevated agricultural pollutants (most notably nitrate) could be anticipated.

1.3.17 Data on the groundwater quality in the vicinity of GWSA-A have been obtained from the EA's water quality database. There is one monitoring point within GWSA-A at The Mount approximately 100m from the Order Limits (NGR 452100, 115500) (Figure A8.1.6, Sheet 1 of 4). This is situated on the Wittering Formation with small patches of superficial River Terrace Deposits locally. The data comprise three samples collected in 2006 and 2007. Generally, the data show the groundwater to be of good quality. Iron and manganese concentrations in the samples are not raised (the concentrations are around the analytical detection limit) and nitrate concentrations are relatively low (2.3 to 5.0mg/l as N). The samples show low electrical conductivity (less than 0.2mS/cm), neutral pH (6.1 to 7.6 measured in situ) and low concentrations of most metals such as lead (<0.002mg/l) and nickel (<0.005mg/l). Copper concentrations, at 0.023mg/l to 0.055mg/l, are slightly elevated. Pesticides and volatile organic compounds (VOCs) are absent.

1.3.18 Groundwater quality has also been assessed using data from groundwater sampling completed as part of the 2018 GI works with BH124 and BH126 each being sampled on three occasions.

1.3.19 At BH124, concentrations of ammoniacal nitrogen (as NH_3) were slightly elevated (at 0.53 to 0.73mg/l) with sulphate (1,300mg/l to 1,500mg/l) and chloride (476mg/l to 649mg/l) considered to be elevated above typical background groundwater concentrations. The data generally show that the water type here is very hard, with total $CaCO_3$ at around 2,000mg/l to 3,000mg/l. Results for organic compounds (polycyclic aromatic hydrocarbons (PAHs), semi volatile organic compounds (SVOCs) and total petroleum hydrocarbons (TPHs)) are all below their analytical detection limits. Metals including lead, nickel and arsenic are all relatively low and typical of uncontaminated groundwater. This borehole is completed at relatively shallow depth (down to 4mbgl) within a firm clay deposit, likely to be the London Clay. It is noted that sulphate concentrations in groundwater can be greatly elevated in the weathered zone of the London Clay due to oxidation of pyrite (BGS, 2018b).

1.3.20 Three groundwater samples were also taken from BH126. The samples show the maximum concentrations of ammoniacal nitrogen (as NH_3) (0.45mg/l) to be slightly elevated. The maximum hardness value of 218mg/l indicates the water type is hard. Results for PAHs, SVOCs, and TPHs are all below or marginally above their analytical detection limits, with other metals including lead, nickel and arsenic all considered to be indicative of uncontaminated groundwater.

1.3.21 No groundwater pollution incidents are reported by the EA within GWSA-A.

Groundwater Dependent Terrestrial Ecosystems

1.3.22 Within GWSA-A, three GWDTE have been identified, as shown in Table 8.1.6 and Figure A8.1.8 (Sheet 1 of 4). Further details of these GWDTE are provided in Appendix 8.3 Groundwater Dependent Terrestrial Ecosystems.

Table 8.1.6: GWDTE within GWSA-A

Site Name	Nature Conservation Designation	Determination of Groundwater Dependency
Ford Lake	Includes Maddoxford Farm Meadows Site of Importance for Nature Conservation (SINC)	Moderate
Durley Green Lane	None	Moderate
Wintershill Floodplain	None	Low

1.4 Groundwater Study Area B

Groundwater Resource and Groundwater Levels

1.4.1 GWSA-B crosses the Chalk which forms a Principal aquifer (Figure A8.1.4). There is a small section of the study area near to Alton passing over the Upper Greensand Formation which also forms a Principal aquifer. Within this study area there are two logistics hubs situated on the A31 at Ropley Dean and A31/A32 at Northfield Lane, Alton. Both of these hubs are located on the Chalk.

1.4.2 The Chalk in this study area is at the ground surface or beneath superficial deposits (i.e. it is “unconfined” Chalk) and is a major source of drinking water in the area. Although chalk has a high porosity, the intergranular permeability is very low as the pores do not drain under gravity (Allen et. al., 1997). Groundwater flow in the Chalk is therefore mainly controlled by fracture flow. The most important flow horizons are concentrated near the top of the Chalk. There is little flow deeper than 50mbgl. Transmissivity (the product of aquifer permeability and aquifer thickness) within the Chalk tends to be greater in the valleys than in the interfluves (the land between the valleys of adjacent watercourses).

1.4.3 The BGS Permeability Index (Lewis et al., 2006) describes the Chalk as having fracture flow with very high permeability. Karst features (a limestone landscape characterised by a dry and barren surface with underground drainage via channels with swallow holes, caves, large springs and other features) can be present in the Chalk. In hydrogeological terms, the importance of karst is that groundwater is concentrated in, and flows rapidly through, a network of fractures, conduits (significantly enlarged fractures) and caves, enlarged by the dissolving chalk.

1.4.4 The extent of karst features in the Chalk near the Order Limits has been determined using data obtained from the BGS National Karst Database (Farrant and Cooper, 2008). This database has retrieved karst data from field notes and maps with additional fine-scale detail gathered during fieldwork, from remote sensing techniques such as light detection and ranging (LiDAR) and from existing documentary data sources such as Ordnance Survey maps, cave surveys, academic papers and historical documents. Data have been collected and mapped for five main types of karst feature:

- sinkholes (or “dolines”);
- stream sinks;
- caves;
- springs; and
- incidences of associated damage to buildings, roads, bridges and other engineered works.

1.4.5 Figure A8.1.9 shows the karst features which have been identified by BGS within GWSA-B. The data show that there is a series of karst features on the southern edge of the Chalk along the boundary where the Chalk becomes confined. Some of these identified features are within the SPZ for Portsmouth Water’s Northbrook abstraction (see Appendix 8.4 Groundwater Abstraction Conceptual Site Models for further consideration of this).

1.4.6 Several dolines are identified within the study area from Bishops Waltham to West Meon. A high concentration of point dolines is then identified in the study area from near West Meon to West Tisted with a small number of these features being mapped within the Order Limits.

1.4.7 A lower concentration of point dolines is then mapped from West Tisted to Chawton. Furthermore, Allen et. al. (1997) notes that in the River Alre catchment (in the vicinity of Section B), karstic flow has developed, resulting in very high yielding boreholes for the Chalk. These karstic features feed discharges for watercress beds.

1.4.8 A small number of springs are identified in the section of the study area between West Tisted and to the north of Alton, including three springs associated with the Peck Copse GWDTE. To the north of Alton, the BGS data show several springs associated with the River Wey, with a further concentration of springs being associated with the northern boundary of the Chalk where the Chalk becomes confined (Figure A8.1.9).

1.4.9 For the logistics hub at A31 Ropley Dean, Figure A8.1.9 shows that dolines in the surrounding area are present, although the nearest one is approximately 700m from the hub. For the logistics hub at A312/A32 Junction Northfield Lane, Alton, the nearest doline is mapped as being 220m northwest of the hub.

1.4.10 The BGS has also published maps identifying rock solubility for the Chalk, and whether dissolution features may be present with potential for difficult ground conditions which have the potential to lead to subsidence. Figure A8.1.9 shows the BGS rock solubility data for GWSA-B.

1.4.11 Due to the Chalk having a low effective porosity (i.e. the fractures), groundwater levels in the Chalk can vary greatly over the course of the year. This can be by as much as 20m to 30m with the highest seasonal water levels typically occurring in late winter or early spring. In general, the groundwater level is closer to the ground surface near to water courses where there are discharges of groundwater rather than further away in the interfluves.

1.4.12 As previously noted, there are many springs in the Chalk. Those that occur on the dip slope of the Chalk are at the bottom of valleys where the water table intersects the surface (Allen et. al., 1997). During the summer and autumn months, when the water table is falling, these springs dry up successively down the valley. In winter, as the water table rises, the springs become active at increasingly higher levels (these seasonal streams are known as “bournes”). In those catchments, where the Chalk groundwater remains connected with the watercourses year-round, the Chalk groundwater provides baseflow to the watercourse. Such watercourses remain flowing all year.

1.4.13 The Upper Greensand Formation over which a small part of GWSA-B runs is defined in the BGS Permeability Index as having mixed flow type (intergranular and fracture flow) with high to moderate permeability.

1.4.14 In terms of superficial aquifers, there is a Secondary A alluvium aquifer associated with watercourses which cross the Chalk near Alton (Figure A8.1.5, Sheet 2 of 4). These deposits are shown to have an intergranular Permeability Index of very high to high. Secondary Undifferentiated aquifers are more widespread, with Head deposits associated with small streams forming these aquifers over much of the Chalk south of Alton. The extreme southern part of the logistics hub at A31 Ropley Dean lies on Head deposits. These deposits are shown to have an intergranular Permeability Index of high to very low.

1.4.15 The Clay-with-Flint Formation superficial deposits which are present within GWSA-B are defined as Unproductive strata. However, their importance in relation to the hydrogeology is that runoff of rain water from the edge of the deposits can lead to zones of high dissolution and creation of karstic features. Areas with a thin cover of superficial deposits commonly have a greater incidence of near surface karst features because the cover serves to concentrate surface runoff, generating discrete point recharge into the underlying bedrock, and concentrating dissolution. The unconsolidated deposits can also slump into dissolutionally enlarged fissures in the underlying bedrock, creating dissolution pipes, cavities and, ultimately, sinkholes. These types of sinkhole are noted to be common in areas with a thin cover of Clay with Flint over the Chalk in southern England (Farrant and Cooper, 2008).

1.4.16 The SPZ map (Figure A8.1.6) shows SPZs throughout much of GWSA-B. In the south of the study area, the Order Limits cross an SPZ2/SPZ3 associated with two Portsmouth Water abstractions called Northbrook and Lower Upham near to Bishop’s Waltham. The Order Limits then cross SPZ2s associated with abstractions near to New Alresford in the River Itchen and River Alre valleys associated with watercress beds. SPZ1s are present within the 1km buffer for this groundwater study area associated with the Northbrook abstraction and for two abstractions at Alton.

1.4.17 The logistics hub at A31 Ropley Dean is located adjacent to SPZ1 and SPZ2 associated with one of the watercress beds near to New Arlesford. For the logistics hub at A31/A32 Junction Northfield Lane, Alton, a portion of the site parallel to the southeastern boundary lies within SPZ3 for the abstractions at Alton.

1.4.18 It is understood that potential degree of karstification has not been taken into account to define SPZs. SPZs and potential preferential flow pathways as a result of karstification are discussed in more detail in Appendix 8.4 Groundwater Abstraction Conceptual Site Models.

1.4.19 Table 8.1.7 and Table 8.1.8 provide a summary of the identified licensed and unlicensed PWS groundwater abstractions within GWSA-B, which are shown on Figure A8.1.6.

Table 8.1.7: Identified Licensed Groundwater Abstractions within GWSA-B

Licence Number	Name	No. of Abstraction Points	Max Annual Quantity (m3/yr)	Max Daily Quantity (m3/day)	NGR	Primary Use of Abstraction
11/42/22.1/133	Brockwood Park Estate	1	7,956	20.5	SU62822636	Agriculture
11/42/22.1/145	Manor Farms	2	40,910	136	SU64802930	Agriculture and water supply
11/42/22.1/16	Bramdean	2	5,046	36.3	SU64582802	Agriculture
11/42/22.1/24A	Brockwood Park	1	10,228	31.8	SU62672644	Agriculture
11/42/22.1/3	Wheely Farm	1	9,897	205	SU61082462	Agriculture
11/42/22.1/8	Wood Farm	1	8,751	36.4	SU62962900	Agriculture
11/42/25.1/59	Belmore House	1	1,591	55	SU55632207	Water supply
11/42/25.2/21	Bigpath Farm	1	3,296	27.3	SU54822099	Agriculture
28/39/24/0237/R02	Oak Park	1	12,000	69	SU8000048750	Industrial, commercial and public services
28/39/30/0259	Selborne Road	4	1,045,602	5,455	SU71523805 and SU71933925	Industrial, commercial and public services
28/39/30/0384		1	17,520	48	SU657291	Agriculture
30/051/R01	Lomer Farm	2	10,000	36	SU5900223791	Agriculture and water supply
SO/042/0031/044	Stanmore Farm	2	7,989	30	SU5924924776	Agriculture and water supply

Table 8.1.8: Identified Unlicensed Groundwater Abstractions within GWSA-B

Local Authority Area	Reference Number	Name	NGR	Primary Use of Abstraction
Winchester City Council	PW000220		SU5379019497	Unknown
Winchester City Council	PW000163		SU5536121622	Unknown
Winchester City Council	PW000164		SU5536221732	Unknown
Winchester City Council	PW000160		SU5563222062	Unknown
Winchester City Council	PW000196		SU5632022903	Unknown
Winchester City Council	PW000202	Betty Mundy's Cottage	SU5787222019	Unknown
Winchester City Council	PW000200		SU5899023757	Unknown
Winchester City Council	PW000111	Rooksgrove Farm	SU5964423799	Unknown
Winchester City Council	PW000101		SU6032424812	Unknown
Winchester City Council	PW000185		SU6110324611	Unknown
Winchester City Council	PW000021	Blackhouse Farm	SU6082825478	Unknown
Winchester City Council	PW000023		SU6258226446	Private school
Winchester City Council	PW000091		SU6281626364	Private nursery school
Winchester City Council	PW000168		SU6330425972	Unknown
Winchester City Council	PW000174		SU6330625706	Unknown
Winchester City Council	PW000092	Parsonage Farm	SU6315828062	Unknown
Winchester City Council	PW000191	Wolfhanger Farm	SU6364628509	Unknown
Winchester City Council	PW000199		SU6369627503	Unknown
Winchester City Council	PW000096		SU6458628023	Unknown
Winchester City Council	PW000095		SU6293628986	Unknown
Winchester City Council	Note 1	Joan's Acre	SU6134426700	Unknown
Winchester City Council	Note 1		SU6348429054	Unknown
Winchester City Council	Note 1		SU6344629116	Unknown
East Hampshire District Council	LP1110 (Note 2)	Beech Farm	SU6771233650	Ground source heat pumps and PWSs
East Hampshire District Council	Hawbridge Farm	Hawbridge Farm	SU7477041070	Unknown

Note 1: These are locations where Winchester City Council has identified a property that does not have a water supply registered with the council, but there is no known mains water in the area. As such, the properties may be reliant on private groundwater abstractions.

Note 2: This PWS was identified by a landowner at a public consultation event.

1.4.20 Groundwater level data for the unconfined Chalk aquifer are shown on the historical hydrogeology map (BGS, 1979) to vary from 35mAOD on the southern Chalk boundary to 120mAOD to the southeast of Alton. The EA Mole groundwater model shows a high groundwater level in the Chalk in the winter of 2001 when maximum groundwater levels within the study area were modelled to be in the order of 125mAOD to the southeast of Alton.

1.4.21 There is a regional groundwater flow direction from north to south in the southern portion of the Chalk (within Sections A and B) and south to north in the northern portion. The groundwater divide occurs around Alton. A series of springs emerge from the Chalk on its northern boundary with the adjoining Lambeth Group deposits. The Ashley Head Spring is present within the groundwater study area close to the village of Crondall. Further large spring flows occur in the headwaters of the River Itchen and River Alre at New Alresford. These features show that groundwater is close to the surface at these locations at least on a seasonal basis.

1.4.22 EA data on groundwater levels for GWSA-B show that there are 17 groundwater monitoring boreholes within this study area (Figure A8.1.7, Sheets 2 and 3 of 4). The measured water levels (Table 8.1.9) show that, generally, the depth to groundwater is moderately deep ranging from 2.5mbgl (Farringdon Station borehole) to 78.5mbgl. The shallowest groundwater level recorded at the Farringdon Station borehole correlates with the BGS flood susceptibility data, which show there is a susceptibility of groundwater flooding at the surface in this area associated with a dry valley running north to south. Seasonal groundwater level variations in this borehole fluctuate, with some years showing less than 10m and others a much larger change (in excess of 20m).

Table 8.1.9: Groundwater Levels Recorded by the EA within GWSA-B

Borehole Name	NGR	Aquifer Monitored	Period of Record	Maximum Groundwater Level Recorded	
				mbgl	mAOD
Street End	SU5563820009	Chalk	1996		111.89
Lomer Farm Kilmeston	SU5898923642	Chalk	1964 to 2017	32.50	120.50
Parrs Barn	SU6000025150	Chalk	1981 to 2017	49.47	100.53
Kilmeston Roadside	SU0591902482	Chalk	1988 to 2018	22.30	95.70
Parsonage Farm Bramdean	SU0632502815	Chalk	1964 to 2018	8.11	93.89
West Tisted	SU0648402974	Chalk	1981 to 2017	78.57	91.43
Long Houses, Bramdean	SU6329629063	Chalk	1963 to 2017	31.28	94.72
Soames Place Ropley	SU0655503065	Chalk	1965 to 2018	39.82	98.18
Hawthorn	SU6772933502	Chalk	1981 to 2017	48.69	105.31
Kitfield, Four Marks	SU6673533687	Chalk	1987 to 2017	41.83	121.17
Lyeway Lane	SU6546031741	Chalk	1981 to 2017	54.48	98.52
Woodside OBH Chalk	SU0700503622	Chalk	2008 to 2017	5.23	117.14
Woodside OBH_Greensand	SU0700503621	Upper Greensand	2008 to 2017	10.45	111.52
Farringdon Station	SU7045934899	Chalk	2008 to 2017	2.47	118.23
Malms Farm	SU0752204100	Upper Greensand	2008 to 2016	12.36	94.12

Borehole Name	NGR	Aquifer Monitored	Period of Record	Maximum Groundwater Level Recorded	
				mbgl	mAOD
6 Cottages	SU0794704866	Chalk	2008 to 2018	4.22	88.12
Montgomerys Farm	SU0780604664	Chalk	2008 to 2018	41.89	127.17

1.4.23 The susceptibility to groundwater flooding map (Figure A8.1.7) shows where shallow groundwater potentially occurs. This gives rise to the potential for groundwater flooding to occur at the surface or potential for flooding of property situated below ground level. The groundwater flooding map shows potential for shallow groundwater at the following locations:

- at the southern edge of the Chalk;
- in a valley known as Betty Mundy's Bottom;
- in the River Alre valley to the east of Bramdean;
- in the area of Alton associated with the Lavant and Caker Streams and River Wey;
- a small valley to the north of Bentley;
- near the village of Crondall at the northern boundary of the Chalk; and
- at the logistics hub at A31 Ropley Dean.

1.4.24 The EA's EHCC, Mole and Test and Itchen groundwater modelling studies model groundwater levels in the Chalk in GWSA-B. An assessment of the model data show that, over the periods modelled, maximum groundwater levels generally occur in the winter of 2001. Illustration 1.1 shows the modelled water levels for a point along the Order Limits in the south of the study area (where the Order Limits run through the SPZ for Portsmouth Water's Northbrook abstraction). Illustration 1.2 shows the modelled water levels for a point near Crondall where the Order Limits pass through an area identified as being susceptible to flooding at the surface.

Illustration 1.1: Modelled Groundwater Levels Over Time within GWSA-B for the Itchen and Test and EHCC Models

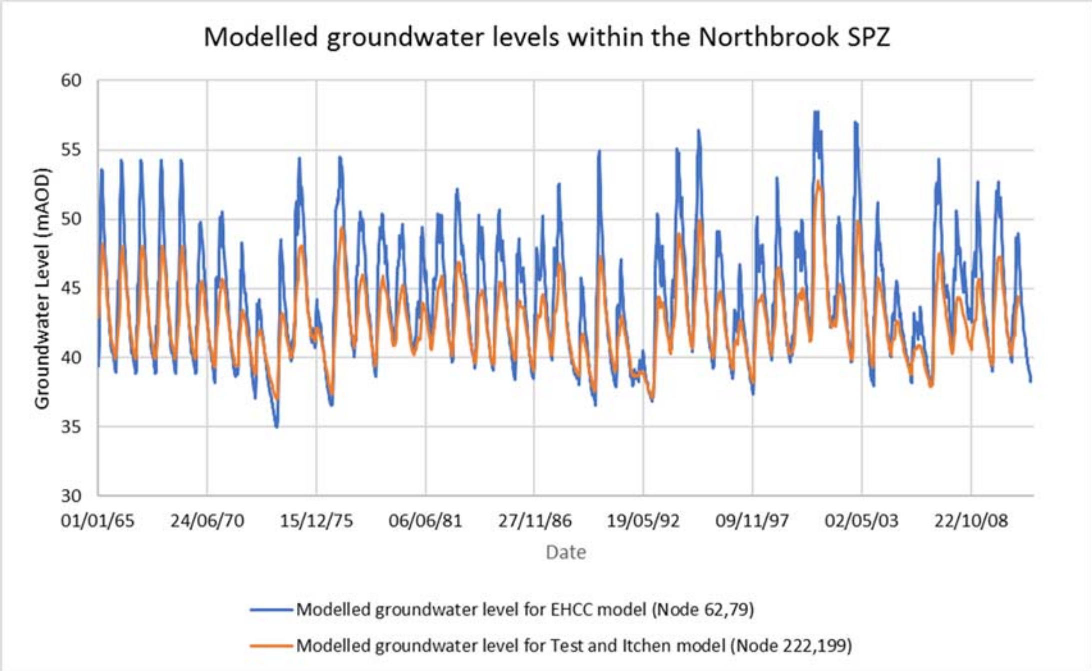
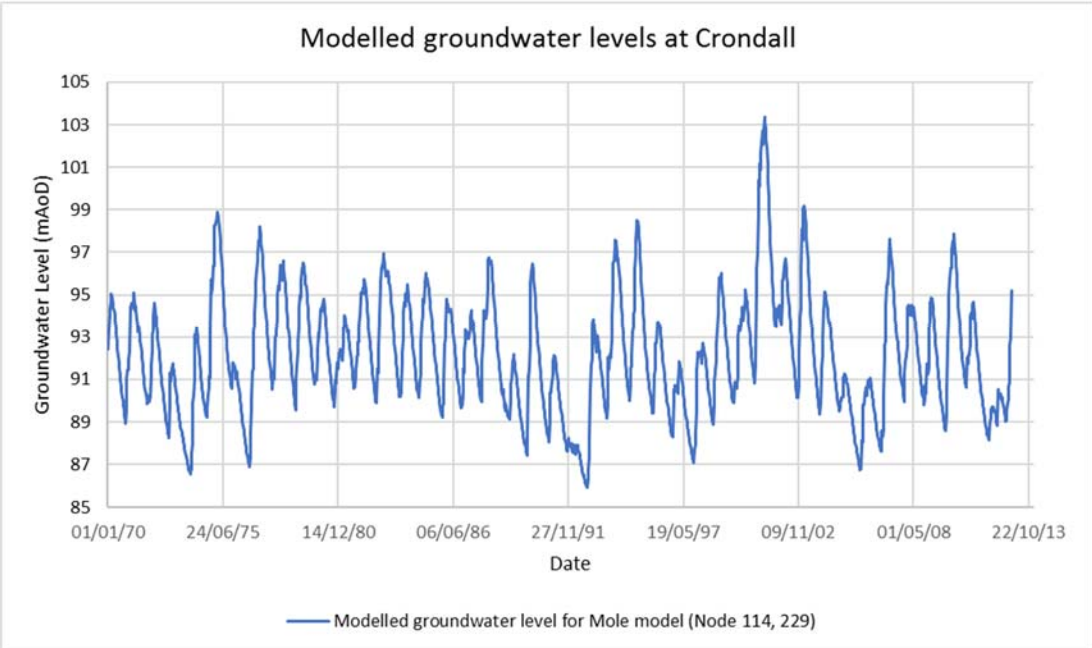


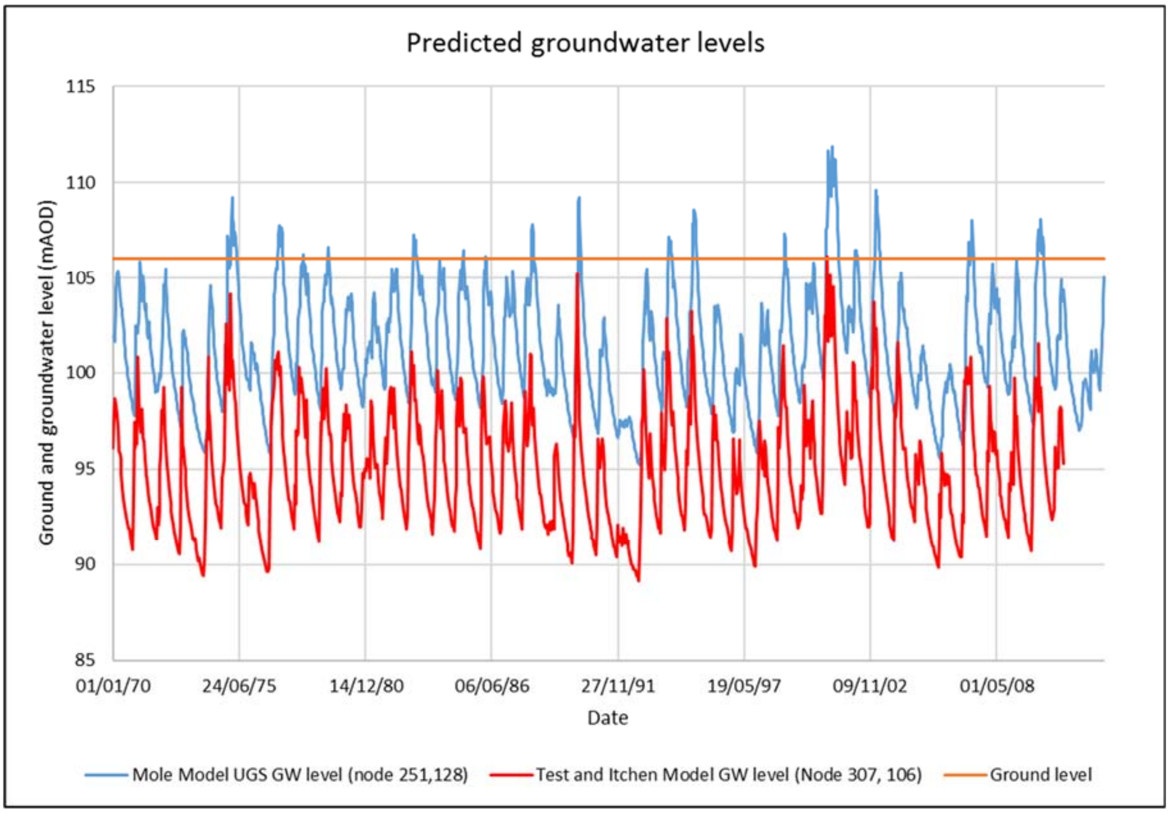
Illustration 1.2: Modelled Groundwater Levels Over Time within GWSA-B for the Mole Model



1.4.25 The groundwater model results show that over much of the area groundwater levels are deep, which does correspond with the majority of the actual monitoring points for the Chalk. The model shows the shallowest levels are recorded at the edge of the Chalk near to where it becomes confined on the northern and southern boundaries of the study area. Shallow groundwater levels are also modelled in the river valleys, particularly the River Wey.

1.4.26 Of particular note for shallow groundwater is the area near Upper Froyle and Lower Froyle where the Order Limits run along the boundary of the Chalk and Upper Greensand aquifers. Here, the Mole and Test and Itchen groundwater models show that potentially, during high groundwater levels, the water table moves above the ground level. For the Test and Itchen groundwater model, only in the most extreme high groundwater level event in 2001 does the groundwater level exceed the ground level (Illustration 1.3). However, for the Mole model the groundwater levels in the Upper Greensand are shown to exceed the ground levels in many winters. This area does correspond to an area identified in the flood susceptibility maps as having potential for groundwater flooding to occur at the surface.

Illustration 1.3: Modelled Groundwater Levels in the Vicinity of Froyle



1.4.27 At the time of writing, 10 boreholes have been installed as part of the 2018 GI in GWSA-B as shown in Table 8.1.10. Groundwater level data loggers have been installed in eight of these boreholes.

Table 8.1.10: Groundwater Levels Recorded in 2018 GI Boreholes within GWSA-B

Borehole Number	NGR	Horizon Monitored	Groundwater Strike		Maximum Groundwater Level Recorded	
			mbgl	mAOD	mbgl	mAOD
BH67	480065 148080	Chalk	No strike recorded		15.62	86.29
BH69	474628 141543	Clay (weathered bedrock)	1.60	96.98	2.42	96.16

Borehole Number	NGR	Horizon Monitored	Groundwater Strike		Maximum Groundwater Level Recorded	
			mbgl	mAOD	mbgl	mAOD
BH98	474783 141440	Sandstone (Upper Greensand)	2.80	88.62	2.46	88.96
BH101	474709 140774	Sandstone (Upper Greensand)	No strike recorded		6.55	93.47
BH102	472968 139007	Chalk	No strike recorded		No data available	
BH103	471422 137091	Chalk	No strike recorded		No data available	
BH104	467215 133164	Chalk	No strike recorded		Dry at 20.25mbgl on all monitoring occasions and on logger	
BH119	462743 127311	Chalk	No strike recorded		8.64	80.31
BH122	454523 119478	Chalk	No strike recorded		Borehole dry at 20.18mbgl on all monitoring occasions	
BH128	470405 136086	Chalk	No strike recorded		7.29	107.48

1.4.28 Based on the above groundwater level information, within GWSA-B, shallow groundwater levels which may be intercepted by the trench excavated to install the pipeline are most likely to occur at the following locations:

- in the vicinity of the A272 to the east of Bramdean (although the crossing of the road would be by trenchless techniques);
- in the vicinity of the A32 to the east of Chawton (although the crossing of the road would be by trenchless techniques);
- the area of Chalk aquifer to the east and northeast of Alton in the Wey Valley, shown on the groundwater flood susceptibility maps as having potential for groundwater flooding at the surface; and
- in the vicinity of Crondall near to where the Chalk aquifer becomes confined.

1.4.29 In terms of WFD groundwater bodies, the Chalk aquifer is split into four waterbodies as shown in Table 8.1.11. Further details, including a map showing the location of the waterbodies, are available in Appendix 8.5 WFD Compliance Assessment. The small section of Upper Greensand Formation crossed near Alton is included in the Alton Chalk groundwater body. The water quantitative and chemical status are also shown in Table 8.1.11.

Table 8.1.11: WFD Groundwater Bodies within GWSA-B

Groundwater Body	Quantitative Status	Chemical Status	Overall Status
East Hants Chalk	Poor	Poor	Poor
River Itchen Chalk	Poor	Poor	Poor
Alton Chalk	Good	Good	Good
Basingstoke Chalk	Poor	Poor	Poor

Groundwater Quality

1.4.30 The natural groundwater quality of the Chalk shows water dominated by calcium bicarbonate. The water is generally of good quality and much of the water is suitable for public supply with minimal treatment. Human impact is most plainly visible in the distributions of nitrate (from agricultural inputs) in the groundwater which is elevated throughout the region (Stuart and Smedley, 2009). Due to the fracture flow and high permeability of the Chalk, if contamination of the aquifer occurs there is rapid transport of contaminants with little attenuation. The absence of superficial deposits overlying much of the Chalk also means that the Chalk aquifer has high vulnerability to contamination from the ground surface with the Permeability Index for the Chalk showing very high fracture permeability. However, where Clay-with-Flints Formation is present these deposits will give some protection to the underlying Chalk.

1.4.31 Data on the groundwater quality in the vicinity of GWSA-B have been obtained from the EA's water quality database. There are seven monitoring points within GWSA-B (Figure A8.1.6). There are a further eight situated on the Chalk and three on the Upper Greensand within 3.6km of the study area (Figure A8.1.6, Sheet 2 of 4). Given the general absence of high permeability superficial aquifers in GWSA-B it is likely that all these monitoring points are measuring water quality in the Chalk or Upper Greensand. Generally, the data show the groundwater to be of good quality and dominated by calcium bicarbonate waters. Nitrate concentrations are typically 5mg/l to 10 mg/l as N. However, one borehole to the east of Bramdean (NGR 467209, 125146) does record up to 13.9mg/l as N and another to the west of Bramdean (NGR 459251, 124780) up to 13.1mg/l as N. The samples show electrical conductivity of around 0.5mS/cm to 0.7mS/cm, and slightly alkaline pH at around 7.4 as measured in situ.

1.4.32 Generally, concentrations of most metals such as lead and nickel are low. However, zinc concentrations are elevated at a number of locations with up to 9.11mg/l recorded in a borehole to the northeast of Upham (NGR 456321, 122899). Copper concentrations are also elevated in this borehole at up to 0.395mg/l. It is noted (Stuart and Smedley, 2009) that some boreholes have groundwaters with relatively high concentrations of copper and zinc. However, this may be due to contamination from wellhead pipework rather than reflecting concentrations in the aquifer. Iron is occasionally recorded at elevated concentrations (up to 5.68mg/l). Pesticides and VOCs are generally absent. Relatively low concentrations of some herbicides such as atrazine and simazine are recorded in a few locations.

1.4.33 Groundwater quality has also been assessed using data from groundwater sampling completed as part of the 2018 GI works with BH67, BH69, BH98, BH101 and BH119 each being sampled on three occasions.

1.4.34 Analytical results from sampling at BH67 shows slightly elevated zinc concentrations on the first two sampling occasions (0.0262mg/l and 0.0292mg/l) but lower concentrations for the third sample collected (0.0757mg/l) and has relatively hard water (up to 1180mg/l total hardness, as $CaCO_3$). Ammoniacal nitrogen was detected at low concentrations during the first two sampling rounds but was not detected in the third sampling round. The groundwater sampled from this borehole also showed low concentrations of TPH, varying from 0.03mg/l to 0.227mg/l. No PAHS or SVOCs were detected in BH67.

1.4.35 At BH119, very hard groundwater was detected in the three sampling rounds (varying from 714mg/l to 6050mg/l). TPH concentrations were elevated during the first sampling round at 0.844mg/l but had fallen to 0.062mg/l in the third sample. Also, during the first sampling round a trace of PAHs was detected (0.00012mg/l) although not on subsequent occasions.

1.4.36 No notable elevated concentrations were detected in the samples collected from BH69, BH98 or BH101, although sulphate concentrations at up to 247mg/l are relatively high. However, these remain within normal limits for the Chalk groundwater. The water type is shown to be hard at all three locations. Results for PAHs, SVOCs, and TPHs are all shown to be below the analytical detection limit in these three boreholes.

1.4.37 With the possible exception of the TPH concentrations decreasing in BH119, no clear temporal trends in concentrations are shown by the data, although the number of samples collected does limit any meaningful assessment.

1.4.38 One groundwater pollution incident is reported by the EA within GWSA-B. This relates to an incident in 2010 approximately 900m to the west of the Order Limits near Alton (NGR 472796, 139287) as shown on Figure A8.1.6 (Sheet 2 of 4). This incident involved the loss of 250 litres of a non-toxic and biodegradeable corrosion inhibitor to a soakaway. Given the age of this incident and nature of pollutant, it is unlikely that any impact on groundwater remains.

Groundwater Dependent Terrestrial Ecosystems

1.4.39 GWDTE identified in GWSA-B are shown in Table 8.1.12 and Figure A8.1.8 (Sheet 2 and Sheet 3 of 4). Further details of these GWDTE are provided in Appendix 8.3 Groundwater Dependent Terrestrial Ecosystems.

Table 8.1.12: GWDTE within GWSA-B

Site Name	Nature Conservation Designation	Determination of Groundwater Dependency*
Peck Copse	SINC	High
Caker and Lavant Streams Floodplain	None	Moderate
Floodplain of River Wey	None	Low
Ashley Head Spring	None	Moderate

1.5 Groundwater Study Area C

Groundwater Resource and Groundwater Levels

1.5.1 Within this study area there are three logistics hubs situated at Hartland Park Village, Farnborough, Ministry of Defence (MoD) land: Deepcut Bridge Road, Frimley Green and at M3 Junction 3: New Road in Windlesham. The Order Limits in GWSA-C cross the bedrock formations as shown in Table 8.1.13. Figure A8.1.4 (Sheet 3 of 4) and Table 8.1.13 show the aquifer designations for these deposits and the table also shows the Permeability Index as defined by the BGS.

Table 8.1.13: Bedrock Geology and Aquifers within GWSA-C

Geological Unit	Description	Aquifer Designation	Permeability Index
Lambeth Group	These sedimentary rocks are detrital, forming sand, silt and clay deposits.	Secondary A aquifer	Mixed moderate to very low permeability
London Clay Formation	These sedimentary rocks are detrital and dominantly comprise clay, with silt and sand forming distinctively graded beds.	Unproductive strata	Mixed moderate to very low permeability
Bagshot Formation (part of the Bracklesham Group)	These sedimentary rocks are detrital, forming coarse to fine grained sand deposits forming interbedded sequences.	Secondary A aquifer	Intergranular, high permeability
Windlesham Formation (part of the Bracklesham Group)	These sedimentary rocks are detrital, forming sand, silt and clay deposits forming interbedded sequences.	Secondary A aquifer	Intergranular, high to low permeability
Camberley Sand Formation (part of the Bracklesham Group)	These sedimentary rocks are detrital, forming coarse to fine grained sand deposits forming interbedded sequences.	Secondary A aquifer	Intergranular, high permeability

1.5.2 There are not many superficial deposits across GWSA-C. However, where present they are associated with the major river valleys. These are likely to be relatively thin deposits. In terms of superficial aquifers, Secondary A aquifers are present in GWSA-C. These are formed by alluvium associated with the Cove Brook and with River Terrace Deposits and alluvium from the River Blackwater and Mill Bourne

(Figure A8.1.5, Sheet 3 of 4). These deposits are shown to have an intergranular Permeability Index of very high to high. Locally, Head deposits composed of clay, silt, sand and gravel are found (classified as Secondary Undifferentiated aquifers with an intergranular Permeability Index of high to very low) as well as Head deposits composed of sand and gravel deposits (classified as Secondary A aquifers with an intergranular Permeability Index of very high to high). The Hartland Park Village, Farnborough logistics hub is situated in an area where Head (sand and gravel) deposits are present whilst the hub at MoD land: Deepcut Bridge Road, Frimley Green is situated on River Terrace Deposits with the potential for Alluvium also to be present. The logistics hub at M3 Junction 2: New Road, Windlesham is shown to be situated on a peat deposit.

1.5.3 In the vicinity of Lightwater, the Surrey Hill Gravel Member (classified as a Secondary A aquifer with intergranular Permeability Index of very high to high) is crossed by the Order Limits. At Chobham Common the Order Limits cross small patches of the Taplow Gravel Formation (classified as a Secondary A aquifer with an intergranular Permeability Index of very high to high). Peat deposits are also locally indicated by the BGS map (classified as unproductive strata with a mixed Permeability Index of low to very low) which are of negligible value in terms of groundwater resources.

1.5.4 The Lambeth Group outcrops for a small portion at the southern end of GWSA-C and this deposit is noted to have variable permeability. However, due to increased clay content, permeability decreases in the west and borehole yields are low (Jones et. al., 2000). The majority of the London Clay Formation is of little significance as an aquifer, due to its predominantly clayey nature.

1.5.5 Of more importance to water supplies (for abstraction and to provide baseflow to watercourses) are the Bagshot and the Camberley Sand Formations associated with the Bracklesham Group. The Bagshot Formation can support small abstractions, but these are often severely limited by fine silt, easily mobilised from the formation. Measured borehole yields indicate that around 600m^3/d may be obtained but supplies of up to 150m^3/d are more common. Springs occur at the junction with underlying clays (Jones et. al., 2000).

1.5.6 Small supplies only are obtained from the Camberley Sand Formation with measured borehole yields of up to 50m^3/d being common. Springs occur at the junction of the Camberley Sand Formation with the lower permeability Windlesham Formation. As a groundwater resource, the Camberley Sand Formation is considered secondary to the Bagshot Formation in the London Basin (Jones et. al., 2000).

1.5.7 Beneath this section, confined Chalk is present as the Chalk is overlain by low permeability Lambeth Group and London Clay deposits which will act as a confining layer for the Chalk groundwater. Over most of GWSA-C, the depth to the confined Chalk aquifer is considerable. For example, a borehole log at Bourley Lane in Aldershot shows the Chalk to be at 141m depth and a borehole drilled at Alexandra Road in Farnborough did not reach the Chalk despite being 79m deep. As such, excavations for the pipeline, even at the deepest river crossings, would not encounter the confined Chalk and a high level of protection would remain.

1.5.8 At the boundary of the Chalk and Lambeth Group deposits, it is possible that groundwater in the two deposits are in hydraulic connection. However, BGS borehole logs at Redlands to the east of Crondall at the edge of the Lambeth Group deposits show these deposits to be very clayey in nature which will confine the groundwater in the Chalk. As such, it is unlikely that the two units are in hydraulic connection.

1.5.9 The SPZ map does not show any SPZs to be present within GWSA-C (Figure A8.1.6, Sheet 3 of 4).

1.5.10 Table 8.1.14 provides a summary of the identified licensed groundwater abstractions within GWSA-C. No unlicensed PWS groundwater abstractions have been identified within GWSA-C, although Hart District Council did not provide any data.

Table 8.1.14: Identified Licensed Groundwater Abstractions within GWSA-C

Licence Number	Name	No. of Abstraction Points	Max Annual Quantity (m3/yr)	Max Daily Quantity (m3/day)	NGR	Primary Use of Abstraction
28/39/29/0058/R01	Foxhills	1	10,000	100	TQ01206482	Industrial, Commercial and Public Services
28/39/30/0436/R01	Woodcock	2	20,000	68	SU9592363164	Agriculture

1.5.11 EA data on groundwater levels for GWSA-C show that there is one groundwater monitoring borehole within this study area (Figure A8.1.7, Sheet 3 of 4). The measured water levels (Table 8.1.15) show that the shallowest groundwater level recorded in this borehole is 4.75mbgl. This borehole is close to the edge of Chobham Common, an area known to have groundwater dependence. This measured thin unsaturated zone agrees with the BGS flood susceptibility data, which identify that there is a susceptibility of groundwater flooding to below ground property in this area.

Table 8.1.15: Groundwater Levels Recorded by the EA within GWSA-C

Borehole Name	NGR	Aquifer Monitored	Period of Record	Highest Groundwater Level Recorded	
				mbgl	mAOD
Brock Cottage OBH	SU9649063340	Bracklesham Group	2008 to 2017	4.75	41.98

1.5.12 Generally, it is likely that groundwater levels are shallowest in the watercourse valleys. This is particularly true for a tributary of the River Blackwater near Frimley Green, where the flood susceptibility map (Figure A8.1.7, Sheet 3 of 4) shows there is the potential for groundwater flooding of below ground property. A further smaller area where there is susceptibility to groundwater flooding at the surface is to the east of Frimley. Further shallow groundwater could be expected from Bagshot Heath to the east of Chobham Common. Here, much of the route runs through areas susceptible to groundwater flooding at the surface or to below ground property. The logistics hub at Hartland Park Village, Farnborough is partly located on an area identified as being susceptible to groundwater flooding for property located below ground level.

1.5.13 The EA's Mole groundwater modelling study does model groundwater levels in the confined Chalk in GWSA-C. However, as the pipeline trench would not reach the Chalk (including at any trenchless crossing points), the water level data from the models are not relevant to the project.

1.5.14 At the time of writing, the 2018 GI has installed 10 boreholes in GWSA-C as shown in Table 8.1.16. Groundwater level data loggers have been installed in nine of these boreholes.

Table 8.1.16: Groundwater Levels Recorded in the 2018 GI Boreholes within GWSA-C

Borehole Number	NGR	Horizon Monitored	Groundwater Strike		Maximum Groundwater Level Recorded	
			mbgl	mAOD	mbgl	mAOD
BH34	498612 164440	Dominantly silty sand	No strike recorded		2.44	37.75
BH35	497779 164074	Slightly silty sand	No strike recorded		1.08	37.66
BH37	496242 163052	Slightly silty sand	3.70	35.17	2.36	36.51
BH39	493920 161645	Clayey sand	No strike recorded		3.12	48.37
BH55	487051 156209	Slightly silty sand	3.75	69.18	5.40	67.53
BH56	485742 155974	Slightly silty sand	1.40	60.57	1.56	60.41
BH59	485281 154829	Silty sand	1.65	61.03	0.47	62.21
BH138	498072 164226	Sand	0.8	39.2	0.08	39.01
BH151	487989 157433	Sandy gravel	1.40 3.18	62.15 60.37	1.22	62.33
BH155	487494 156660	Slightly silty sand	3.1	61.98	2.32	62.76

1.5.15 Based on the above groundwater level information, within GWSA-C, shallow groundwater levels which may be intercepted by the trench excavated to install the pipeline are most likely to occur at the following locations:

- in the vicinity of Folly Bog (part of Colony Bog and Bagshot Heath SSSI) to the south of Lightwater;
- at the crossing of the Haleborne to the north of West End;
- in the vicinity of Windlesham Road and the B383 to the northwest of Chobham; and

- at Chobham Common SSSI (although the shallowest areas would use trenchless crossings (see Appendix 8.2 Detailed Trenchless and Targeted Trench Assessments for further details)).

1.5.16 In terms of WFD groundwater bodies, GWSA-C incorporates three waterbodies as shown in Table 8.1.17. Further details, including a map showing the location of the waterbodies being available in Appendix 8.5 WFD Compliance Assessment. The water quantitative and chemical status are also shown in Table 8.1.17.

Table 8.1.17: WFD Groundwater Bodies within GWSA-C

Groundwater Body	Quantitative Status	Chemical Status	Overall Status
Old Basing Tertiaries	Poor	Good	Poor
Farnborough Bagshot Beds	Good	Good	Good
Chobham Bagshot Beds	Good	Good	Good

Groundwater Quality

1.5.17 Bearcock and Smedley (2010) indicate that the most common water type found in the Palaeogene aquifer is calcium bicarbonate to calcium sulphate type groundwater. High levels of agricultural pollutants (most notably nitrate) are found in many areas. These waters are generally fresh with slightly acidic conditions with a pH of less than 7. Iron and manganese concentrations vary over a wide range, but high concentrations are recorded as being present near to the Order Limits. Given the rural nature of much of the study area, human influence on groundwater quality (other than agricultural) is likely to be slight, although in the more urbanised areas groundwater contamination cannot be ruled out.

1.5.18 Data on the groundwater quality in the vicinity of GWSA-C have been obtained from the EA's water quality database. There are two monitoring points within GWSA-C with a further three within 1.1km (Figure A8.1.6, Sheet 3 of 4). Groundwater and leachate quality data in relation to the Trumps Farm landfill site situated on the northern boundary of GWSA-C are also available. Given the general absence of high permeability superficial aquifers in GWSA-C, it is likely that all monitoring points are measuring water quality in the Bracklesham Group bedrock. The samples show electrical conductivity of around 0.2 to 0.4mS/cm, and slightly acidic pH at around 5.0 to 6.5 as measured in situ.

1.5.19 Generally, concentrations of most metals such as lead and copper are low. However, nickel concentrations of up to 0.045mg/l and aluminium concentrations of up to 13.1mg/l have been recorded. Zinc concentrations are also elevated with up to 1.64mg/l recorded in a borehole at Camberley Heath Golf Club, 500m north of the study area (NGR 489100, 159720). Pesticides and VOCs are generally absent in the monitoring data.

1.5.20 The data collected around Trumps Farm landfill show that groundwater is potentially being impacted by landfill leachate, with elevated ammoniacal nitrogen being detected in one location.

1.5.21 Water quality samples have also been collected during the 2018 with three samples being collected from each of the boreholes shown in Table 8.1.16.

1.5.22 The results from BH34 showed slightly elevated ammoniacal nitrogen concentrations on the first sampling occasion (0.77mg/l) and also showed relatively low pH (acidic conditions) at around 5.8 on all sampling occasions. Groundwater from this borehole also showed trace concentrations of PAHs and TPH.

1.5.23 The results from BH35 show elevated chemical oxygen demand (COD) concentrations (up to 266mg/l) with a low concertation of ammoniacal nitrogen detected during the first monitoring round (0.53mg/l). Zinc concentrations varied from 0.019mg/l to 0.047mg/l with all samples showing relatively low pH (acidic conditions) at around 5.5 to 6.0. Trace concentrations of PAHs were detected in all three samples from BH35 with TPH showing elevated concentrations in the first monitoring round (0.46mg/l) but this had fallen to a trace concentration by the third monitoring round.

1.5.24 The results for BH37 show slightly elevated nickel (0.0288mg/l to 0.0341mg/l) and zinc concentrations (0.016mg/l to 0.02mg/l) as do the results from BH39 (nickel concentrations of 0.037mg/l and zinc concentrations varying from 0.069mg/l to 0.076mg/l). BH39 also showed slightly elevated chloride concentrations at around 140mg/l. Very low TPH concentrations have been detected in these two boreholes with a maximum concentration of 0.045mg/l. PAHs and SVOCs have not been detected.

1.5.25 The results from BH56 show elevated ammoniacal nitrogen concentrations with a maximum concentration recorded of 5.90mg/l. Groundwater from this borehole also showed slightly elevated COD concentrations (up to 58.3mg/l) and elevated sulphate concentrations (up to 329mg/l).

1.5.26 The results from BH59 showed elevated ammoniacal nitrogen concentrations at up to 3.65mg/l and elevated COD concentrations up to 749mg/l in all three samples. Boron concentrations in this borehole were also elevated (up to 1.42mg/l) with slightly elevated sulphate and chloride concentrations (up to 85mg/l and 75mg/l respectively). Low concentrations of PAHs were detected on all three sampling occasions in BH59 with TPH also being detected. For TPH, the concentrations fell from 8.14mg/l in the first sampling round to 0.40mg/l in the third.

1.5.27 The results from BH138 showed slightly elevated ammoniacal nitrogen concentrations at up to 1.04mg/l with slightly acidic conditions recorded (pH of around 6.0). This borehole also recorded trace concentrations of TPH on two sampling occasions and trace concentrations of PAHs on the third sampling occasion.

1.5.28 BH55, BH151 and 155 showed no notable results with the exception of a very low concentration of TPH detected in BH55 on one occasion (0.030mg/l) and slightly higher TPH concentration in BH151 on two occasions at 0.103mg/l and 0.181mg/l and in BH155 on one occasion (0.091mg/l). A very low concentration of PAHs was also detected on one occasion at 0.000121mg/l in BH151 and at 0.000105mg/l in BH155. The SVOC n-dibutyl phthalate was detected within the SVOC analysis on two occasions in BH155 (at 0.000124mg/l and 0.000171mg/l).

1.5.29 One groundwater pollution incident is reported by the EA within GWSA-C. This relates to an incident in 2002 approximately 1km to the east of the Order Limits at

Farnborough (NGR 485580, 153850) as shown on Figure A8.1.6 (Sheet 3 of 4). This incident involved the loss of an unknown quantity of diesel fuel. Following the incident, approximately 40 tonnes of contaminated soils were excavated and groundwater testing carried out. Pending receipt of the full report, the EA considered remediation to be complete and acceptable.

Groundwater Dependent Terrestrial Ecosystems

1.5.30 An assessment of designated ecology sites along the route has identified that, in GWSA-C, GWDTE are present as shown in Table 8.1.18 and Figure A8.1.8 (Sheet 3 of 4). Further details of these GWDTE are provided in Appendix 8.3 Groundwater Dependent Terrestrial Ecosystems.

Table 8.1.18: GWDTE within GWSA-C

Site Name	Nature Conservation Designation	Determination of Groundwater Dependency
Ewshot Meadows	SINC	Moderate
Bourley and Long Valley Sub-sites: Wet heathland, Southerly wet woodland	SSSI, Special Protection Area (SPA)	High to moderate
Bourley and Long Valley Sub-sites: Gelvert Stream floodplain, Southwest Order Limits and Northeast Order Limits	SSSI, SPA	Low
Eelmoor Marsh	SSSI, SPA	High
Ively Road (Golf course)	Includes South of Ively Road SINC	Low
Cove Brook (flood storage)	SINC	Low to moderate
Blackwater Valley - Frimley Hatches Sub-site: Blackwater Valley - Frimley Green	SINC	Low
Blackwater Valley - Frimley Hatches Sub-site: Blackwater Valley - Frimley Hatches	Site of Nature Conservation Interest (SNCI)	Moderate
Colony Bog and Bagshot Heath Sub-site: West and North Order Limits	SSSI, SPA, Special Area of Conservation (SAC)	Low
Colony Bog and Bagshot Heath Sub-site: Turf Hill	SSSI, SPA, SAC	Moderate
Colony Bog and Bagshot Heath Sub-site: Centre of Site	SSSI, SPA, SAC	High
Folly Bog Sub-site: majority of Bog Mire	SSSI, SPA, SAC	High
Folly Bog Sub-site: Northeastern area	SSSI, SPA, SAC	Moderate
Chobham Common Sub-site: Central and northeastern part of Order Limits	SSSI, SPA, SAC	Moderate
Chobham Common Sub-site: remaining part of Chobham Common	SSSI, SPA, SAC	Low or none
Foxhills	None	High to moderate

1.6 Groundwater Study Area D

Groundwater Resource and Groundwater Levels

1.6.1 GWSA-D has been defined based on the superficial deposits as these deposits form Principal aquifers. As such, in this length of the route the bedrock deposits may be of less importance than the superficial deposits in terms of the shallow groundwater. Within GWSA-D, a logistics hub would be located at Brett Aggregates, Littleton Lane, Shepperton. This hub would be adjacent to the Order Limits for the pipeline and, as such, is not considered separately in this section.

1.6.2 Superficial deposits are extensive across GWSA-D and many of these deposits form Principal aquifers, as shown in Table 8.1.19 and Figure A8.1.5 (Sheet 4 of 4). The gravel deposits are known collectively as the Lower Thames Gravel Aquifer. The gravels have a typical thickness of around 5m to 8m, but can be much thicker where they infill deep hollows. Table 8.1.19 also shows the Permeability Index as defined by the BGS.

Table 8.1.19: Superficial Geology and Aquifers within GWSA-D

Geological Unit	Description	Aquifer Designation	Permeability Index
Alluvium Silt	Principally silt associated with river deposits. Mainly encountered in the vicinity of the River Thames.	Secondary A aquifer	Intergranular, high to very low permeability
Kempton Park Gravel Member	These deposits are detrital, forming sand, and gravel beds and lenses.	Principal aquifer	Intergranular very high to high permeability
Shepperton Gravel Member	These deposits are detrital, forming sand, and gravel beds and lenses.	Principal aquifer	Intergranular very high to high permeability
Lynch Hill Gravel Member	These deposits are detrital, forming sand and gravel beds, locally with lenses of silt, clay or peat.	Secondary A aquifer	Intergranular very high to high permeability
Head deposits	These deposits are detrital, of clay, silt, sand and gravel.	Secondary Undifferentiated aquifer	Intergranular high to very low permeability
Langley Silt Member	These deposits are detrital, forming clay and silt beds and lenses.	Unproductive strata	Intergranular low to very low permeability

1.6.3 The Order Limits in GWSA-D cross the bedrock formations as shown in Table 8.1.20. Figure A8.1.4 (Sheet 4 of 4) and Table 8.1.20 show the aquifer designations for these deposits. The table also shows the Permeability Index as defined by the BGS.

Table 8.1.20: Bedrock Geology and Aquifers within GWSA-D

Geological Unit	Description	Aquifer Designation	Permeability Index
Bagshot Formation (part of the Bracklesham Group)	These sedimentary rocks are detrital, forming coarse to fine grained sand deposits forming interbedded sequences.	Secondary A aquifer	Intergranular, high permeability

Claygate Member (part of the London Clay Formation)	These sedimentary rocks are detrital, forming sand, silt and clay deposits forming interbedded sequences.	Secondary A aquifer	Intergranular high to low permeability
London Clay Formation	These sedimentary rocks are detrital and mainly comprise clay, with silt and sand forming distinctively graded beds.	Unproductive strata	Mixed moderate to very low permeability

1.6.4 In GWSA-D, the confined Chalk is present beneath the overlying bedrock. However, the depth to confined Chalk is considerable (for example, a log for a borehole at Staines Reservoir shows the Chalk being encountered at 88m depth and a log for a borehole in Stanwell as being 96m deep) and is overlain by low permeability London Clay deposits. These deposits will act as a confining layer for the Chalk groundwater. Excavations for the pipeline, even at the deepest river crossings, would not encounter the confined Chalk. A high level of protection would therefore remain.

1.6.5 The SPZ map (Figure A8.1.6, Sheet 4 of 4) shows that the Order Limits cross SPZ2 associated with an abstraction operated by Affinity Water about 1.2km to the north of the Order Limits at Chertsey. This abstraction takes groundwater from the superficial deposits and the geology map indicates this to be the Shepperton Gravel Member. Data provided by Affinity Water show that, when abstracting groundwater, groundwater levels to the east of the Thames are affected by the pumping and the Thames does not provide a barrier to flow in this area.

1.6.6 Table 8.1.21 and Table 8.1.22 provide a summary of the identified licensed and unlicensed PWS groundwater abstractions within GWSA-D.

Table 8.1.21: Identified Licensed Groundwater Abstractions within GWSA-D

Licence Number	Name	No. of Abstraction Points	Max Annual Quantity (m3/yr)	Max Daily Quantity (m3/day)	NGR	Primary Use of Abstraction
28/39/27/0033	Chertsey	10	9,983,225	40,914	TQ0467	Water Supply
28/39/31/0004		1	16,500	190	TQ0681070900	Industrial, Commercial and Public Services
28/39/31/0007	Littleton Lane	4	1,272	22.7	TQ067683	Agriculture
28/39/31/0113	Shepperton Lane	2	25,000	400	TQ059683 and TQ058678	Agriculture
28/39/31/0143	Laleham Road	2	6,818	304.6	TQ063685	Agriculture
28/39/31/0144	Mayfield Farm	1	22,730	218.2	TQ07587334	Agriculture
28/39/31/0146	Bridge Farm Nursery	2	2,909	36.4	TQ075722	Agriculture
28/39/31/0168	Littleton Lane	1	9,000	50	TQ0579067300	Industrial, Commercial

						and Public Services
28/39/31/0176/R01	Notcutts Garden Centre	2	13,000	60	TQ0480069700	Agriculture
28/39/31/0185/R01	Clock House Lane	3	322,800	4,906	TQ0770072940 and TQ0755672841	Industrial, Commercial and Public Services
28/39/31/0189/R01	Hengrove Farm	1	625,000	2,727	TQ0535072100	Industrial, Commercial and Public Services
TH/039/0031/007	Littleton Gravel Pit	2	1,272,037	4,819	TQ0578067628 and TQ0579767353	Industrial, Commercial and Public Services
TH/039/0031/008	Gravels at Ashford Road		1,760,000	5,730	TQ0616970248	Industrial, Commercial and Public Services

Table 8.1.22: Identified Unlicensed Groundwater Abstractions within GWSA-D

Local Authority Area	Reference Number	Name	NGR	Primary Use of Abstraction
Spelthorne District Council		Laleham Nurseries*	TQ0631468504	Plant nursery
Runnymede Borough Council	P3100004	Highlands	TQ0570566324	Unknown
Runnymede Borough Council	P3100005	Delicia	TQ0580866406	Unknown

** The location of this abstraction matches that of the licensed groundwater abstraction 28/39/31/0143 and is likely to be the same abstraction.*

1.6.7 Several flooded gravel pits are present within and around GWSA-D. Water in these pits is very likely to be connected to the groundwater in the surrounding gravel aquifers. This would indicate that groundwater is at a relatively shallow depth.

1.6.8 The groundwater flood susceptibility map (Figure A8.1.7, Sheet 4 of 4) shows there is the potential for groundwater flooding of below ground property and at the surface for much of the length of the route in GWSA-D. It is therefore anticipated that shallow groundwater levels would be encountered for almost the entire length of the GWSA-D Order Limits, from the north of Addlestone to the Esso West London Terminal storage facility.

1.6.9 At the time of writing, 10 boreholes were installed as part of the 2018 GI in GWSA-D, as shown in Table 8.1.23. Groundwater level data loggers have been installed in eight of these boreholes, although data are still required to be downloaded from some of them. The data show that groundwater strikes are encountered at shallow depth, with the shallowest strike being 0.83mbgl in BH10.

Table 8.1.23: Groundwater Levels Recorded in the 2018 GI Boreholes within GWSA-D

Borehole Number	NGR	Horizon Monitored	Groundwater Strike		Maximum Groundwater Level Recorded	
			mbgl	mAOD	mbgl	mAOD
BH01	506861 173357	No installation	No strike recorded		No data available	
BH03	506647 172493	Made ground (very sandy clay)	2.10	13.49	2.14	13.45
BH04	506611 172293	Made ground (gravelly clay)	4.5	13.21	4.09	13.62
BH06	506515 172057	Very gravelly sand	No strike recorded		1.83	13.56
BH08	505795 171330	Slightly silty clay	1.7	11.96	0.83	12.83
BH09	505882 171036	Silty clay	1.7	11.71	0.62	12.79
BH10	506308 170724	Sand and gravel	0.83	11.97	0.13	12.67
BH25	505975 166819	Very sandy gravel	13.5	-2.07	0.55	10.88
BH26	505990 166652	Sand and gravel	1.26	10.19	0.88	10.57
BH29	505011 165824	Sandy silty clay and silty sand	No strike recorded		1.09	9.81
BH30	504686 165624	Gravel, silty sandy clay and clayey silty sand	1.4 2.0	11.84 11.24	0.32	12.92
BH32	503445 165953	Sandy clay, silty sand	1.4	20.84	5.71	14.19
BH139	505234 166096	Very sandy gravel	1.93	10.31	0.84	11.40
BH150	505792 166251	Silty clay	1.5	9.8	0.09	11.21

1.6.10 Due to the presence of authorised and historical landfills within GWSA-D, a number of historical site investigations have been undertaken within the study area, although the dataset is limited (Appendix 11.1 Soils and Geology Baseline Condition Report and Land Contamination Assessment, identifies these landfills). Table 8.1.24 records the depth to groundwater in monitoring boreholes present within the Order Limits for GWSA-D.

Table 8.1.24: Groundwater Levels Recorded in Landfill Ground Investigation Boreholes within the Order Limits of GWSA-D

Landfill	Borehole No.	Maximum Groundwater Level Recorded	Average Groundwater Level

		mbgl	mAOD	mbgl	mAOD
Laleham	GWM42	1.31	11.69	2.3	10.7
	GWM43	1.15	11.85	2.3	10.7
South of Queen Mary Reservoir	M8	1.8	12.2	1.6	11.4
	M6	1.6	11.4	1.6	11.4
Reservoir Aggregates Limited	W11a	2.5	11.5	2.5	11.5
	W16a	1.4	11.6	1.4	11.6
	W12a	1.8	12.2	1.8	12.2

1.6.11 Based on the above groundwater level information, within GWSA-D, shallow groundwater which may be intercepted by the trench excavated to install the pipeline are most likely to occur at the following locations:

- the area where the proposed trench crosses the Bourne and Chertsey Meads SSSI to the east of Chertsey; and
- the entire length of the proposed pipeline route to the north of the River Thames to the Esso West London Terminal storage facility.

1.6.12 In terms of WFD groundwater bodies, the Chobham Bagshot Beds extend into GWSA-D associated with the bedrock aquifer. GWSA-D then extends into the Lower Thames Gravels groundwater body. This has good quantitative and chemical status and consequently has good overall status. Further details, including a map showing the location of the waterbodies is available in Appendix 8.5.WFD Compliance Assessment.

Groundwater Quality

1.6.13 Groundwater quality of GWSA-D may be impacted as a result of the urbanised nature of the area and the presence of various landfills and backfilled gravel pits (see Chapter 11 Soils and Geology for the location of landfills). As waste degrades, a liquid called “leachate” is produced which can potentially enter the groundwater system. The composition of the leachate will depend to a large extent on the material which has been placed in the landfill and will vary over time. However, elevated chloride and ammoniacal nitrogen concentrations are key indicators of landfill leachate, and in some cases, metals and organic compounds may also be elevated. Landfills which have accepted “inert waste” will normally have lower concentrations of contaminants in its leachate than landfills which have accepted household or industrial waste.

1.6.14 Data on the groundwater quality in the vicinity of GWSA-D have been obtained from the EA’s water quality database. There are no monitoring points within GWSA-D although there is one close to the study area at Chertsey (NGR 504660, 167660), located approximately 120m outside the GWSA-D boundary (Figure A8.1.6, Sheet 4 of 4). This is situated on the boundary of alluvium and the Shepperton Gravel Member with Bagshot Beds beneath. The borehole description indicates the borehole to be 6.7m deep, and based on geological logs on the BGS website it is likely that the groundwater is obtained from the gravels.

1.6.15 The data comprise eight samples collected between 2000 and 2006. Generally, the data show the groundwater to be of good quality with electrical conductivity of around 0.6 to 0.7mS/cm, and slightly alkaline pH (7.4 measured in situ). Orthophosphate concentrations are slightly raised, but there are low concentrations of metals. Pesticides and VOCs are generally absent, although the pesticides atrazine, simazine and permethrin have been detected.

1.6.16 Groundwater samples were also taken on three occasions as part of the 2018 GI at BH03, BH04, BH06, BH08, BH09, BH10, BH25, BH26, BH29, BH30, BH139 and BH150.

1.6.17 BH03 and BH04 both showed elevated concentrations of certain determinands with the following being of particular note:

- ammoniacal nitrogen up to 14.8mg/l in BH03 and 17.0mg/l in BH04;
- sulphate up to 638mg/l in BH03 and 452mg/l in BH04;
- chloride in BH04 up to 169mg/l;
- certain metals in BH04 including boron up to 19.2mg/l, total chromium up to 0.395mg/l (although only in one sample was chromium so elevated), nickel up to 0.0235mg/l and zinc up to 0.037mg/l;
- boron and chromium in BH03 up to 3.35mg/l and 0.514 mg/l respectively;
- pH in BH03 up to 10.30 (indicative of alkaline conditions);
- PAHs up to 0.0212mg/l in BH03 and up to 0.164mg/l in BH04; and
- TPH up to 2.2mg/l in BH03 and 8.95mg/l in BH04.

1.6.18 The samples from BH06 showed slightly elevated ammoniacal nitrogen concentrations at up to 1.31mg/l and slightly elevated pH at up to 8.13. TPH was detected in the first two samples at up to 0.906mg/l. Other organic compounds were largely absent in the samples from BH06, although bis(2-ethylhexyl) phthalate was detected on one occasion at 0.00364mg/l.

1.6.19 Samples form BH08 and BH09 showed no notable results, although both showed low concentrations of ammoniacal nitrogen (up to 0.66mg/l) and the SVOC bis(2-ethylhexyl) phthalate was detected on one occasion in BH08 at 0.00262mg/l.

1.6.20 Within BH10, chloride concentrations are elevated at up to 197mg/l and ammoniacal nitrogen concentrations are also slightly elevated at up to 0.96mg/l. In BH25, ammoniacal nitrogen concentrations are also slightly elevated at up to 1.26mg/l. BH25 also detected low concentrations of organic determinands, with TPH detected on the first two sampling occasions (at up to 0.303mg/l) and PAHs on the first sampling occasion (at 0.000199mg/l).

1.6.21 In BH26, ammoniacal nitrogen concentrations were slightly elevated (up to 0.64mg/l) with trace TPH and trace PAH concentrations recorded on one occasion. In BH29 and BH30 no notable results were detected with the exception of slightly elevated concentrations of ammoniacal nitrogen in BH30 (up to 0.62mg/l) with the third sample from this borehole also showing elevated cyanide (0.34mg/l). With the exception of one slightly elevated TPH result (0.020mg/l), no noteworthy elevated concentrations were measured in BH139.

1.6.22 In BH150, elevated ammoniacal nitrogen concentrations were detected on all three sampling occasions with a maximum concentration of 1.11mg/l detected on the first sampling occasion. This sample also showed slightly elevated zinc concentration at 0.041mg/l.

1.6.23 Data have also been made available from long term water quality monitoring at landfill monitoring locations. Location GWM42 in Laleham has data derived from monitoring on a bi-annual basis with the most recent data available being for February 2017. The results show a slightly elevated ammoniacal nitrogen (as N) concentration of 2.1mg/l and a slightly elevated electrical conductivity value of 0.874mS/cm. Metals including potassium, sodium and zinc show values that are variable over time, but generally below concentrations that may be indicative of contaminated groundwater.

1.6.24 Data from the landfills are also available for location GWM43 in Laleham. The most recent data for February 2018 show that ammoniacal nitrogen (as N) was elevated at 10.4mg/l with slightly elevated electrical conductivity at 0.755mS/cm. The pH value of 8.6 shows slightly alkaline groundwater. In this borehole, metal concentrations vary over time but are either below their respective analytical limits of detection or are present at concentrations that are considered to not be greatly elevated.

1.6.25 No groundwater pollution incidents are reported by the EA within GWSA-D.

Groundwater Dependent Terrestrial Ecosystems

1.6.26 An assessment of designated ecological sites along the route has identified that in GWSA-D, GWDTE are present as shown in Table 8.1.25 and Figure A8.1.8 (Sheet 4 of 4). Further details of these GWDTE are provided in Appendix 8.3 Groundwater Dependent Terrestrial Ecosystems.

Table 8.1.25: GWDTE within GWSA-D

Site Name	Nature Conservation Designation	Determination of Groundwater Dependency
Addlestone Moor	None	Moderate to low
Chertsey Meads	LNR	Low
Dumsey Meadow hollows	SSSI	Low to moderate
Dumsey Meadow high ground	SSSI	None

1.7 Changes to Groundwater Baseline Due to Climate Change

1.7.1 Over the medium and long term, groundwater resources in the study area may be affected by climate change. There are a number of models covering the UK which simulate the change in climate. The UK Climate Impact Programme (2018) indicates that, in the future, winters may be generally wetter and summers substantially drier for the whole of the UK.

1.7.2 The direct effect of climate change on groundwater resources depends primarily on the change in the volume and distribution of groundwater recharge. If drier, warmer summers lead to the seasonal deficits in the moisture content of soils extending into the autumn, the winter groundwater recharge season may be shortened. This could be compensated, at least to some extent, by an increase in winter rainfall. However, aquifers are recharged more effectively by prolonged steady rain, which continues into the spring, rather than short periods of intense rainfall, which often result in a high proportion of rapid surface runoff rather than infiltration (UK Groundwater Forum, 2018).

1.7.3 In general, the effects of climate change on groundwater in the UK therefore may include:

- a long term decline in groundwater storage;
- increased frequency and severity of groundwater droughts;
- increased frequency and severity of groundwater-related floods; and
- mobilisation of pollutants due to seasonally high water tables.

1.7.4 Therefore, with respect to the project and surrounding area, these effects could result in local impacts on the stream flows that are sustained in part by groundwater flow. In addition, a reduction in groundwater levels during prolonged dry periods could affect PWSs and GWDTE that are sustained by shallow groundwater flows. If seasonally high groundwater levels are encountered, due to increased winter rainfall, then groundwater levels could rise into trenches in which the pipeline is laid that are currently not in contact with groundwater.

1.8 References

Allen, D J, Brewerton, L J, Coleby, L M, Gibbs, B R, Lewis, M A, MacDonald, A M, Wagstaff, S J and Williams, A T (1997). The Physical Properties of Major Aquifers in England and Wales. Technical Report WD/97/34. NERC and Environment Agency, British Geological Survey, Keyworth.

Bearcock J M and Smedley P L (2010). Baseline groundwater chemistry: The Palaeogene of the Thames Basin. Groundwater Programme. Open Report OR/10/057. British Geological Survey, Keyworth.

British Geological Survey (1979). Hydrogeological Map of Hampshire and the Isle of Wight. Accessed April 2018. http://www.largeimages.bgs.ac.uk/iip/hydromaps.html?id=hampshire-iow.jp2

British Geological Survey (2017). Susceptibility to Groundwater Flooding. Accessed January 2018. https://www.bgs.ac.uk/research/groundwater/datainfo/GFSD.html

British Geological Survey (2018a). BGS Geoindex: Superficial deposits 1:50,000 scale; Bedrock geology 1:50,000 scale; and Borehole scans. Accessed April 2018. http://mapapps2.bgs.ac.uk/geoindex/home.html?submit=Open+the+onshore+GeoIndex

British Geological Survey (2018b). Sulphates and sulphides. Accessed November 2018. https://www.bgs.ac.uk/research/environmentalModelling/GeoProperties/SulphatesSulphides.html

British Geological Survey (2019). BGS GeoSure: soluble rocks. Accessed May 2019. https://www.bgs.ac.uk/products/geosure/soluble.html

Department for Environment, Food and Rural Affairs (2019). Multi-Agency Geographical Information for the Countryside (MAGIC). Accessed January 2019. https://magic.defra.gov.uk/MagicMap.aspx

Environment Agency (2005). Environment Agency Southern Region. Test and Itchen Groundwater Modelling Study. Final Report. Entec UK Limited.

Environment Agency (2007). Environment Agency Southern Region. East Hampshire and Chichester Chalk Numerical Modelling Project. Phase 2a – Model Construction and Refinement. Entec UK Limited.

Environment Agency (2011). Environment Agency Thames Region. Mole Groundwater Modelling Study. Phase 2 – Model Development Report. Entec UK Limited.

Environment Agency (2018). Environmental data. Accessed April 2018. http://environment.data.gov.uk.

Farrant ,A R and Cooper, A H (2008). Karst Geohazards In The UK: The Use of Digital Data for Hazard Management. Accessed April 2018 http://nora.nerc.ac.uk/id/eprint/4227/1/QJEGH_201_Geosure_Karst_paper_corrected.pdf

Jones, H K, Morris, B L, Cheney, C S, Brewerton, L J, Merrin, P D, Lewis, M A, MacDonald, A M, Coleby, L M, Talbot, J C, McKenzie, A A, Bird, M J, Cunningham, J and Robinson, V K (2000). The Physical Properties of Minor Aquifers in England and Wales. Technical Report WD/00/04. NERC and Environment Agency, British Geological Survey.

Lewis, M A, Cheney, C S and ÓDochartaigh, B É (2006). Guide to Permeability Indices. Open Report CR/06/160N. NERC, British Geological Survey, Keyworth.

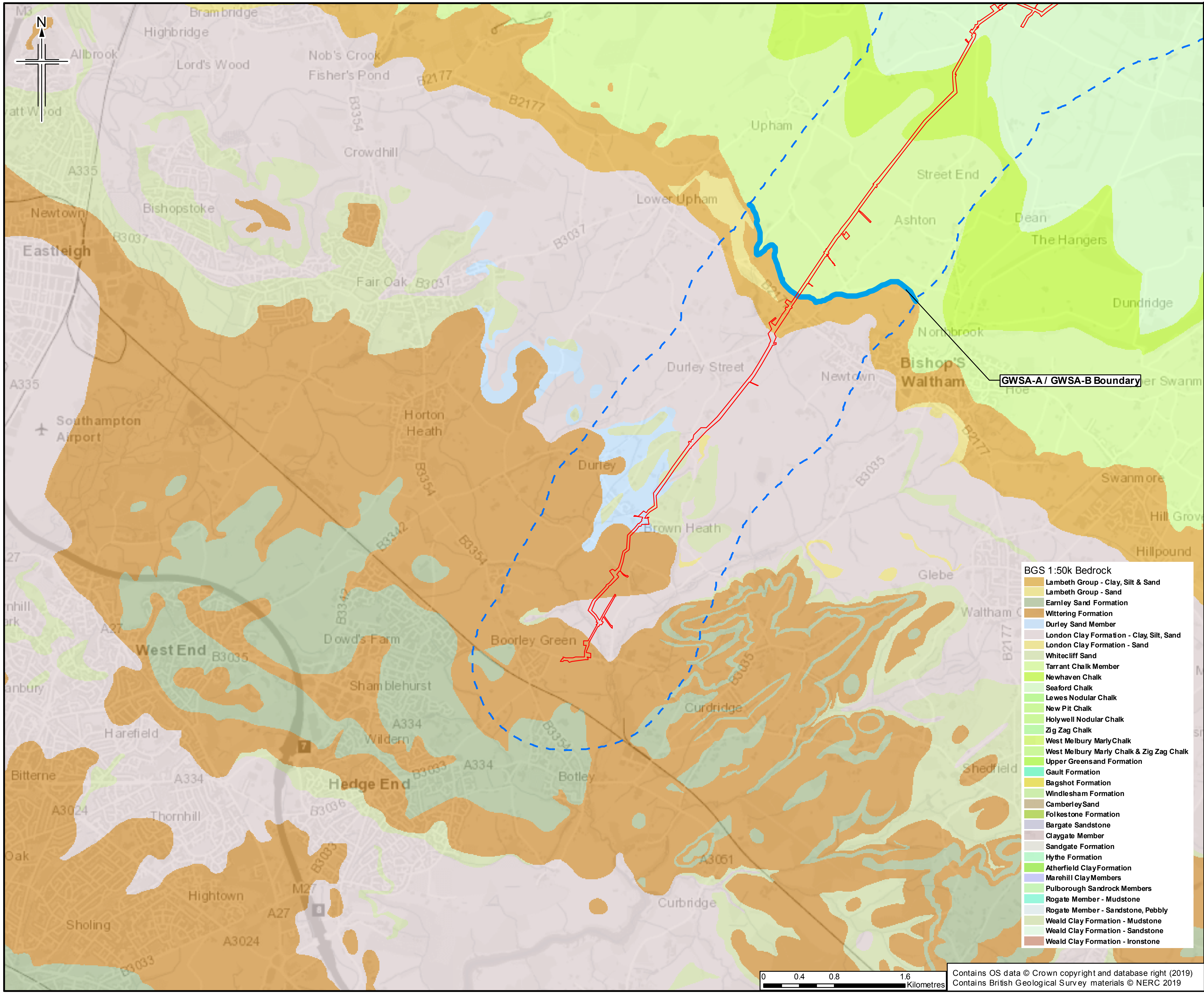
Neumann, I, Cobbing, J, Tooth, A F and Shand, P (2004). Baseline Report Series: 15. The Palaeogene of the Wessex Basin. Groundwater Systems and Water Quality. Technical Report NC/99/74/15. NERC and Environment Agency, British Geological Survey, Keyworth.

Stuart, M E and Smedley, P L (2009). Baseline Groundwater Chemistry: The Chalk Aquifer of Hampshire. Open Report OR/09/052. British Geological Survey, Keyworth.

The UK Climate Impact Programme (2018). Accessed October 2018. http://www.ukcip.org.uk/

UK Groundwater Forum (2018). Accessed October 2018. http://www.groundwateruk.org/Groundwater_resources_climate_change.aspx

Figures



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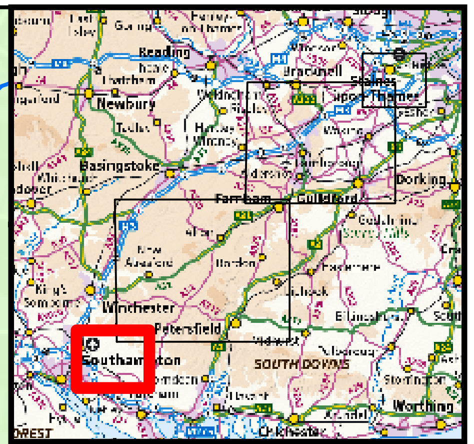

Legend

- Order Limits
- Order Limits 1km buffer
- Groundwater study area division lines

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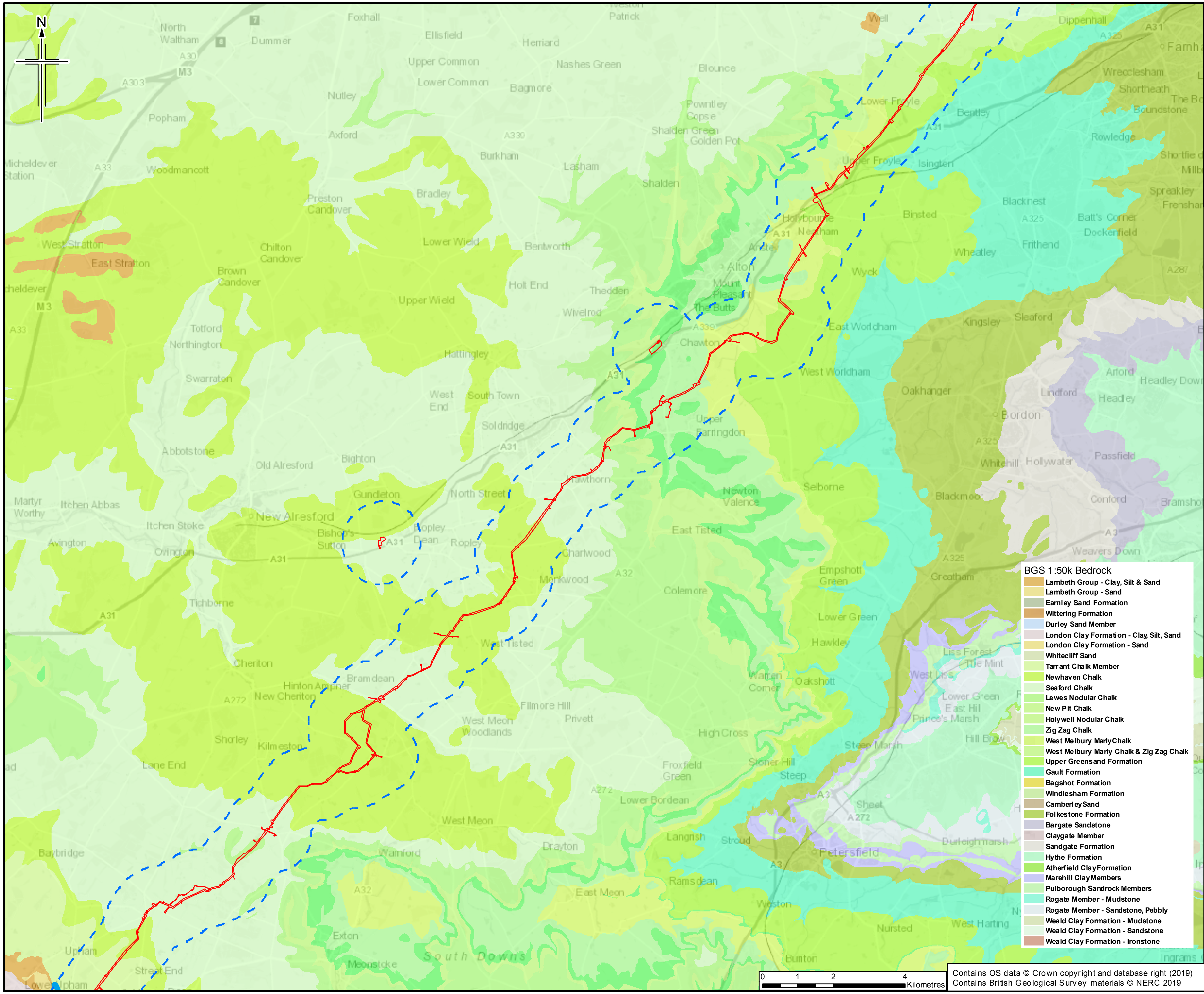

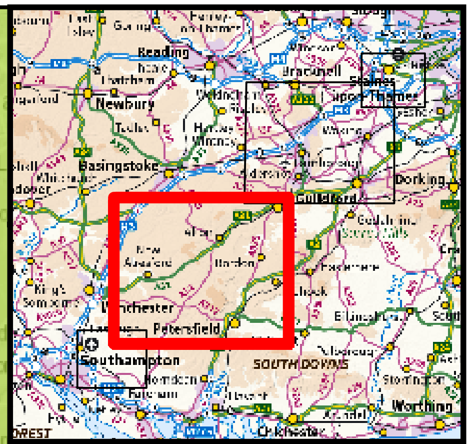

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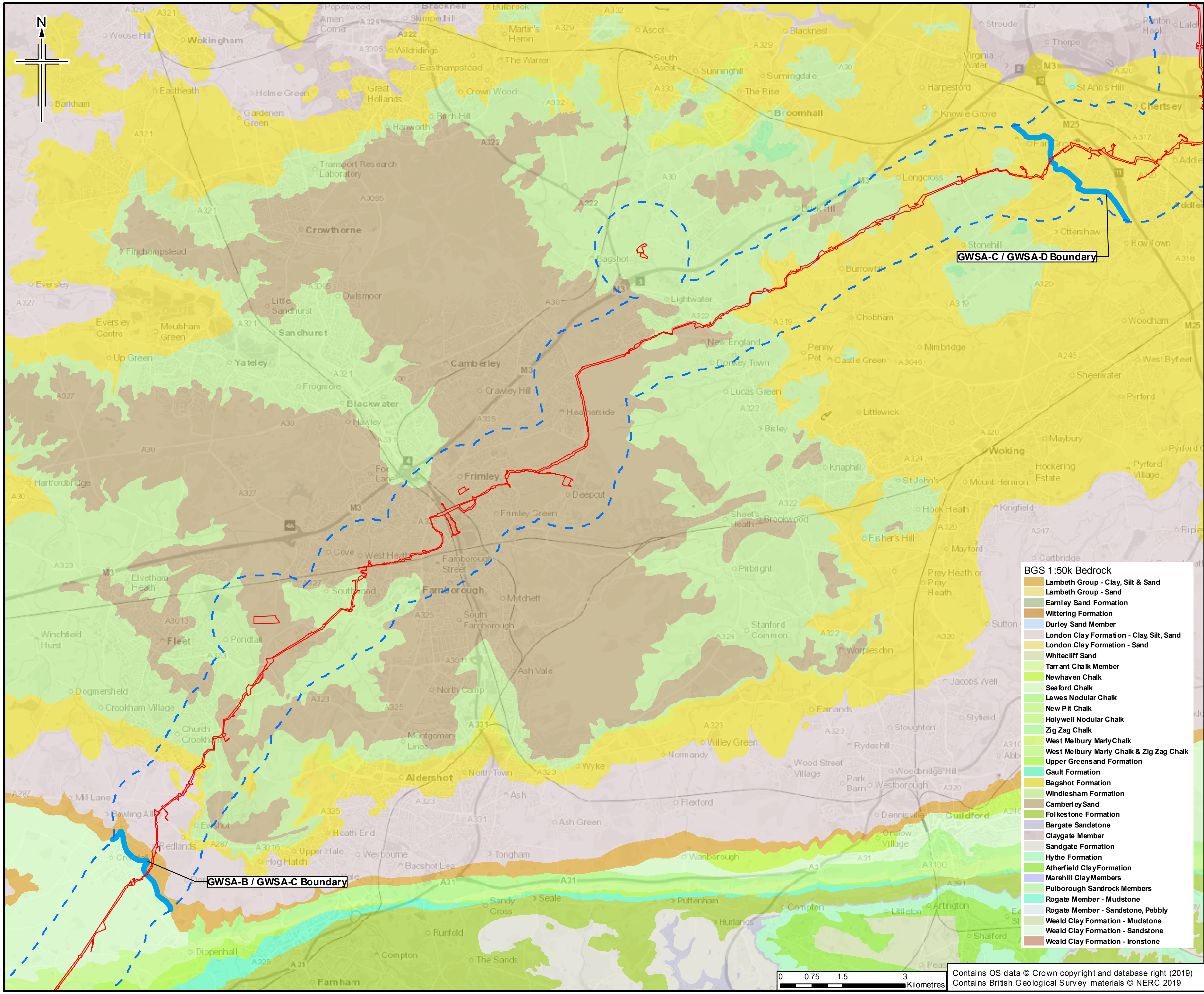

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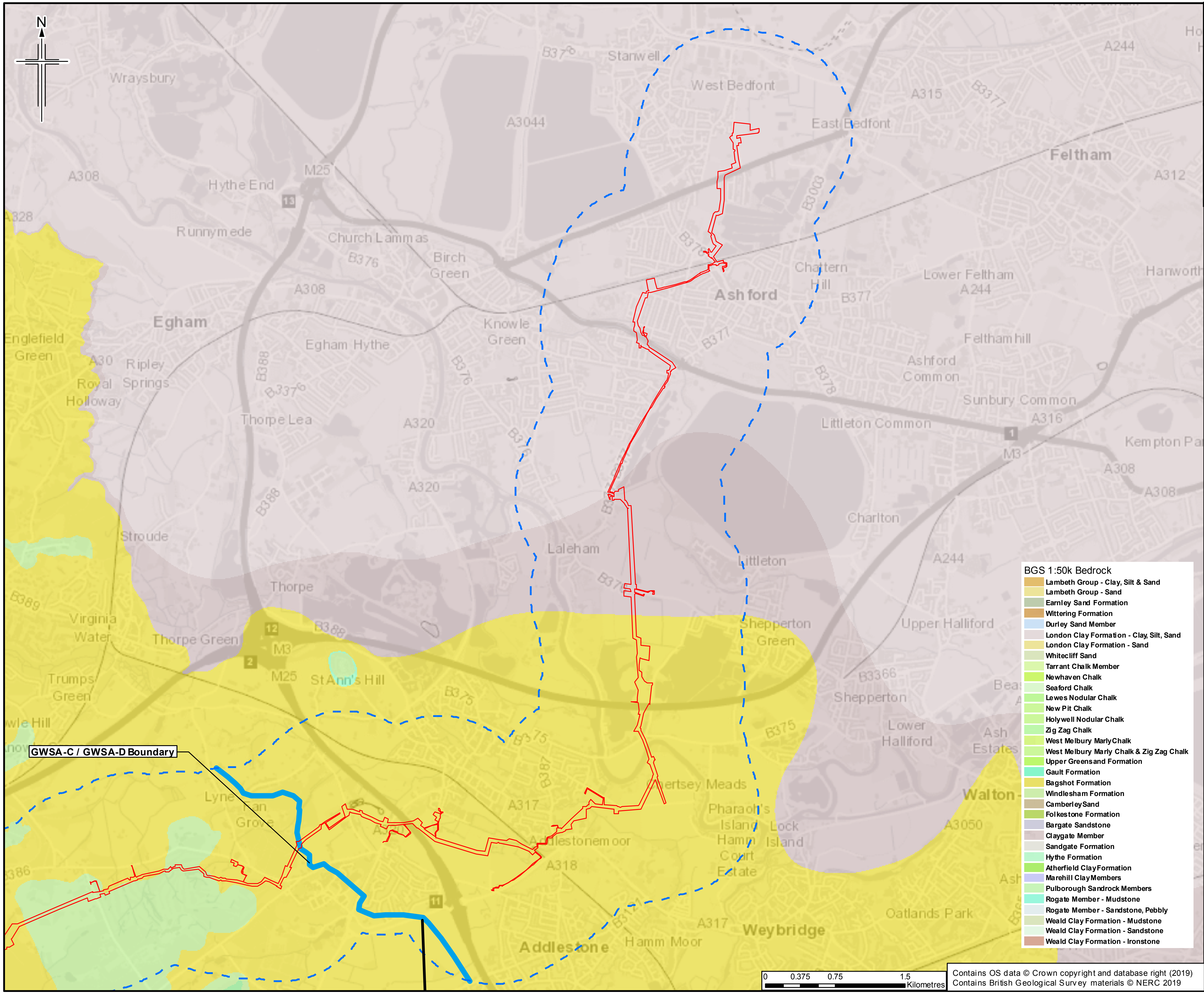

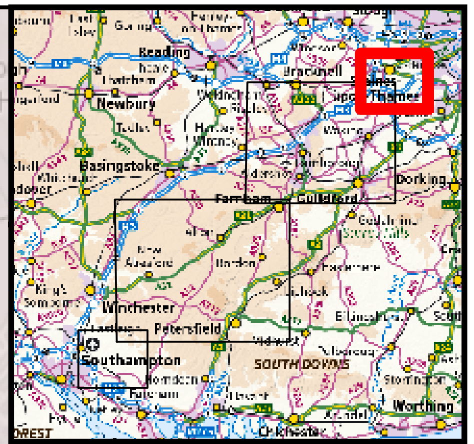

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- Order Limits 1km buffer
- Groundwater study area division lines

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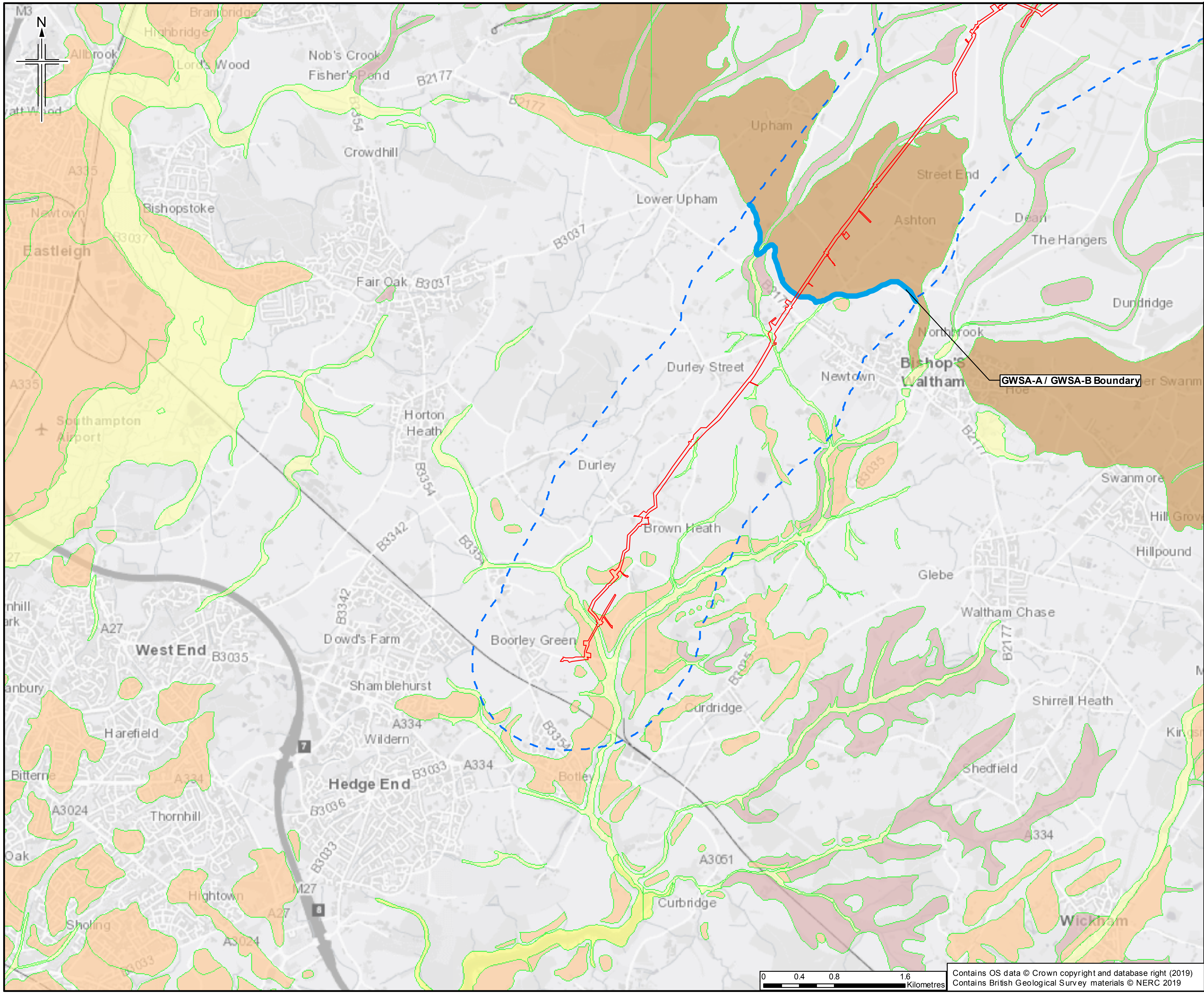

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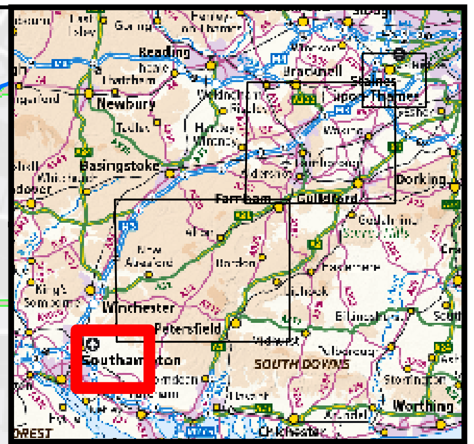

Legend

- Order Limits
- Order Limits 1km buffer
- Groundwater study area division lines

BGS 1:50k superficial deposits

- Head
- Peat
- Alluvium
- Langley Silt
- Shepperton Gravel
- Kempton Park Gravel
- Taplow Gravel
- Lynch Hill Gravel
- Surrey Hill Gravel
- Caesar's Camp Gravel
- River Terrace Deposits
- Clay with Flints
- Head Diamicton
- Sand And Gravel Of Uncertain Age And Origin

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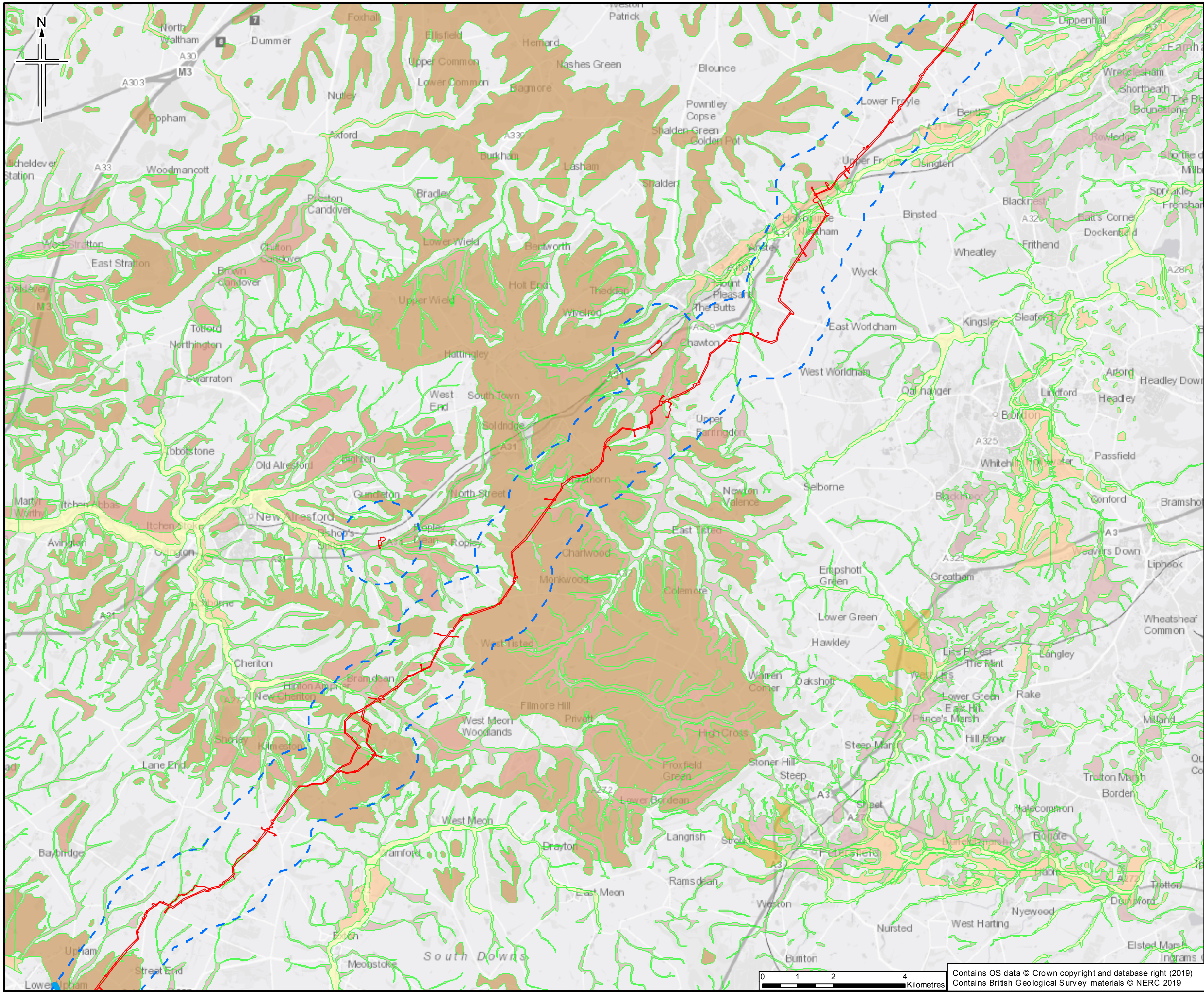

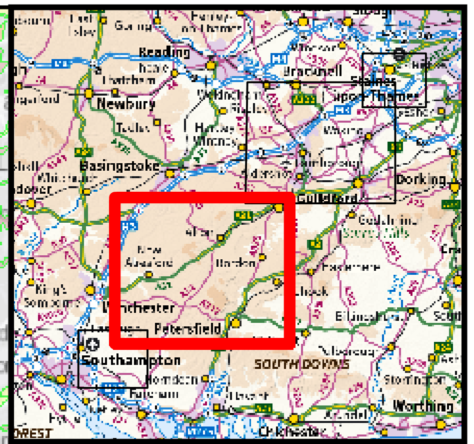

Legend

- Order Limits
- Order Limits 1km buffer
- Groundwater study area division lines

BGS 1:50k superficial deposits

- Head
- Peat
- Alluvium
- Langley Silt
- Shepperton Gravel
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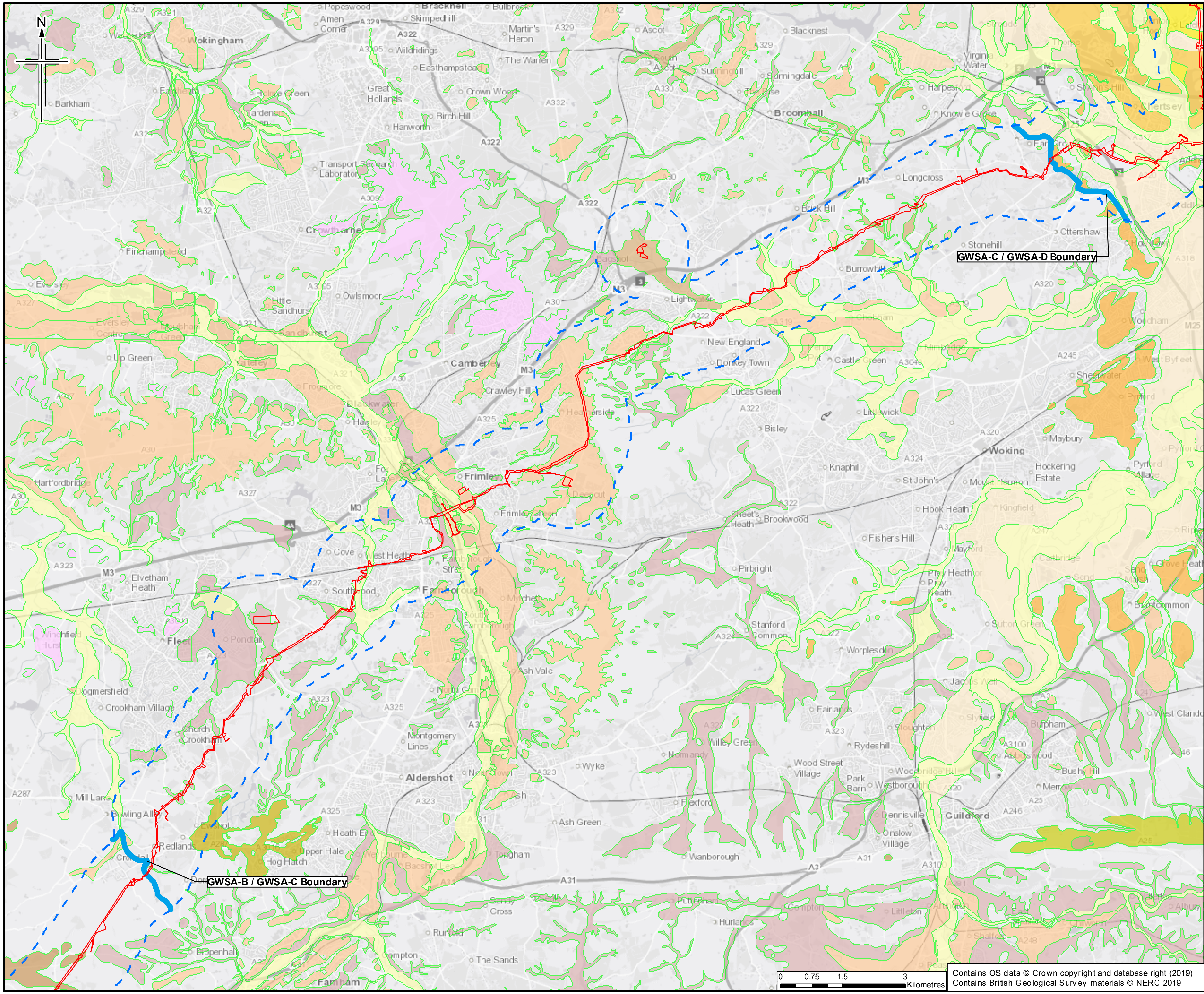

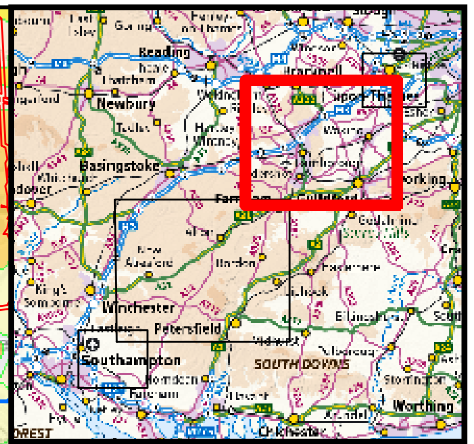

Legend

- Order Limits
- Order Limits 1km buffer
- Groundwater study area division lines

BGS 1:50k superficial deposits

- Head
- Peat
- Alluvium
- Langley Silt
- Shepperton Gravel
- Kempton Park Gravel
- Taplow Gravel
- Lynch Hill Gravel
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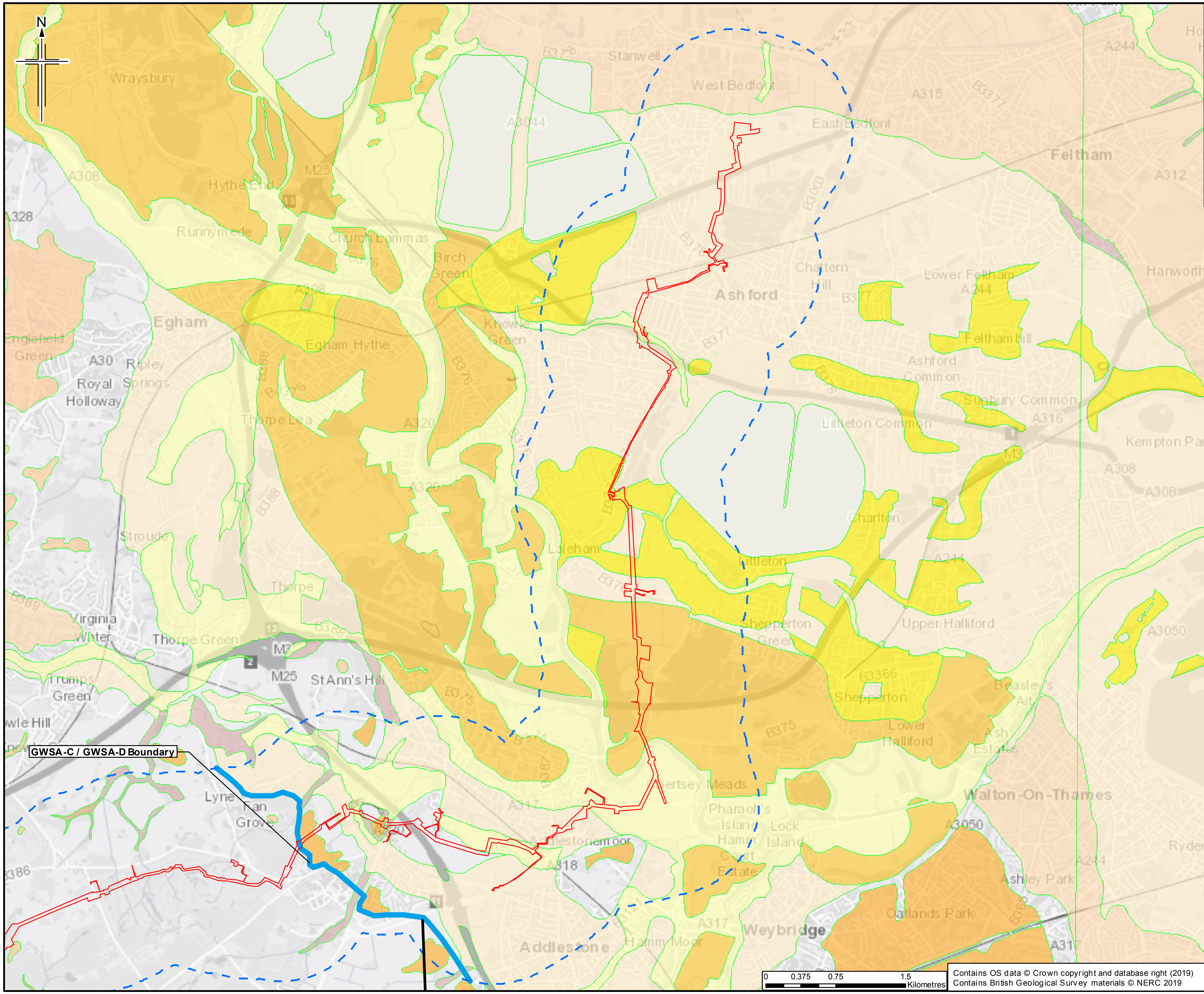

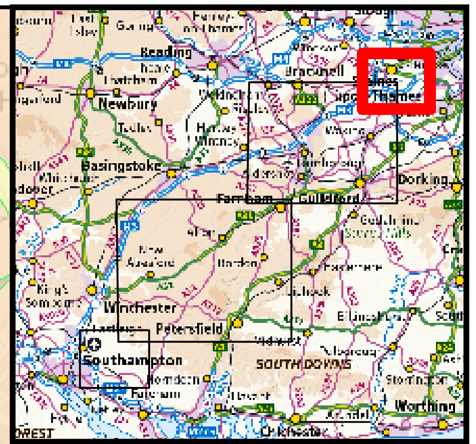

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- Order Limits 1km buffer
- Groundwater study area division lines

BGS 1:50k superficial deposits

- Head
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- Alluvium
- Langley Silt
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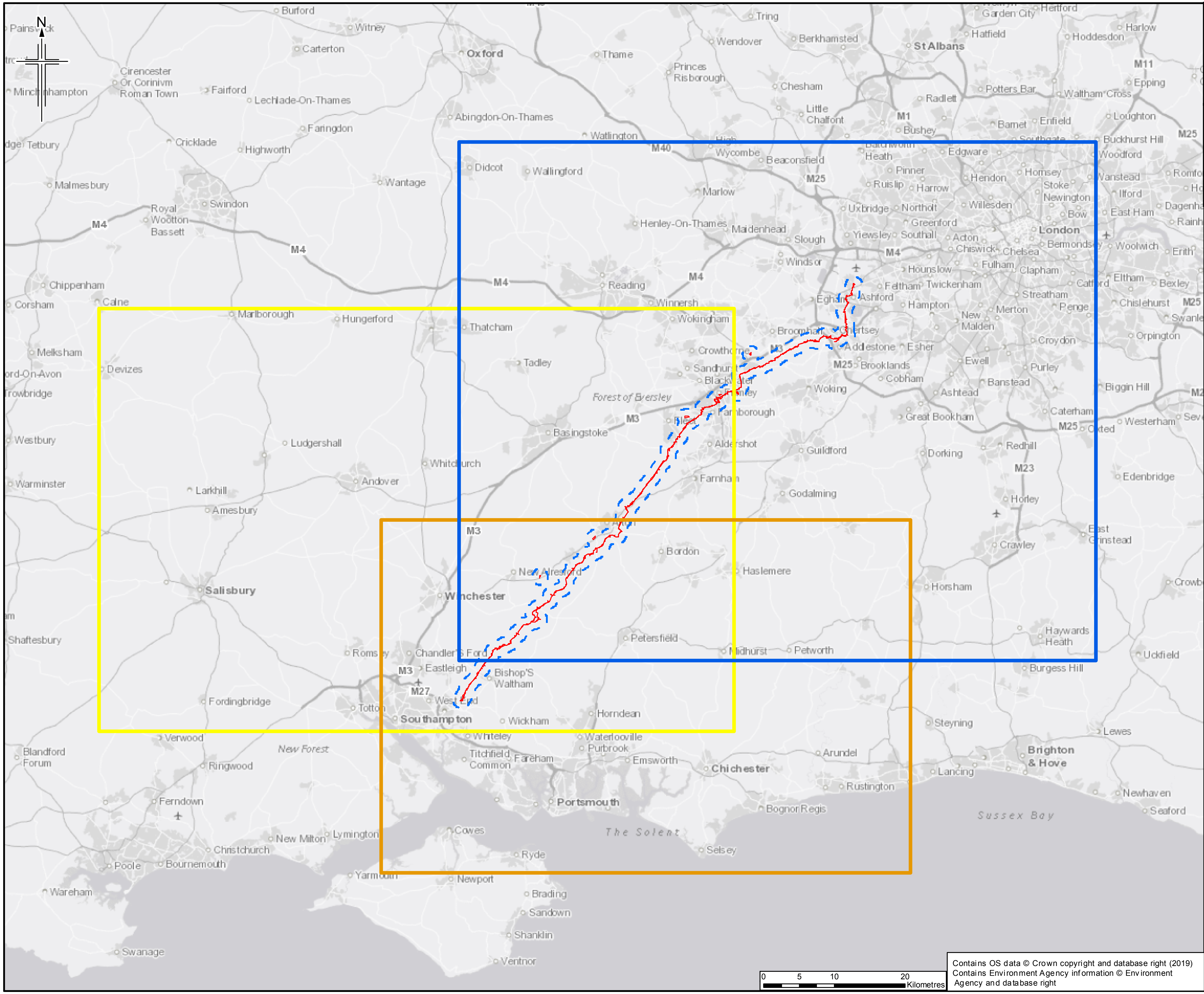

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Legend

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- Order Limits 1km buffer
- River Mole model area
- East Hampshire and Chichester Chalk model area
- Test and Itchen model area

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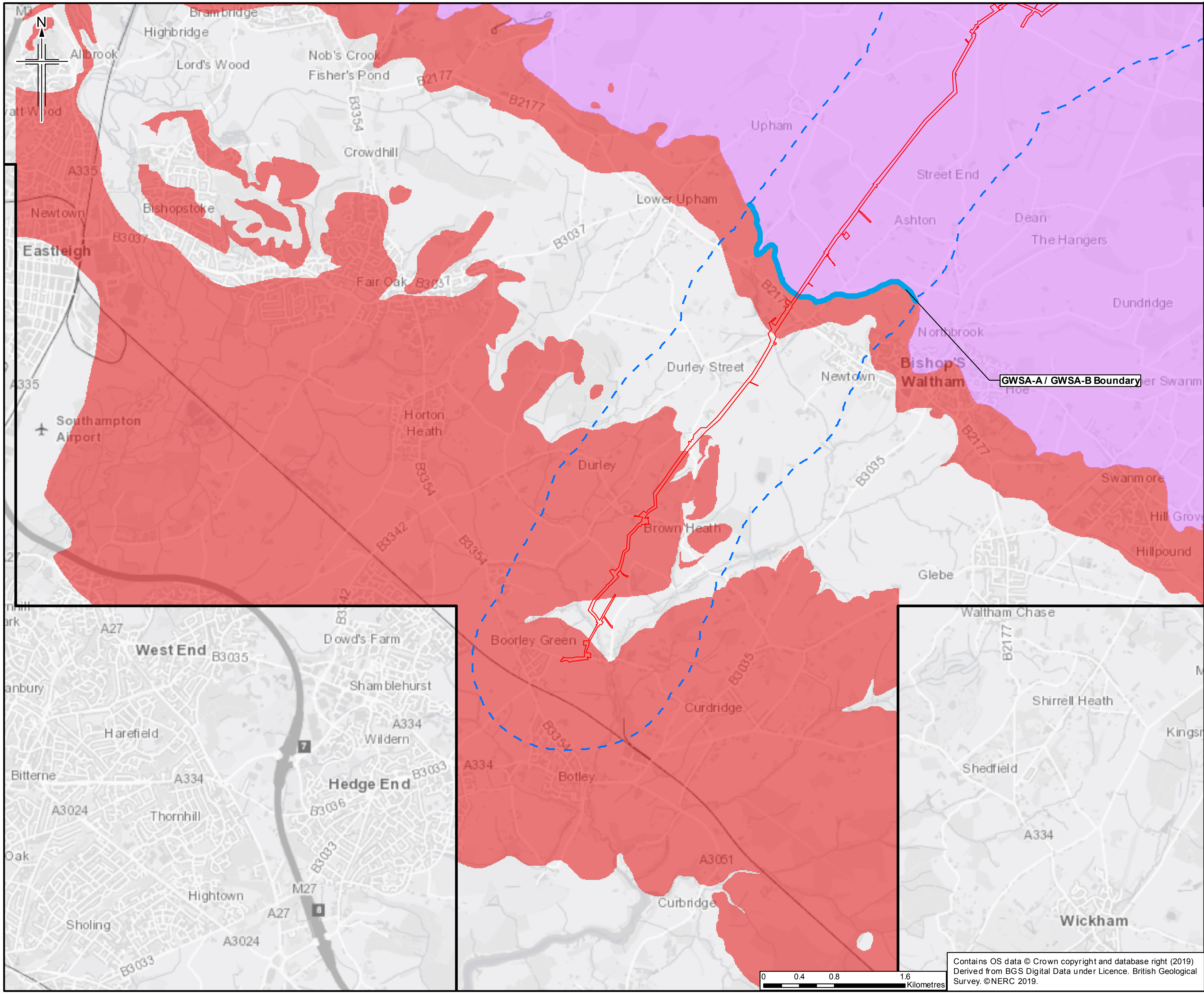

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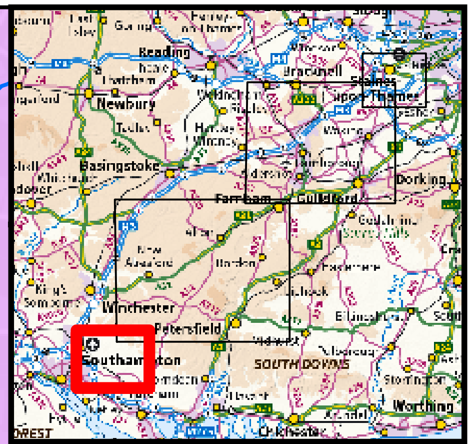

Legend

- Order Limits
- Extent of data coverage
- Order Limits 1km buffer
- Groundwater study area division lines
- Principal bedrock aquifer
- Secondary A bedrock aquifer

Where there is no shading within the extent of data coverage, the bedrock is defined as "Unproductive strata"

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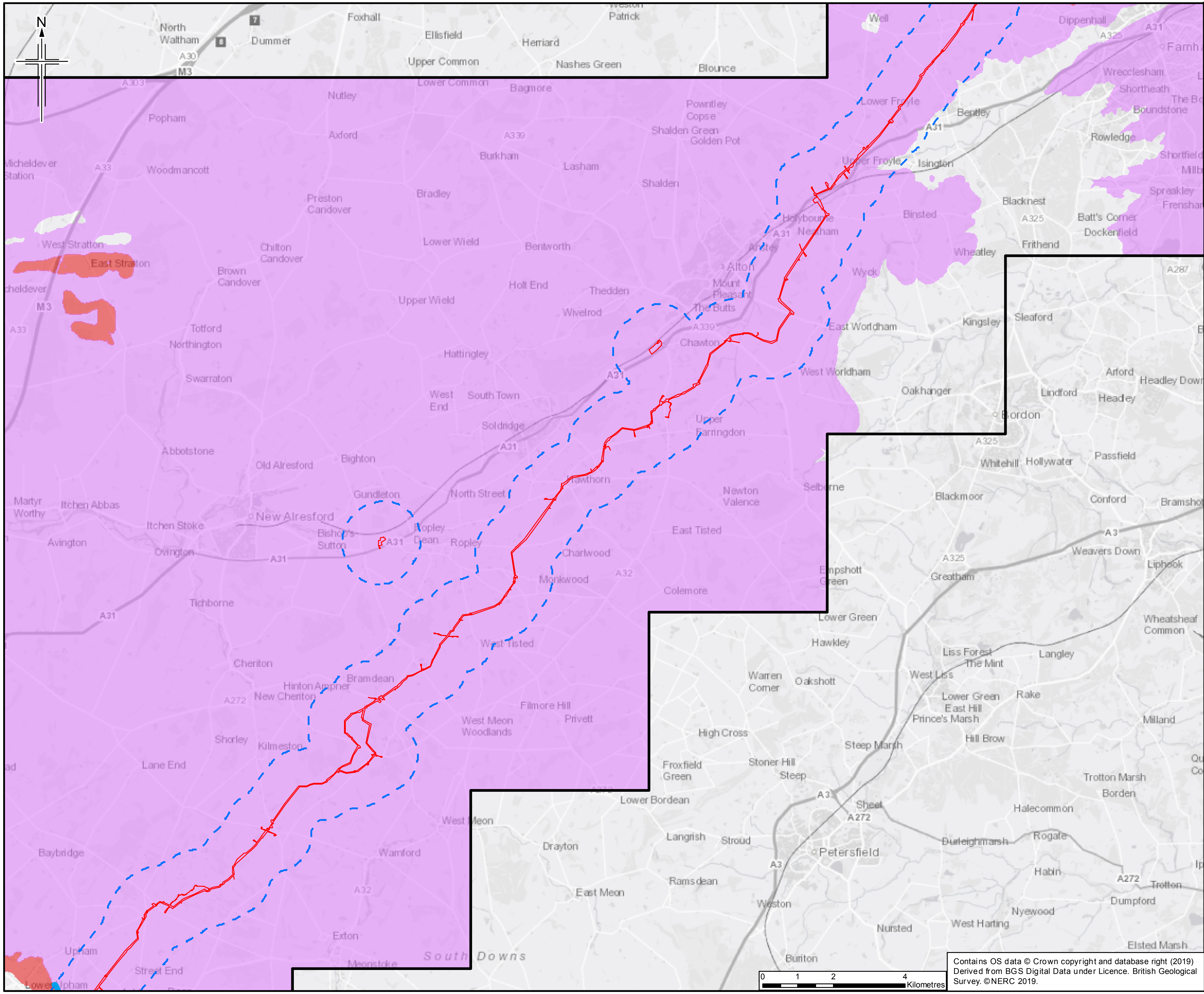

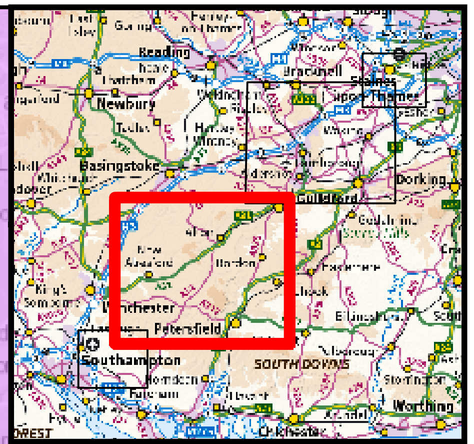

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- Extent of data coverage
- Order Limits 1km buffer
- Groundwater study area division lines
- Principal bedrock aquifer
- Secondary A bedrock aquifer

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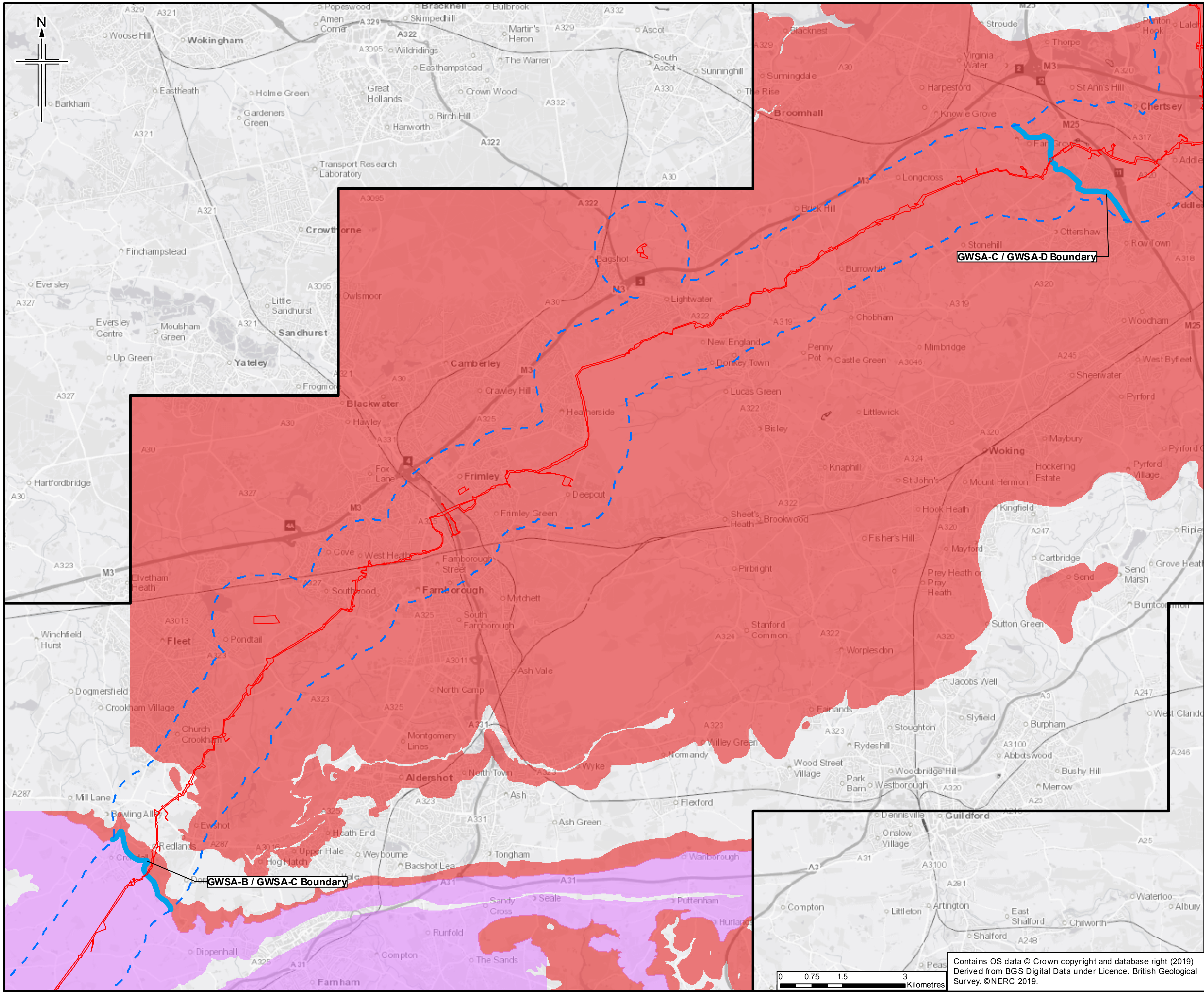

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- Order Limits 1km buffer
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- Principal bedrock aquifer
- Secondary A bedrock aquifer

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Project

Esso

Southampton to London Pipeline Project

Drawing title

ENVIRONMENTAL STATEMENT
AQUIFER DESIGNATIONS
FOR BEDROCK DEPOSITS
APFP Reg. (2009) 5(2)(l)

Drawing Status	For Issue	
Scale	1:85,000 @ A3	DO NOT SCALE
Jacobs No.	B2325300	
ProjectWise No.	B2325300-JAC-000-ENV-DRG-001112	
Drawing number	Figure A8.1.4 Sheet 3 of 4	Rev 0

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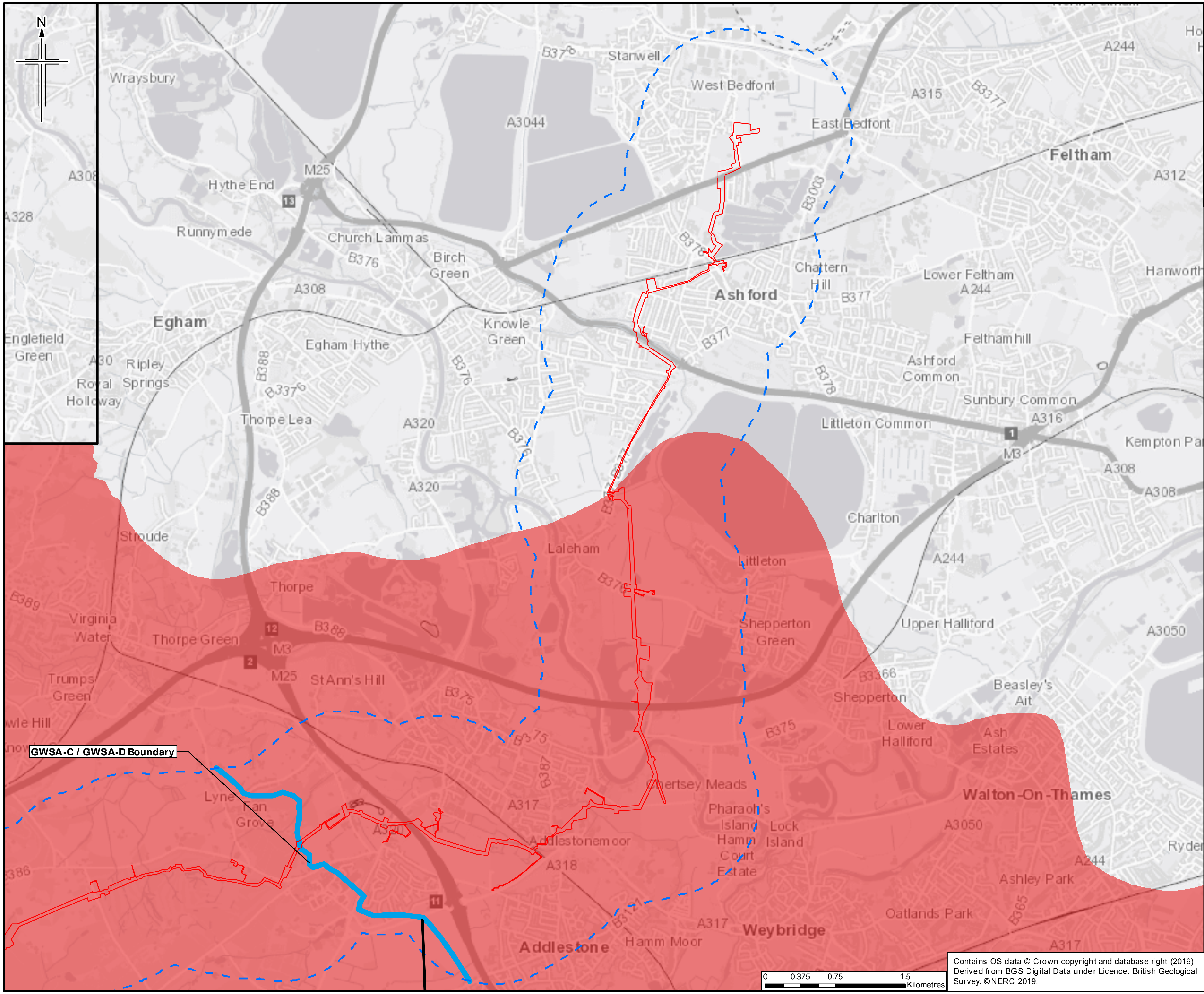

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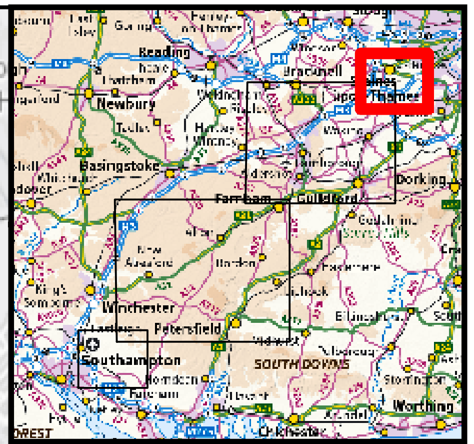

Legend

- Order Limits
- Extent of data coverage
- Order Limits 1km buffer
- Groundwater study area division lines
- Principal bedrock aquifer
- Secondary A bedrock aquifer

Where there is no shading within the extent of data coverage, the bedrock is defined as "Unproductive strata"

Sheet displays parts of Section F, Section G and Section H

Rev.	Rev. Date	Purpose of revision	Orig/Dwn	Checkd	Rev'd	Apprv'd
0	2/04/2019	For Issue	HM	TC	MB	SH

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ENVIRONMENTAL STATEMENT
AQUIFER DESIGNATIONS
FOR BEDROCK DEPOSITS
APFP Reg. (2009) 5(2)(I)

Drawing Status	For Issue	
Scale	1:38,000 @ A3	DO NOT SCALE
Jacobs No.	B2325300	
ProjectWise No.	B2325300-JAC-000-ENV-DRG-001112	
Drawing number	Figure A8.1.4 Sheet 4 of 4	Rev 0

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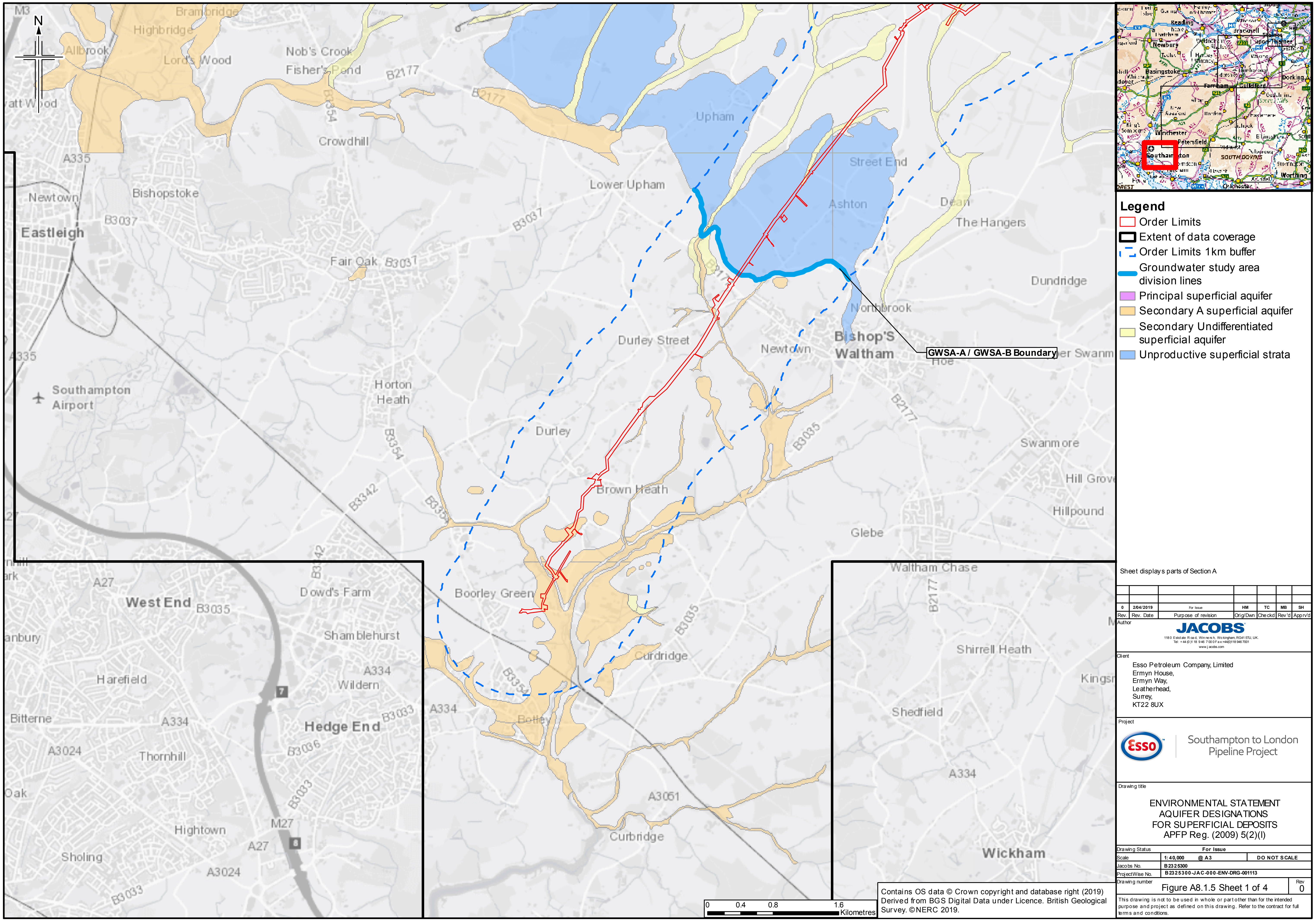

Legend

- Order Limits
- Extent of data coverage
- Order Limits 1km buffer
- Groundwater study area division lines
- Principal superficial aquifer
- Secondary A superficial aquifer
- Secondary Undifferentiated superficial aquifer
- Unproductive superficial strata

Sheet displays parts of Section A

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0	2/04/2019	For Issue	HM	TC	MB	SH

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Drawing Status	For Issue	
Scale	1:40,000 @ A3	DO NOT SCALE
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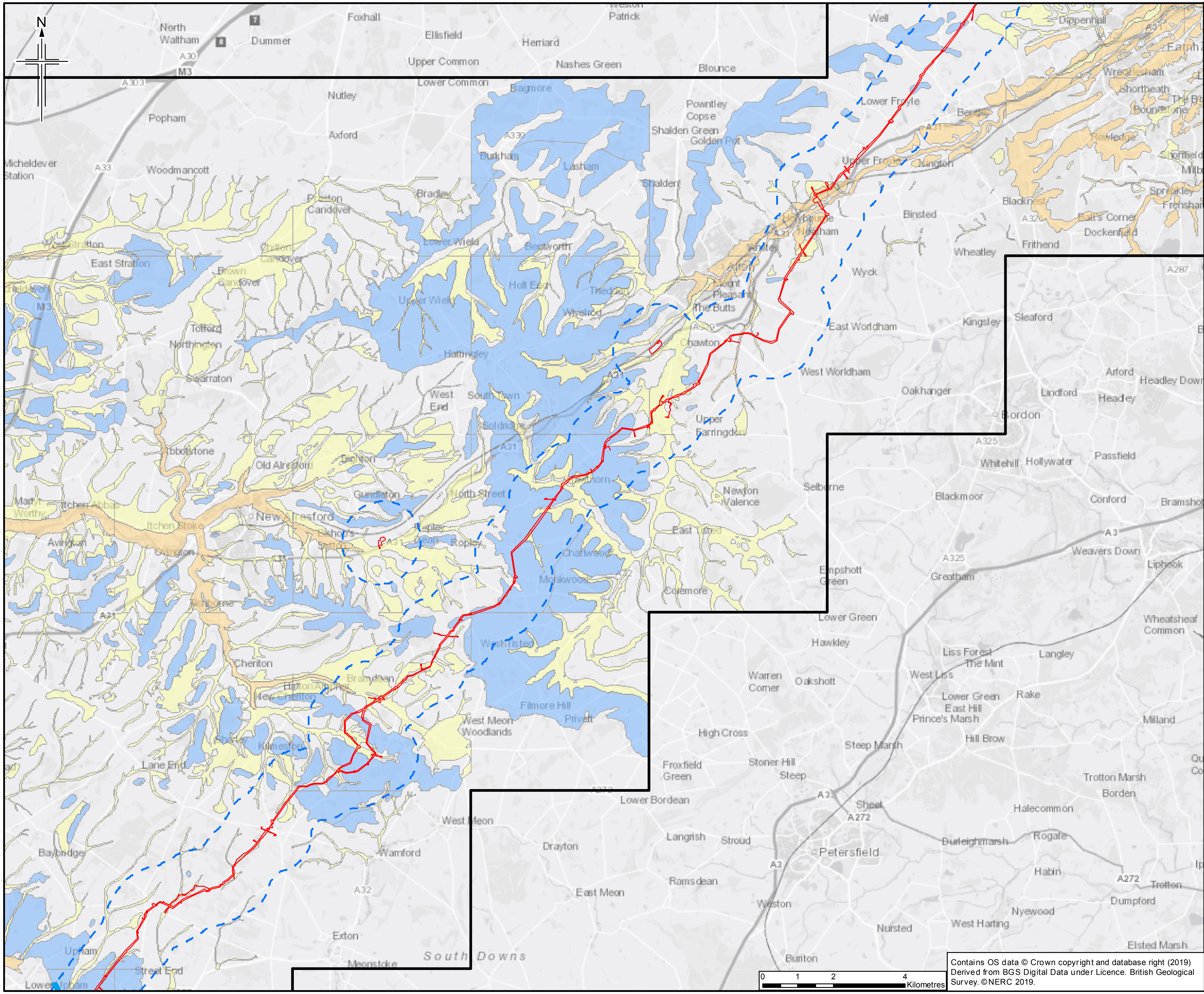
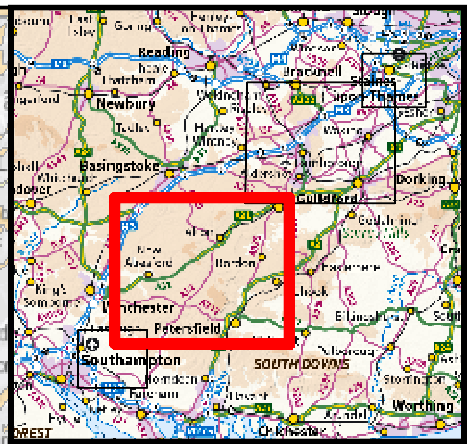
ProjectWise No.	B2325300-JAC-000-ENV-DRG-001113	

Drawing number: Figure A8.1.5 Sheet 1 of 4 — Rev 0





Legend

- Order Limits
- Extent of data coverage
- Order Limits 1km buffer
- Groundwater study area division lines
- Principal superficial aquifer
- Secondary A superficial aquifer
- Secondary Undifferentiated superficial aquifer
- Unproductive superficial strata

Sheet displays parts of Section A, Section B and Section C

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APFP Reg. (2009) 5(2)(l)

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Jacobs No.	B2325300	
ProjectWise No.	B2325300-JAC-000-ENV-DRG-001113	
Drawing number	Figure A8.1.5 Sheet 2 of 4	Rev 0

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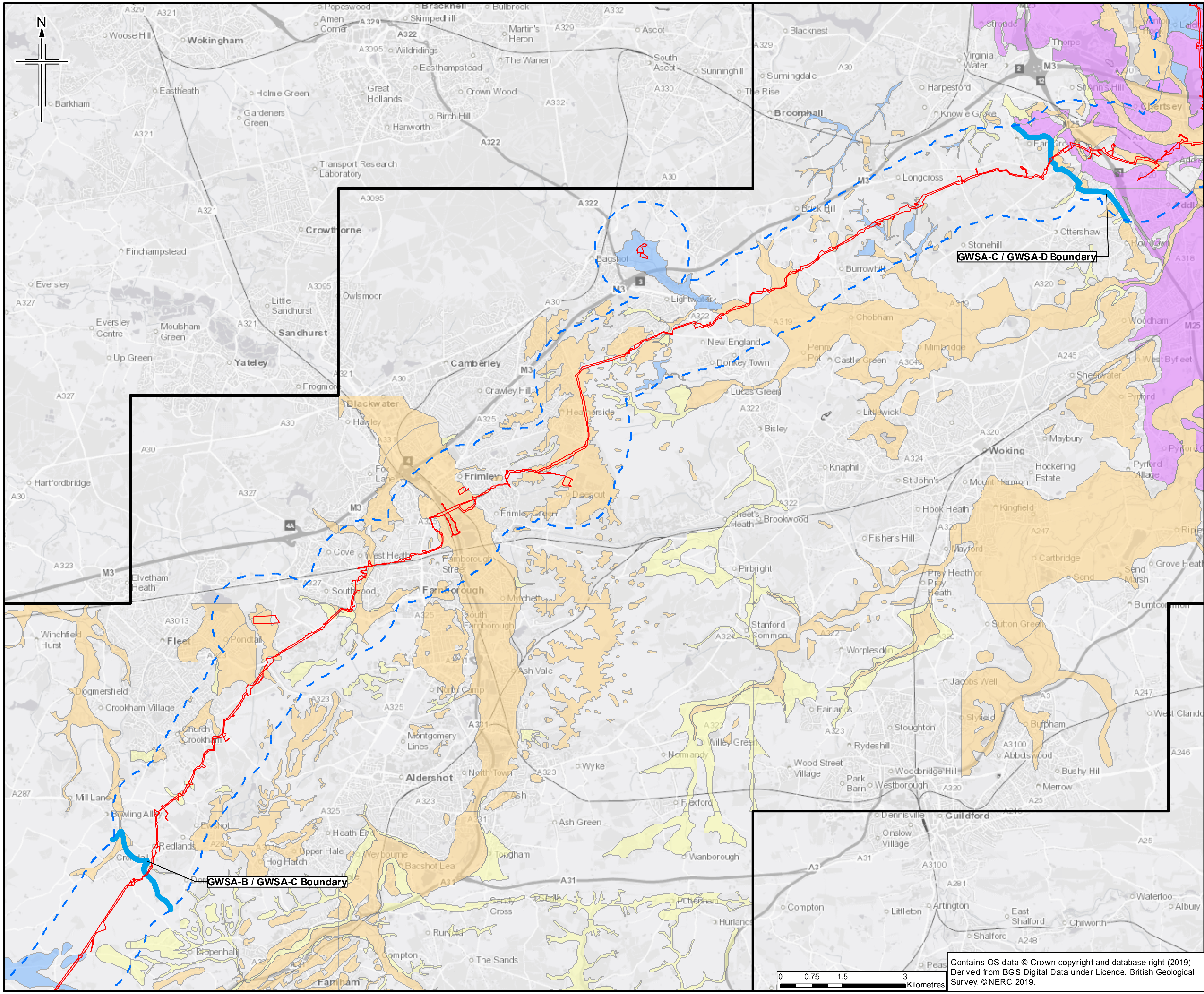

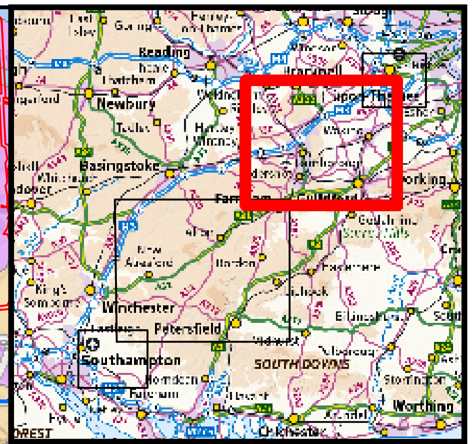

Legend

- Order Limits
- Extent of data coverage
- Order Limits 1km buffer
- Groundwater study area division lines
- Principal superficial aquifer
- Secondary A superficial aquifer
- Secondary Undifferentiated superficial aquifer
- Unproductive superficial strata

Sheet displays parts of Section C through to Section G

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ProjectWise No.	B2325300-JAC-000-ENV-DRG-001113	
Drawing number	Figure A8.1.5 Sheet 3 of 4	Rev 0

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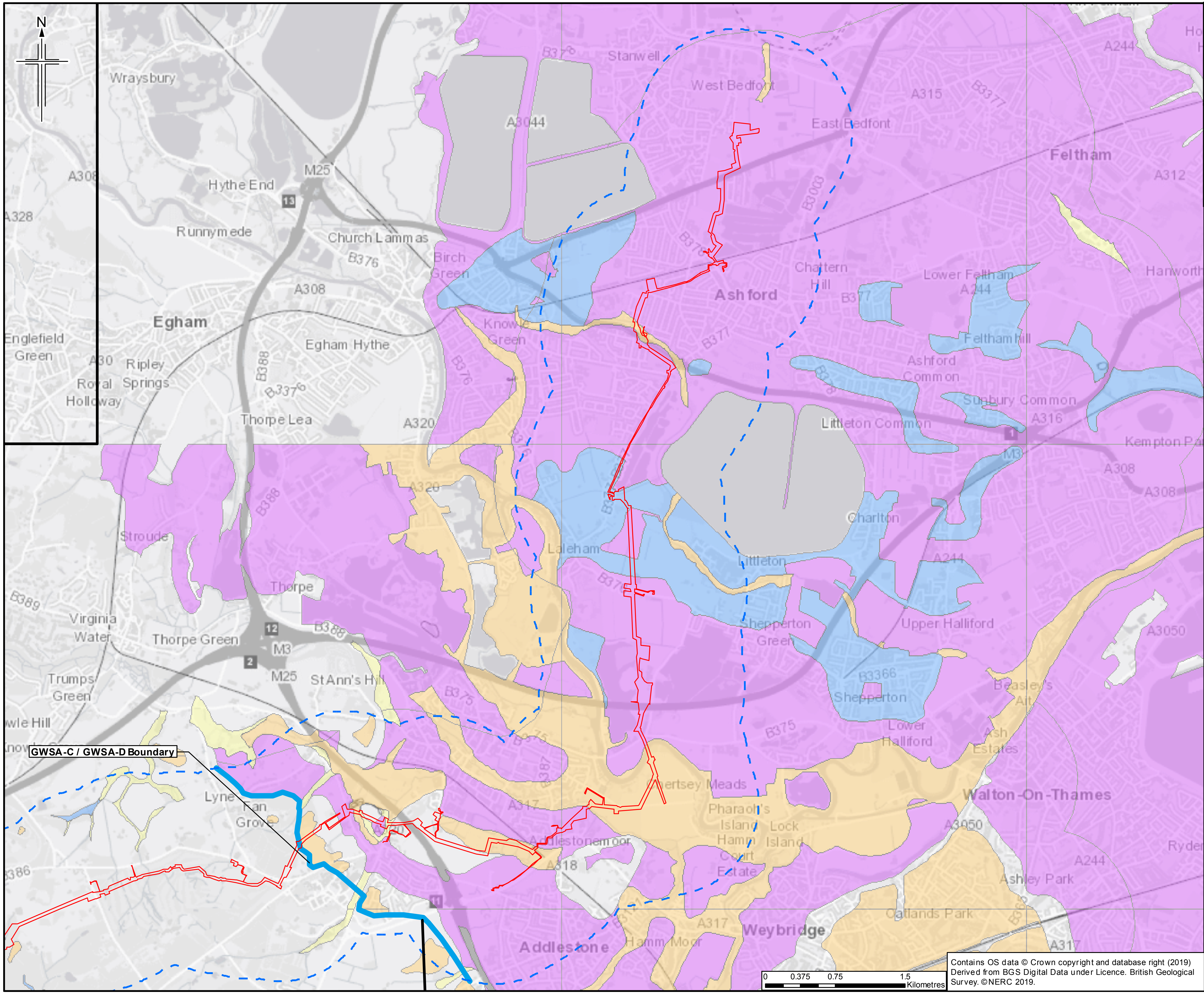
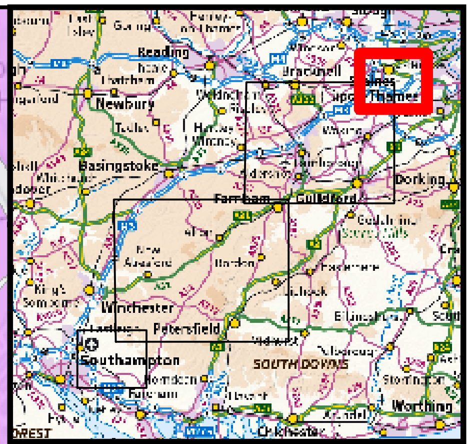
0 0.75 1.5 3 Kilometres





Legend

- Order Limits
- Extent of data coverage
- Order Limits 1km buffer
- Groundwater study area division lines
- Principal superficial aquifer
- Secondary A superficial aquifer
- Secondary Undifferentiated superficial aquifer
- Unproductive superficial strata

Sheet displays parts of Section F, Section G and Section H

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Scale	1:38,000 @ A3	DO NOT SCALE
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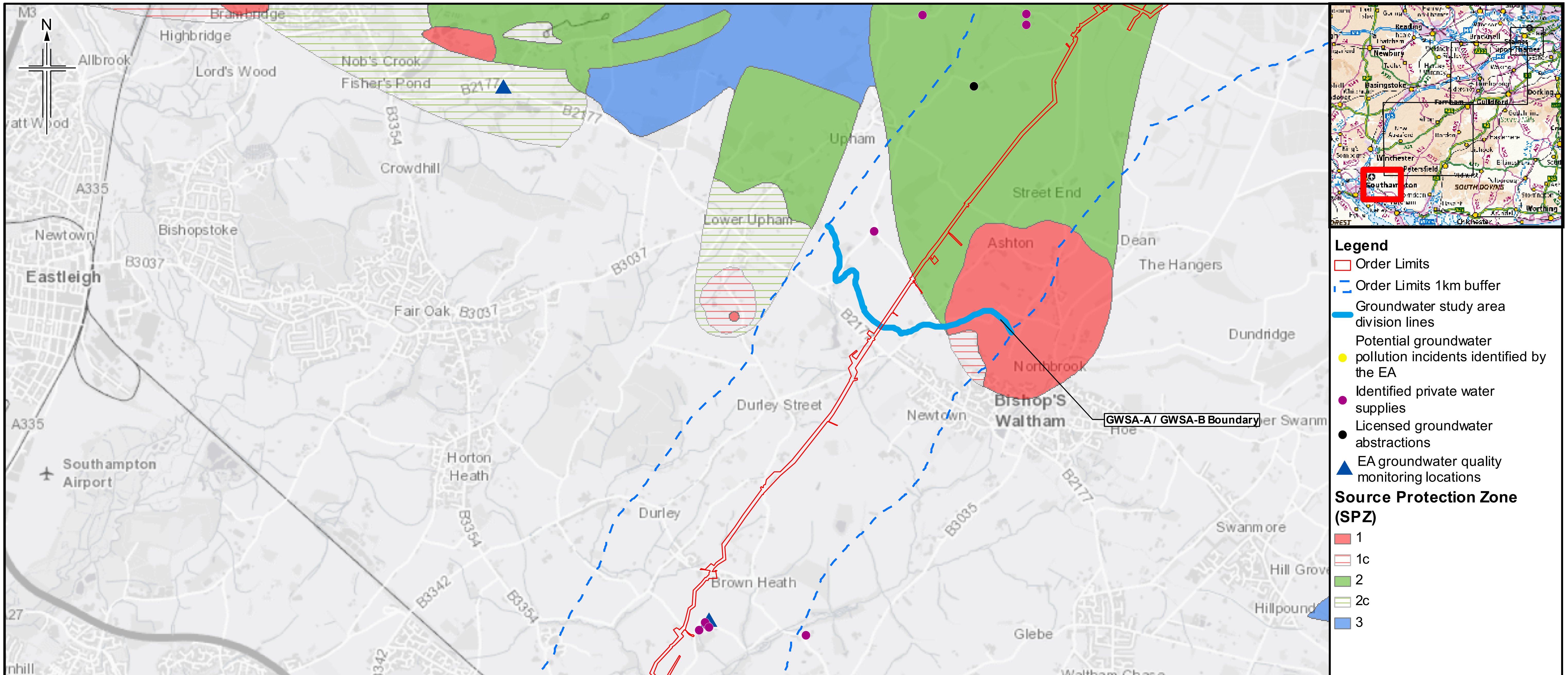
ProjectWise No.	B2325300-JAC-000-ENV-DRG-001113	
Drawing number	Figure A8.1.5 Sheet 4 of 4	Rev 0



Sheet displays parts of Section A

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Drawing title

ENVIRONMENTAL STATEMENT
GROUNDWATER SOURCE PROTECTION ZONES,
GROUNDWATER ABSTRACTIONS,
LOCATION OF EA GROUNDWATER QUALITY MONITORING POINTS AND POLLUTION INCIDENTS TO GROUNDWATER
APFP Reg. (2009) 5(2)(l)

Drawing Status	For Issue	
Scale	1:40,000 @ A3	DO NOT SCALE
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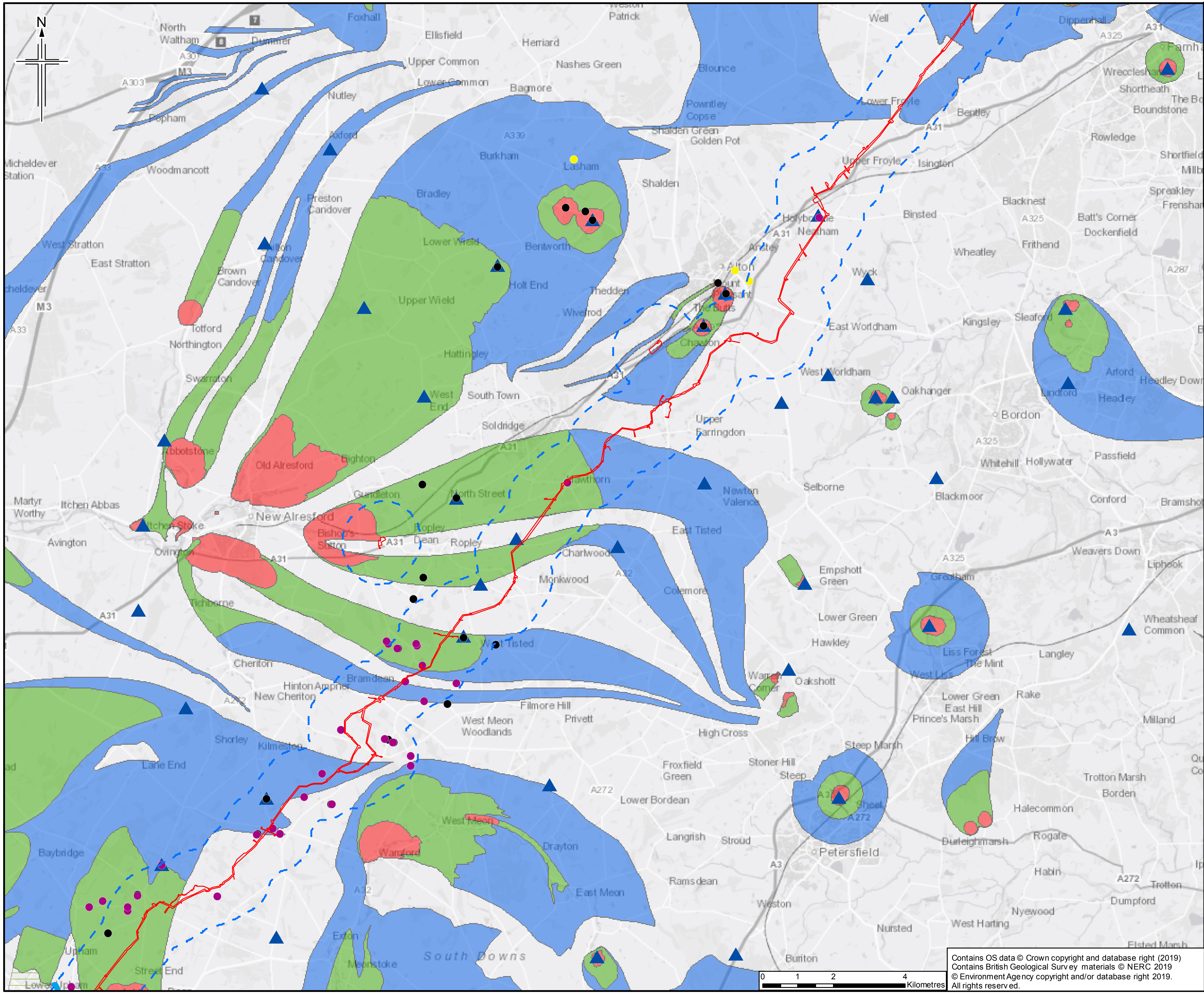
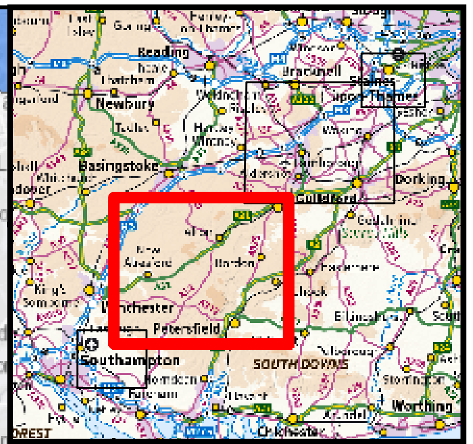
ProjectWise No.	B2325300-JAC-000-ENV-DRG-001114	
Drawing number	Figure A8.1.6 Sheet 1 of 4	Rev 0





Legend

- Order Limits
- Order Limits 1km buffer
- Groundwater study area division lines
- Potential groundwater pollution incidents identified by the EA
- Identified private water supplies
- Licensed groundwater abstractions
- EA groundwater quality monitoring locations

Source Protection Zone (SPZ)

- 1
- 1c
- 2
- 2c
- 3

Sheet displays parts of Section A, Section B and Section C

Rev.	Rev. Date	Purpose of revision	Orig/Dwn	Checkd	Rev'd	Apprv'd
0	2/04/2019	For Issue	HM	TC	MB	SH

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Drawing title

ENVIRONMENTAL STATEMENT
GROUNDWATER SOURCE PROTECTION ZONES,
GROUNDWATER ABSTRACTIONS,
LOCATION OF EA GROUNDWATER QUALITY MONITORING POINTS AND POLLUTION INCIDENTS TO GROUNDWATER
APFP Reg. (2009) 5(2)(l)

Drawing Status	For Issue	
Scale	1:99,000 @ A3	DO NOT SCALE
Jacobs No.	B2325300	
ProjectWise No.	B2325300-JAC-000-ENV-DRG-001114	

Drawing number	Rev
Figure A8.1.6 Sheet 2 of 4	0

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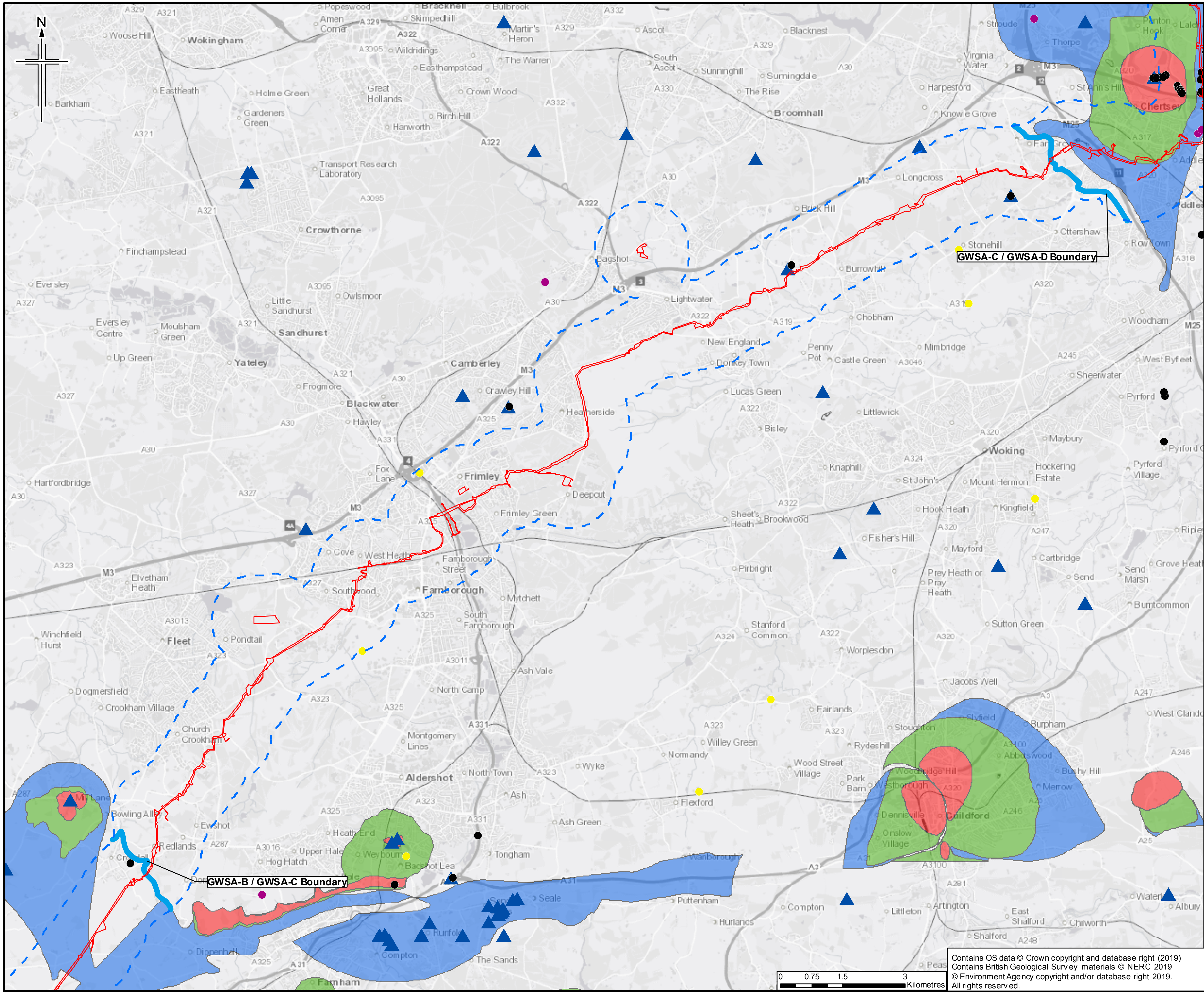

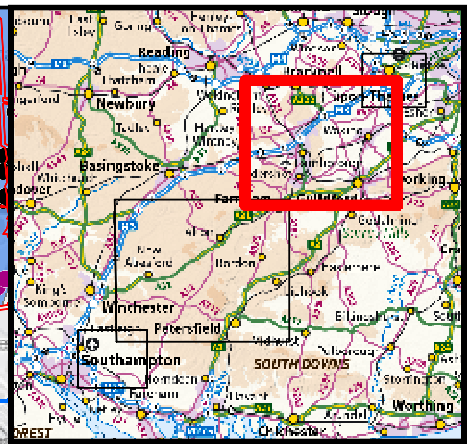

Legend

- Order Limits
- Order Limits 1km buffer
- Groundwater study area division lines
- Potential groundwater pollution incidents identified by the EA
- Identified private water supplies
- Licensed groundwater abstractions
- EA groundwater quality monitoring locations

Source Protection Zone (SPZ)

- 1
- 1c
- 2
- 2c
- 3

Sheet displays parts of Section C through to Section G

Rev.	Rev. Date	Purpose of revision	Orig/Dwn	Checkd	Rev'd	Apprv'd
0	2/04/2019	For Issue	HM	TC	MB	SH

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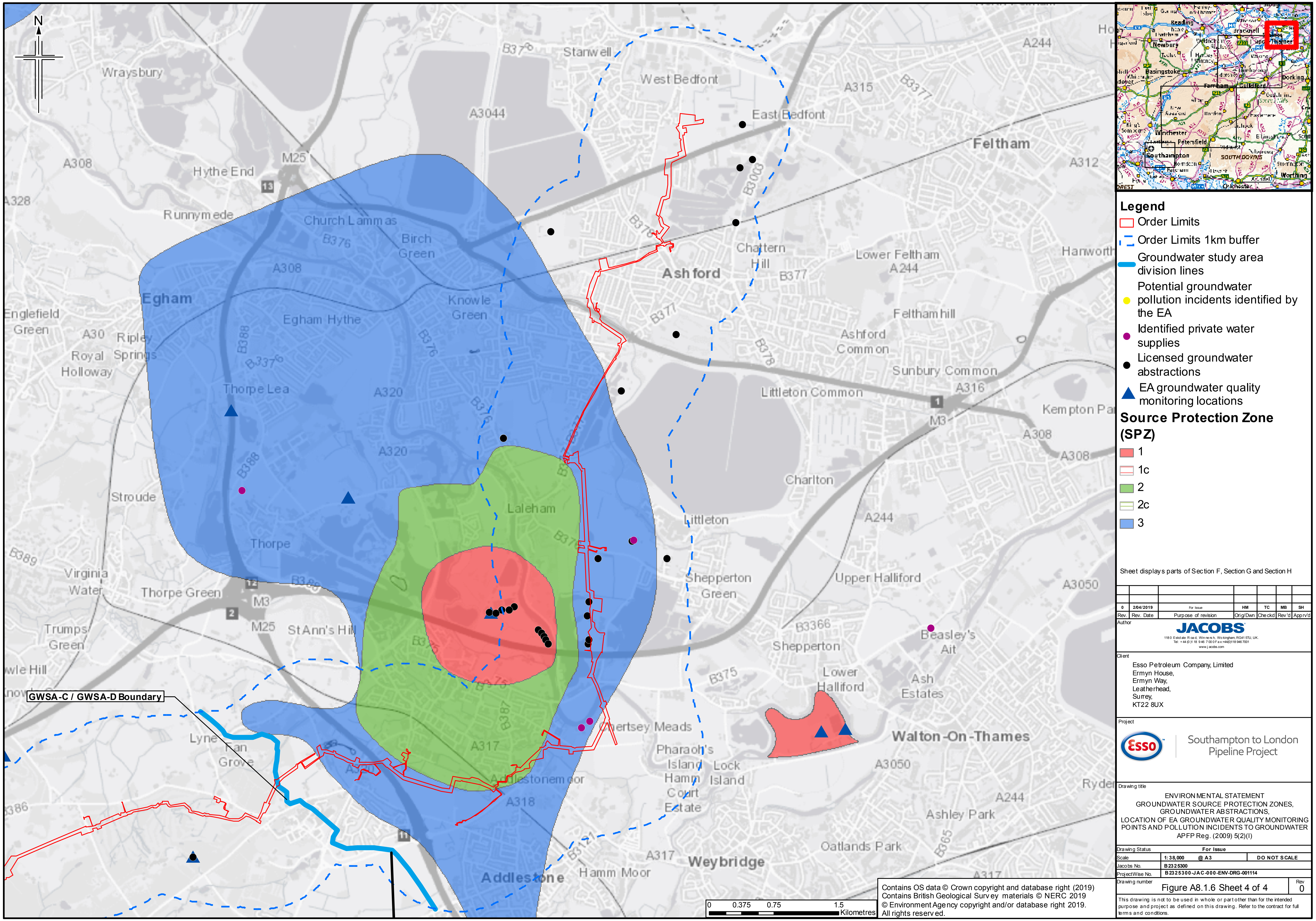
Southampton to London Pipeline Project

Drawing title

ENVIRONMENTAL STATEMENT
GROUNDWATER SOURCE PROTECTION ZONES,
GROUNDWATER ABSTRACTIONS,
LOCATION OF EA GROUNDWATER QUALITY MONITORING POINTS AND POLLUTION INCIDENTS TO GROUNDWATER
APFP Reg. (2009) 5(2)(l)

Drawing Status	For Issue	
Scale	1:85,000 @ A3	DO NOT SCALE
Jacobs No.	B2325300	
ProjectWise No.	B2325300-JAC-000-ENV-DRG-001114	
Drawing number	Figure A8.1.6 Sheet 3 of 4	Rev 0



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Legend

- Order Limits
- Order Limits 1km buffer
- Groundwater study area division lines
- Potential groundwater pollution incidents identified by the EA
- Identified private water supplies
- Licensed groundwater abstractions
- EA groundwater quality monitoring locations

Source Protection Zone (SPZ)

- 1
- 1c
- 2
- 2c
- 3

Sheet displays parts of Section F, Section G and Section H

Rev.	Rev. Date	Purpose of revision	Orig/Dwn	Checkd	Rev'd	Apprv'd
0	2/04/2019	For Issue	HM	TC	MB	SH

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GROUNDWATER SOURCE PROTECTION ZONES, GROUNDWATER ABSTRACTIONS,
LOCATION OF EA GROUNDWATER QUALITY MONITORING POINTS AND POLLUTION INCIDENTS TO GROUNDWATER
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Drawing Status	For Issue	
Scale	1:38,000 @ A3	DO NOT SCALE
Jacobs No.	B2325300	
ProjectWise No.	B2325300-JAC-000-ENV-DRG-001114	

Drawing number: Figure A8.1.6 Sheet 4 of 4 — Rev 0

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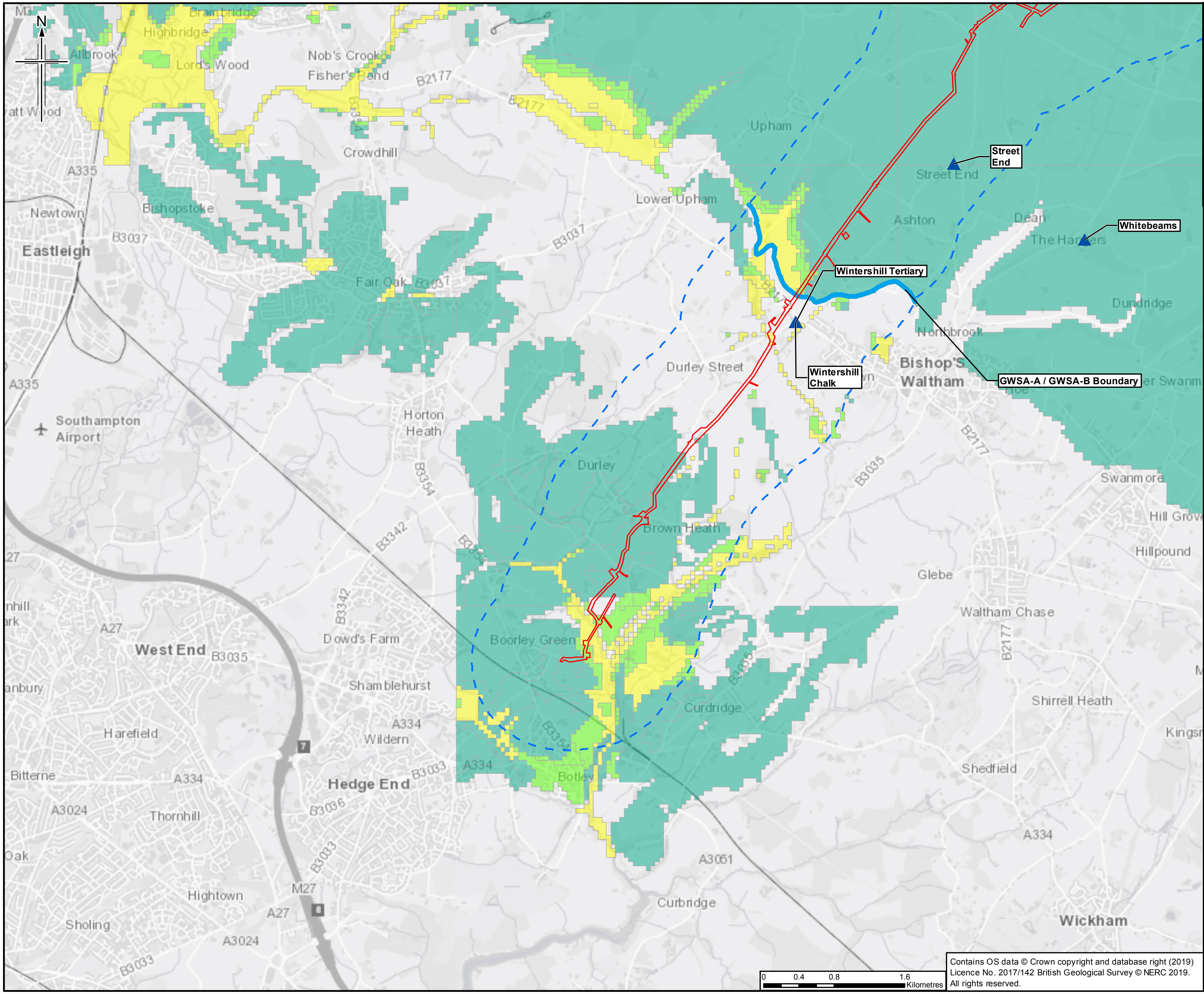

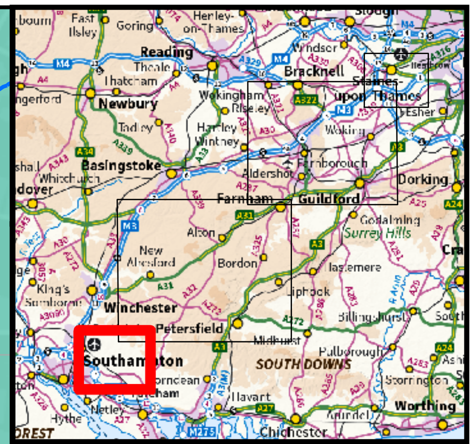

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Legend

- Order Limits
- Order Limits 1km buffer
- EA groundwater level monitoring boreholes
- Groundwater study area division lines

Groundwater Flooding

- Limited potential for groundwater flooding to occur
- Potential for groundwater flooding of property situated below ground level
- Potential for groundwater flooding to occur at surface

Sheet displays parts of Section A

Rev.	Rev. Date	Purpose of revision	Orig/Dwn	Checkd	Rev'd	Apprv'd
0	30/04/2019	For Issue	VW	NS	MB	SH

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Drawing title

ENVIRONMENTAL STATEMENT
AREAS SUSCEPTIBLE TO GROUNDWATER FLOODING AND EA GROUNDWATER LEVEL MONITORING POINTS
APFP Reg. (2009) 5(2)(l)

Drawing Status	For Issue
Scale	1:40,000 @A3 DO NOT SCALE
Jacobs No.	B2325300
ProjectWise No.	B2325300-JAC-000-ENV-DRG-001115
Drawing number	Figure A8.1.7 Sheet 1 of 4
Rev	0

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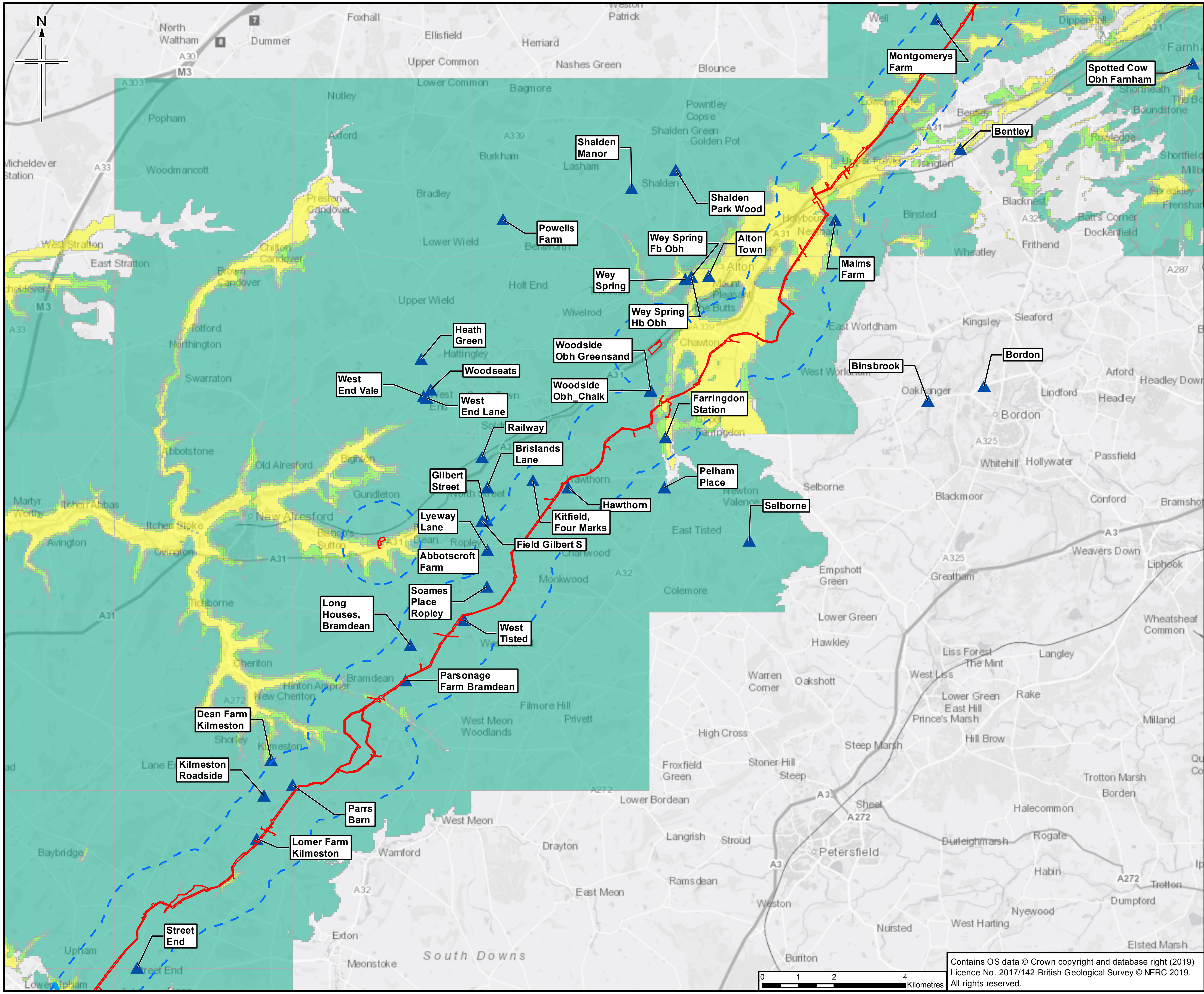

Legend

- Order Limits
- Order Limits 1km buffer
- EA groundwater level monitoring boreholes
- Groundwater study area division lines

Groundwater Flooding

- Limited potential for groundwater flooding to occur
- Potential for groundwater flooding of property situated below ground level
- Potential for groundwater flooding to occur at surface

Sheet displays parts of Section A, Section B and Section C

Rev.	Rev. Date	Purpose of revision	Orig/Dwn	Checkd	Rev'd	Apprv'd
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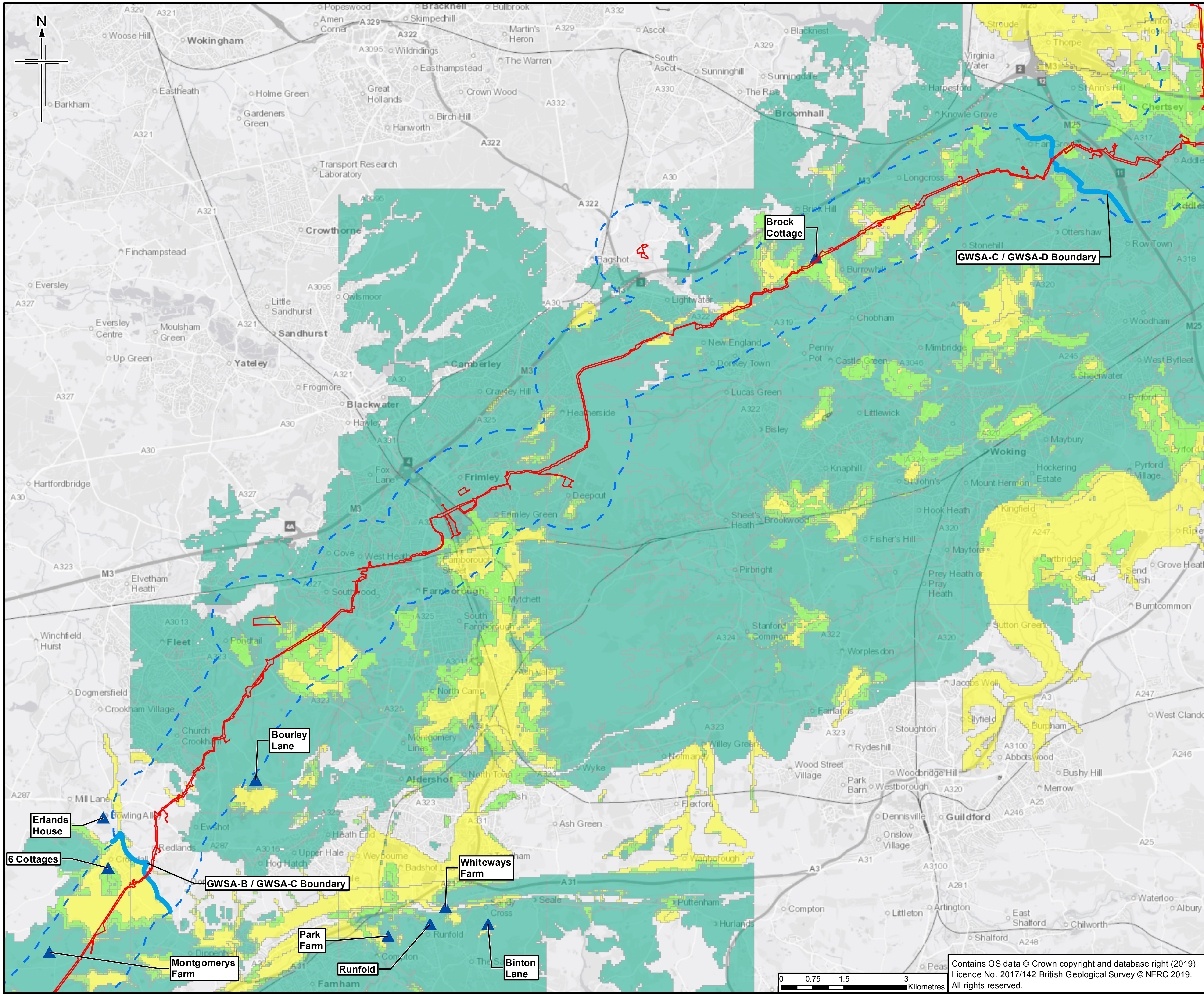
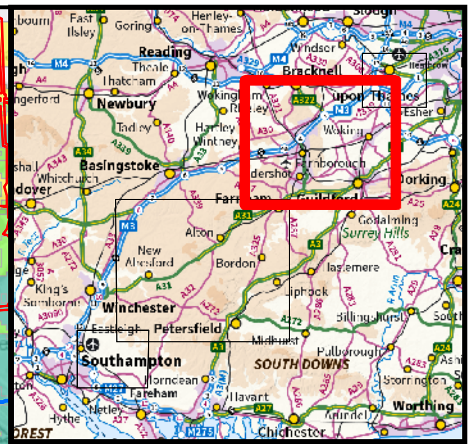
Drawing number	Figure A8.1.7 Sheet 2 of 4	Rev 0





Legend

- Order Limits
- Order Limits 1km buffer
- EA groundwater level monitoring boreholes
- Groundwater study area division lines

Groundwater Flooding

- Limited potential for groundwater flooding to occur
- Potential for groundwater flooding of property situated below ground level
- Potential for groundwater flooding to occur at surface

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Drawing number	Figure A8.1.7 Sheet 3 of 4	Rev	0

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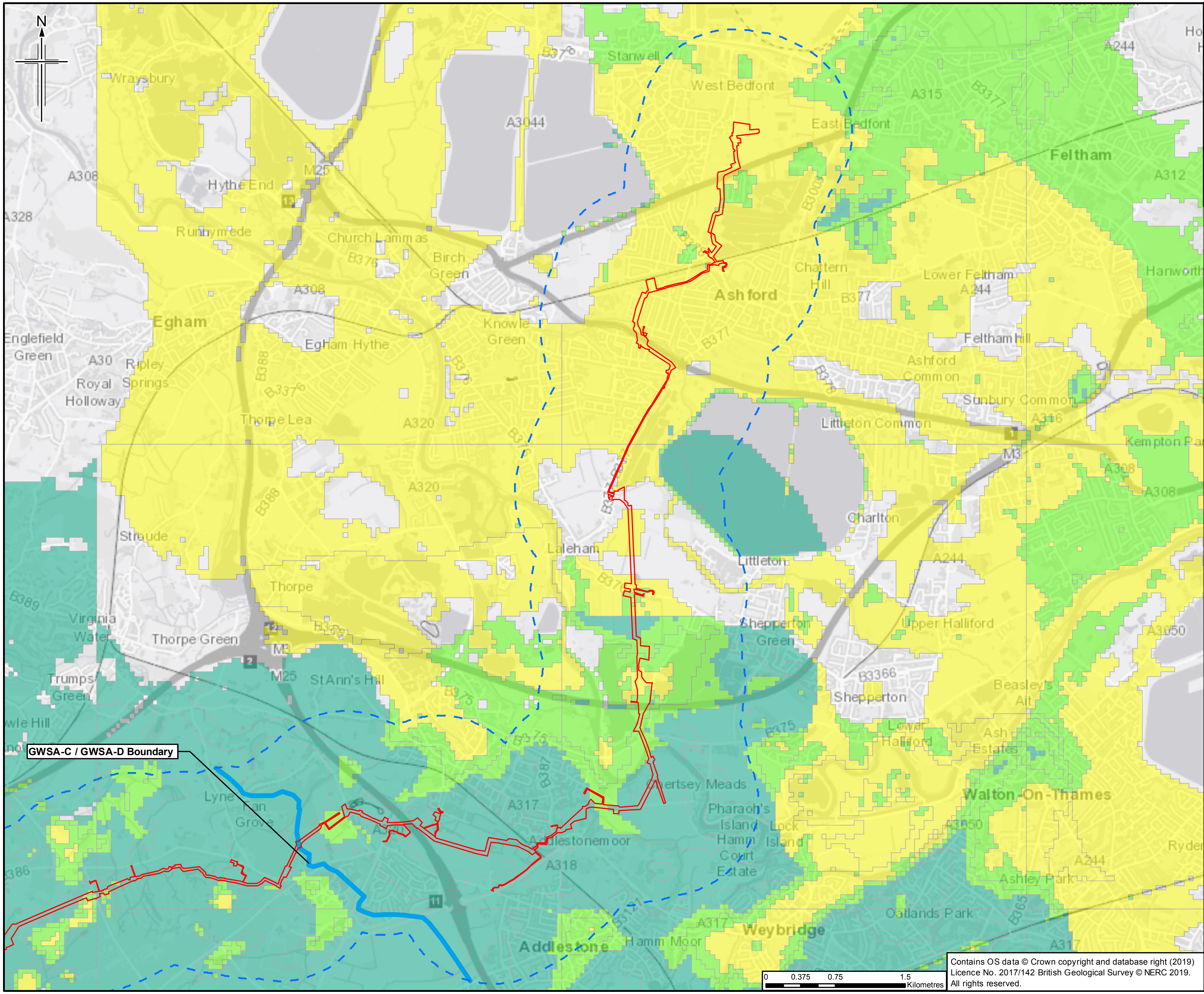

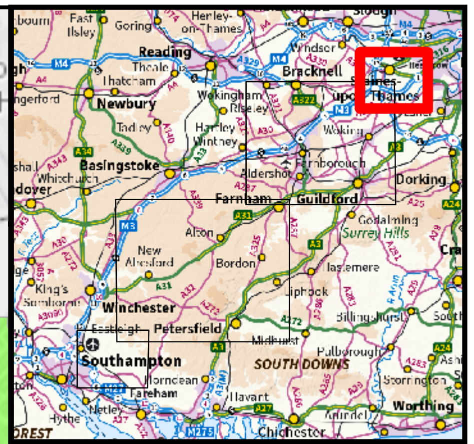

Legend

- Order Limits
- Order Limits 1km buffer
- EA groundwater level monitoring boreholes
- Groundwater study area division lines

Groundwater Flooding

- Limited potential for groundwater flooding to occur
- Potential for groundwater flooding of property situated below ground level
- Potential for groundwater flooding to occur at surface

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APFP Reg. (2009) 5(2)(l)

Drawing Status	For Issue
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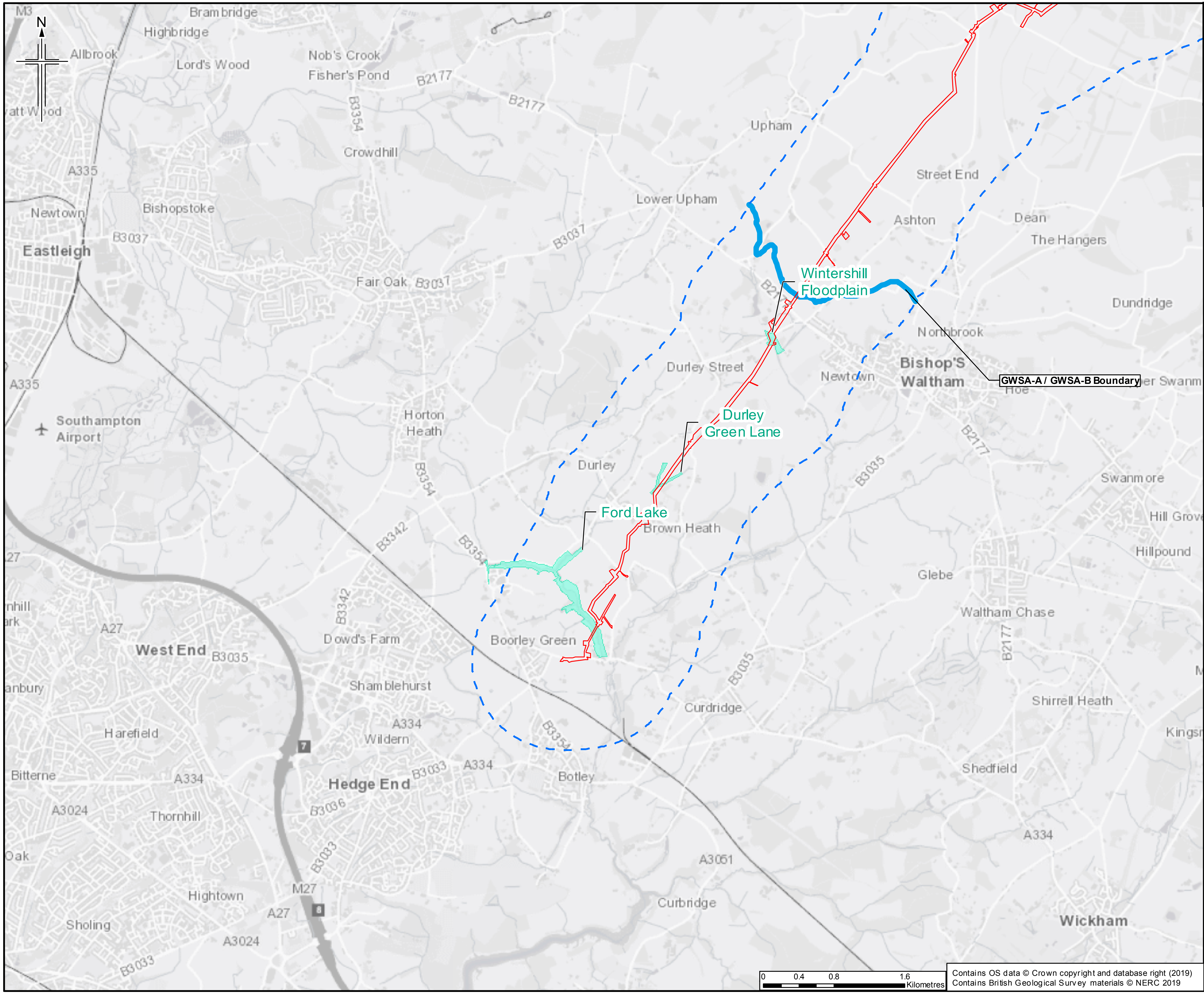
Drawing number	Figure A8.1.7 Sheet 4 of 4
Rev	0



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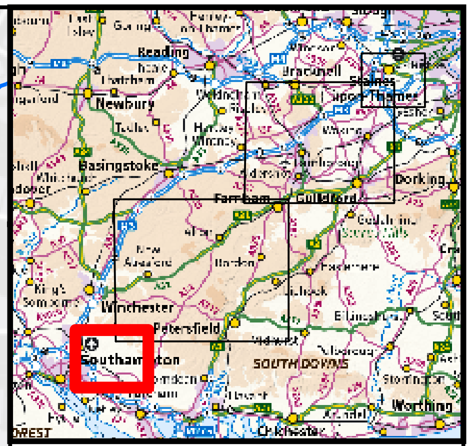

Legend

- Order Limits
- Order Limits 1km buffer
- Groundwater study area division lines
- GWDTE scoping report sites

Sheet displays parts of Section A

Rev.	Rev. Date	Purpose of revision	Orig/Dwn	Checkd	Rev'd	Apprv'd
0	29/03/2019	For Issue	HM	TC	MB	SH

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Project

Southampton to London Pipeline Project

Drawing title

ENVIRONMENTAL STATEMENT
GROUNDWATER DEPENDENT
TERRESTRIAL ECOSYSTEMS
APFP Reg. (2009) 5(2)(l)

Drawing Status	For Issue	
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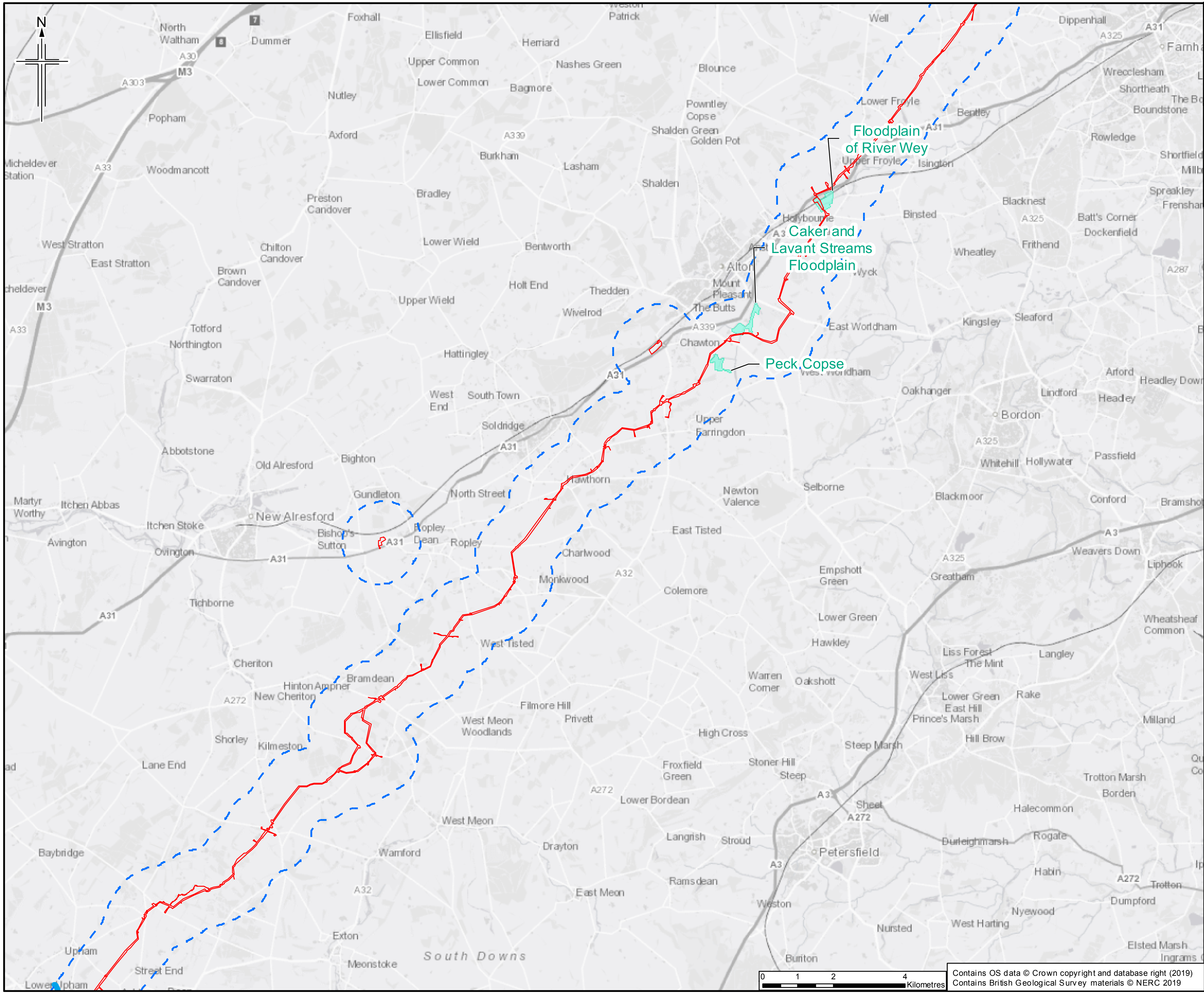
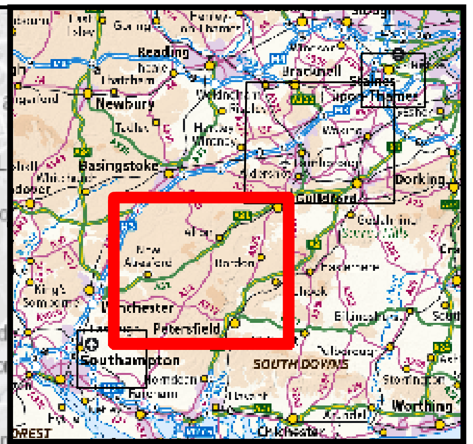
Drawing number	Figure A8.1.8 Sheet 1 of 4	Rev 0





Legend

- Order Limits
- Order Limits 1km buffer
- Groundwater study area division lines
- GWDTE scoping report sites

Sheet displays parts of Section A, Section B and Section C

Rev.	Rev. Date	Purpose of revision	Orig/Dwn	Checkd	Rev'd	Apprv'd
0	29/03/2019	For Issue	HM	TC	MB	SH

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GROUNDWATER DEPENDENT TERRESTRIAL ECOSYSTEMS
APFP Reg. (2009) 5(2)(l)

Drawing Status	For Issue		
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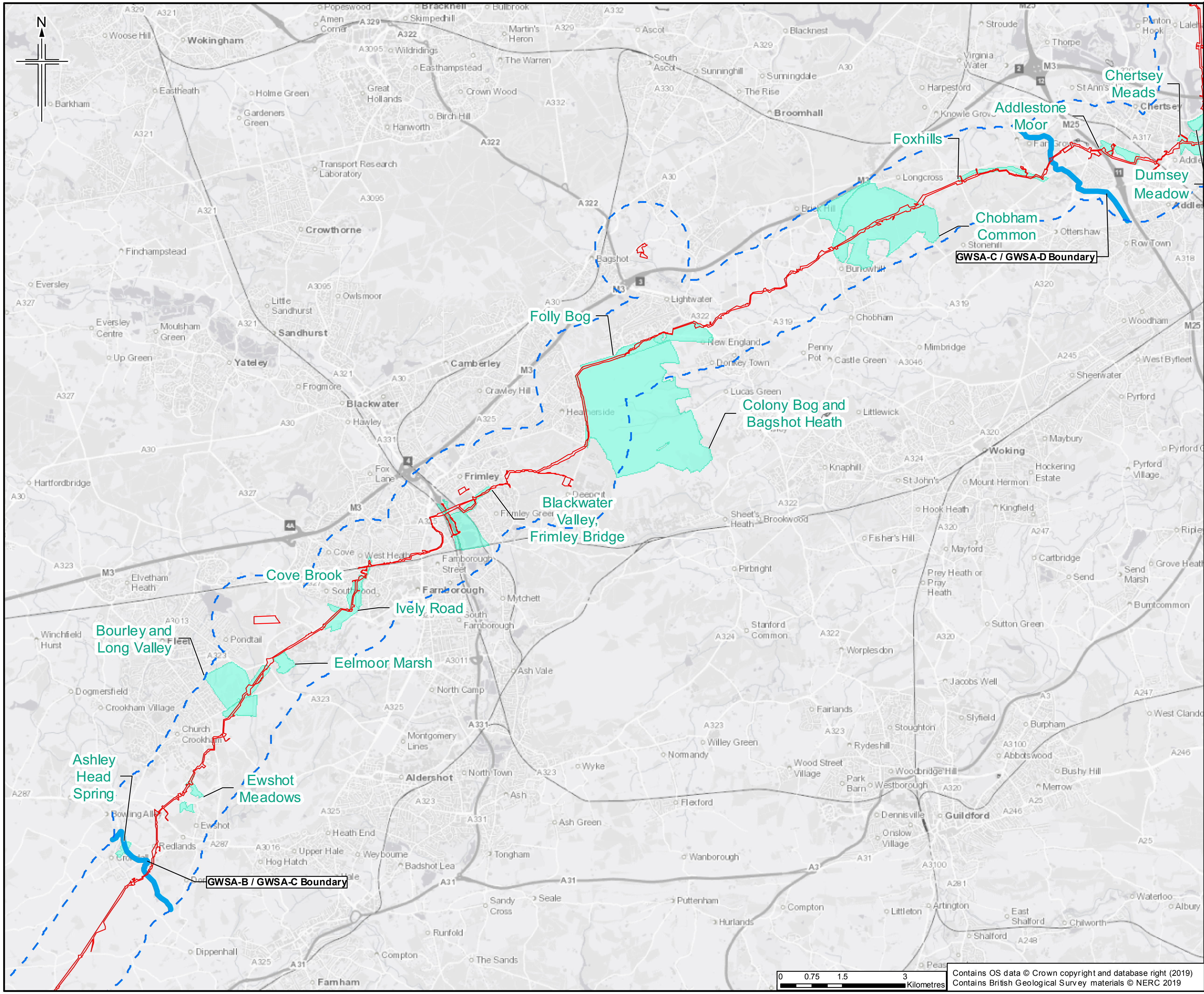
Drawing number	Figure A8.1.8 Sheet 2 of 4	Rev	0



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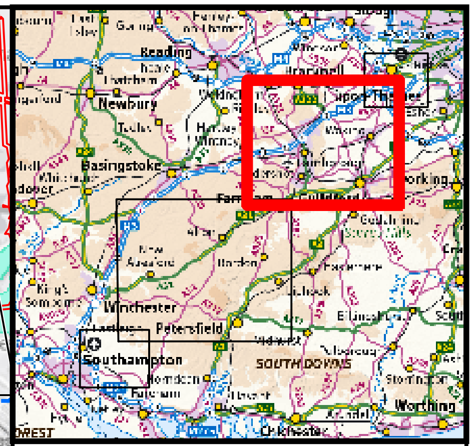

Legend

- Order Limits
- Order Limits 1km buffer
- Groundwater study area division lines
- GWDTE scoping report sites

Sheet displays parts of Section C through to Section G

Rev.	Rev. Date	Purpose of revision	Orig/Dwn	Checkd	Rev'd	Apprv'd
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ENVIRONMENTAL STATEMENT
GROUNDWATER DEPENDENT
TERRESTRIAL ECOSYSTEMS
APFP Reg. (2009) 5(2)(l)

Drawing Status	For Issue	
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Jacobs No.	B2325300	
ProjectWise No.	B2325300-JAC-000-ENV-DRG-001116	
Drawing number	Figure A8.1.8 Sheet 3 of 4	Rev 0

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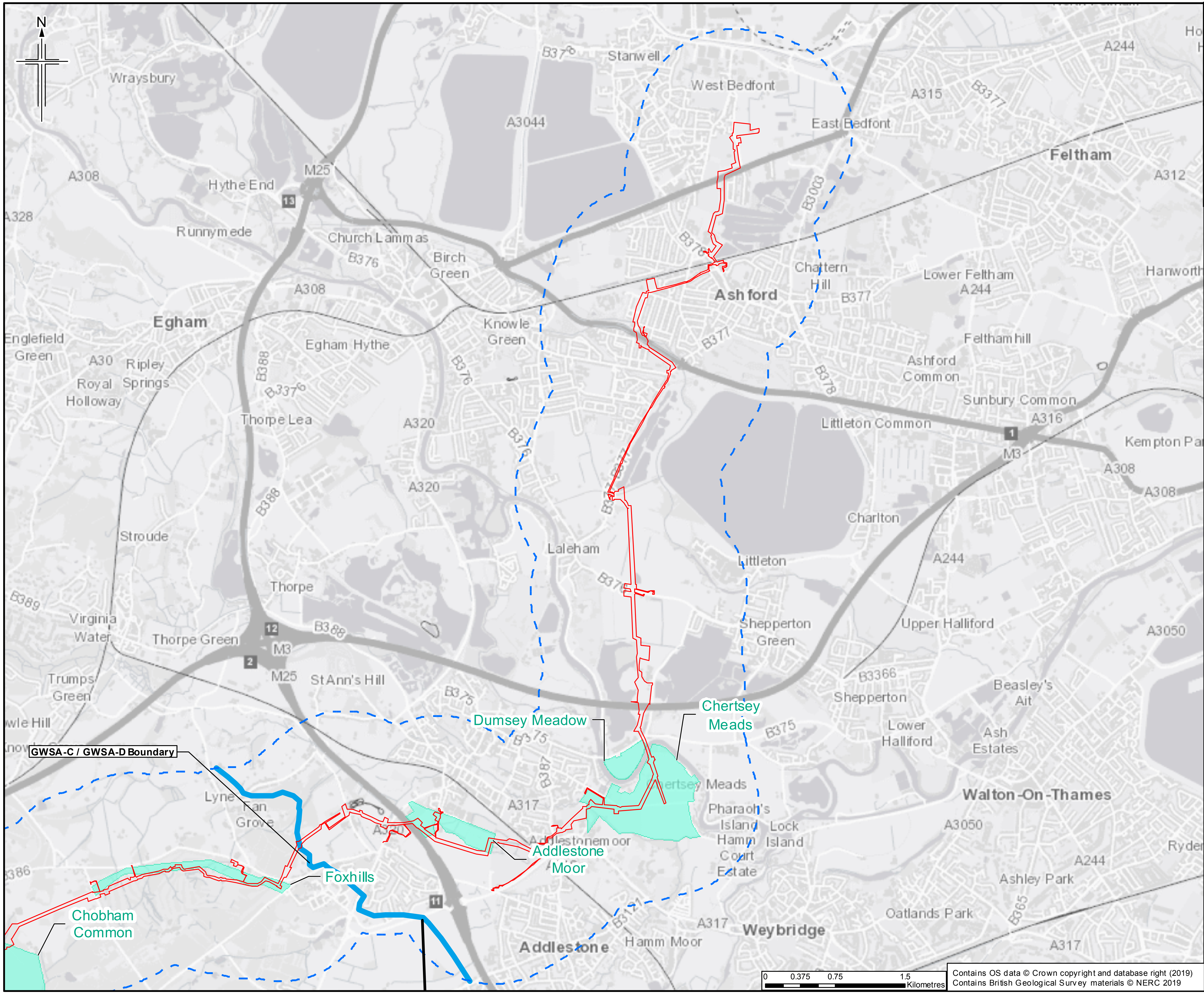

Legend

- Order Limits
- Order Limits 1km buffer
- Groundwater study area division lines
- GWDTE scoping report sites

Sheet displays parts of Section F, Section G and Section H

Rev.	Rev. Date	Purpose of revision	Orig/Dwn	Checkd	Rev'd	Apprv'd
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GROUNDWATER DEPENDENT TERRESTRIAL ECOSYSTEMS
APFP Reg. (2009) 5(2)(l)

Drawing Status	For Issue		
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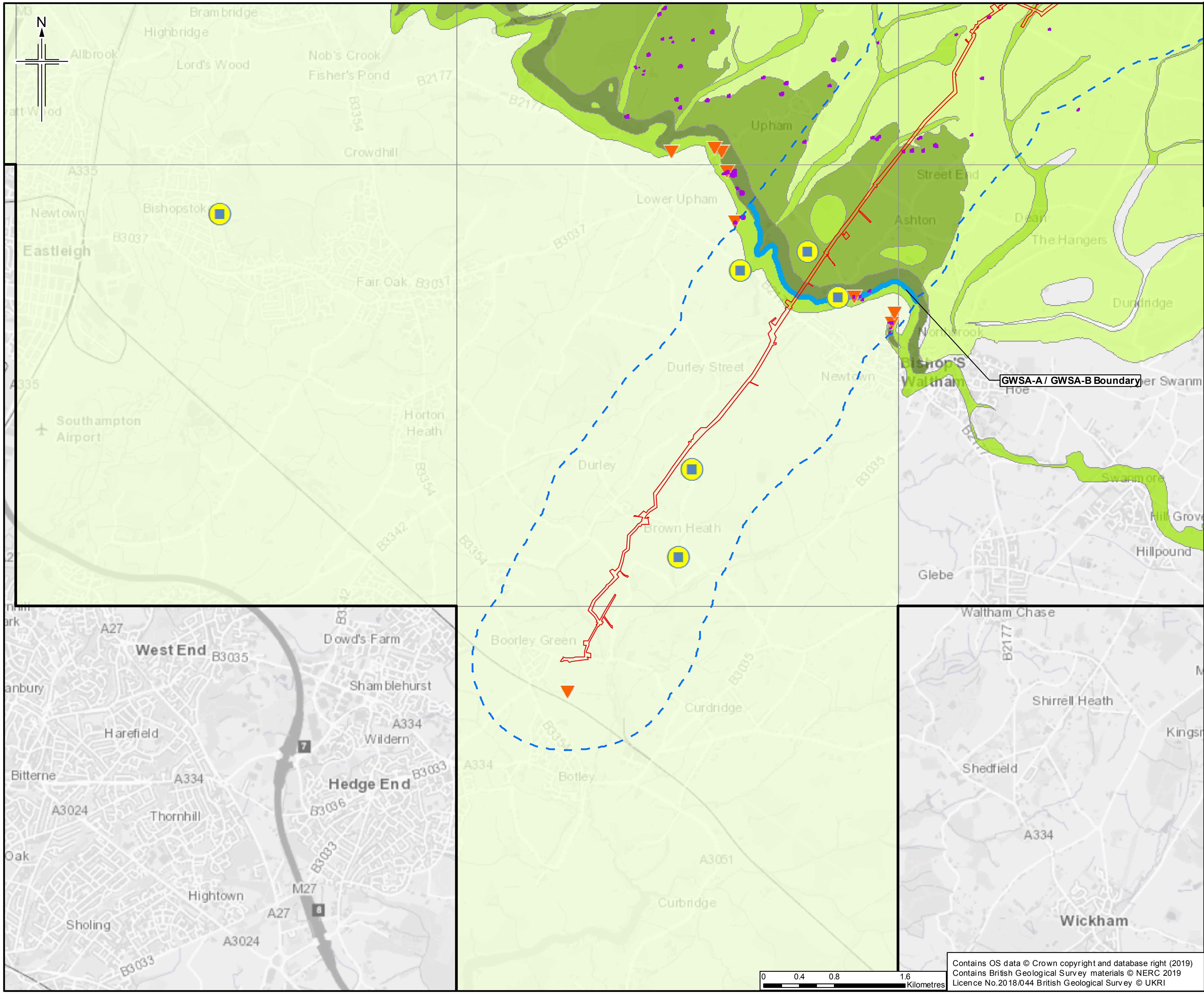
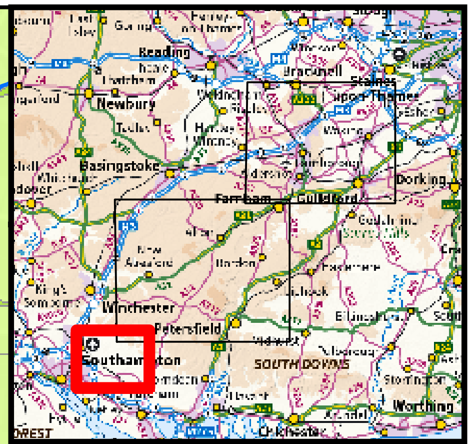
ProjectWise No.	B2325300-JAC-000-ENV-DRG-001116		
Drawing number	Figure A8.1.8 Sheet 4 of 4	Rev	0





Legend

- Order Limits
- Extent of data coverage
- Order Limits 1km buffer
- Groundwater study area division lines
- BGS karst, stream sinks
- BGS karst, dolines (point)
- BGS karst, dolines (area)
- BGS karst, springs
- Soluble rocks are either not thought to be present within the ground, or not prone to dissolution. Dissolution features are unlikely to be present.
- Soluble rocks are present within the ground. Few dissolution features are likely to be present. Potential for difficult ground conditions or localised subsidence are at a level where they need not be considered.
- Soluble rocks are present within the ground. Some dissolution features may be present. Potential for difficult ground conditions are at a level where they may be considered. Localised subsidence need not be considered except in exceptional circumstances.
- Soluble rocks are present within the ground. Many dissolution features may be present. Potential for difficult ground conditions are at a level where they should be considered. Potential for subsidence is at a level where it may need to be considered.
- Soluble rocks are present within the ground. Numerous dissolution features may be present. Potential for difficult ground conditions should be investigated. Potential for localised subsidence is at a level where it should be considered.

Sheet displays parts of Section A

Rev.	Rev. Date	Purpose of revision	Orig/Dwn	Checkd	Rev'd	Apprv'd
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ENVIRONMENTAL STATEMENT ROCK SOLUBILITY AND KARST FEATURES APFP Reg. (2009) 5(2)(l)

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Scale	1:40,000 @ A3	DO NOT SCALE
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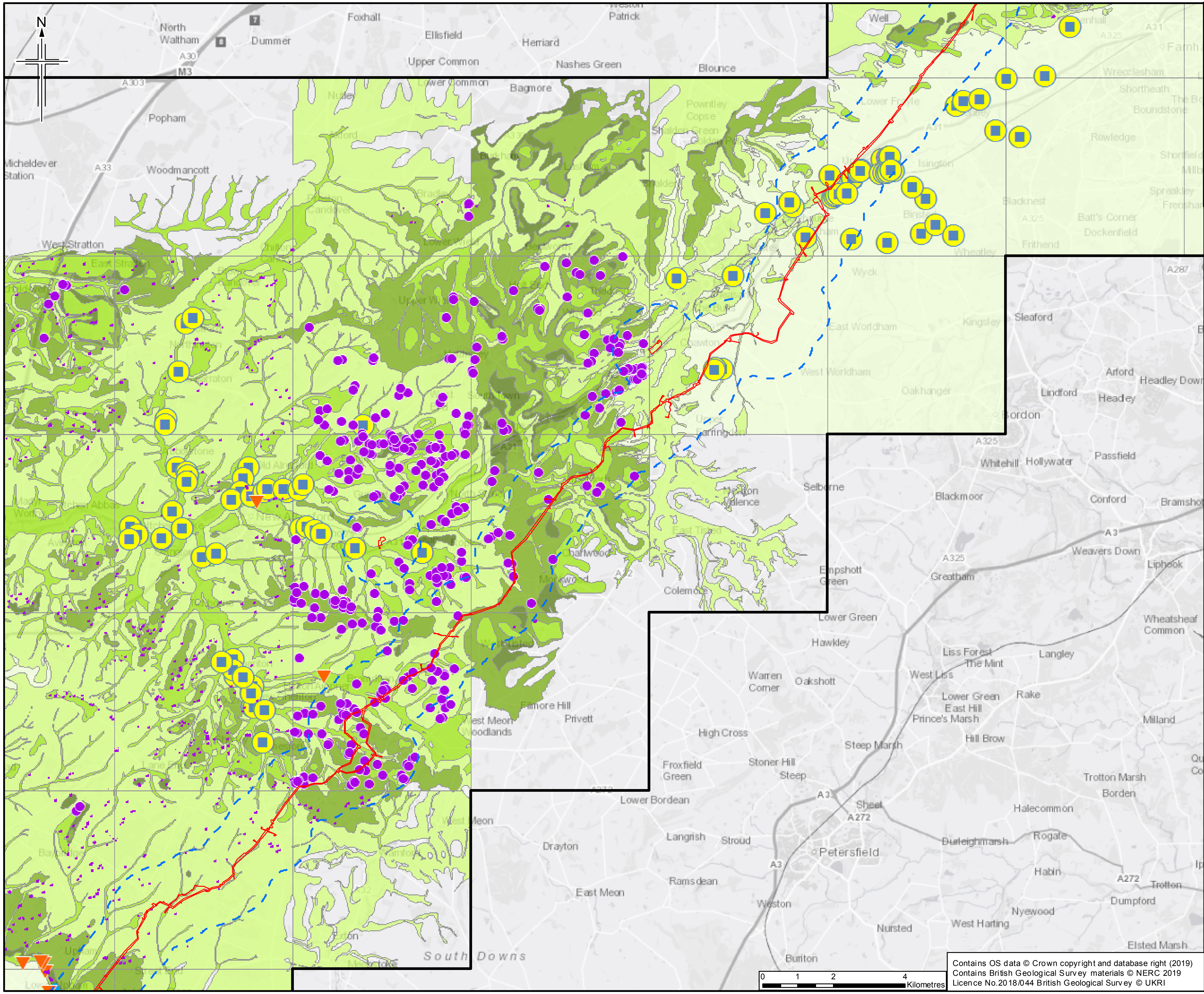
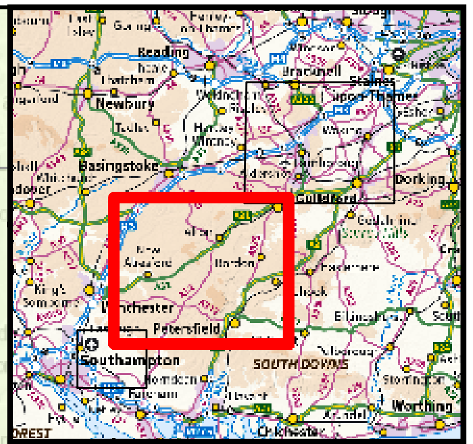
Drawing number	Figure A8.1.9 Sheet 1 of 3	Rev 0





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Legend

- Order Limits
- Extent of data coverage
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Sheet displays parts of Section A, Section B and Section C

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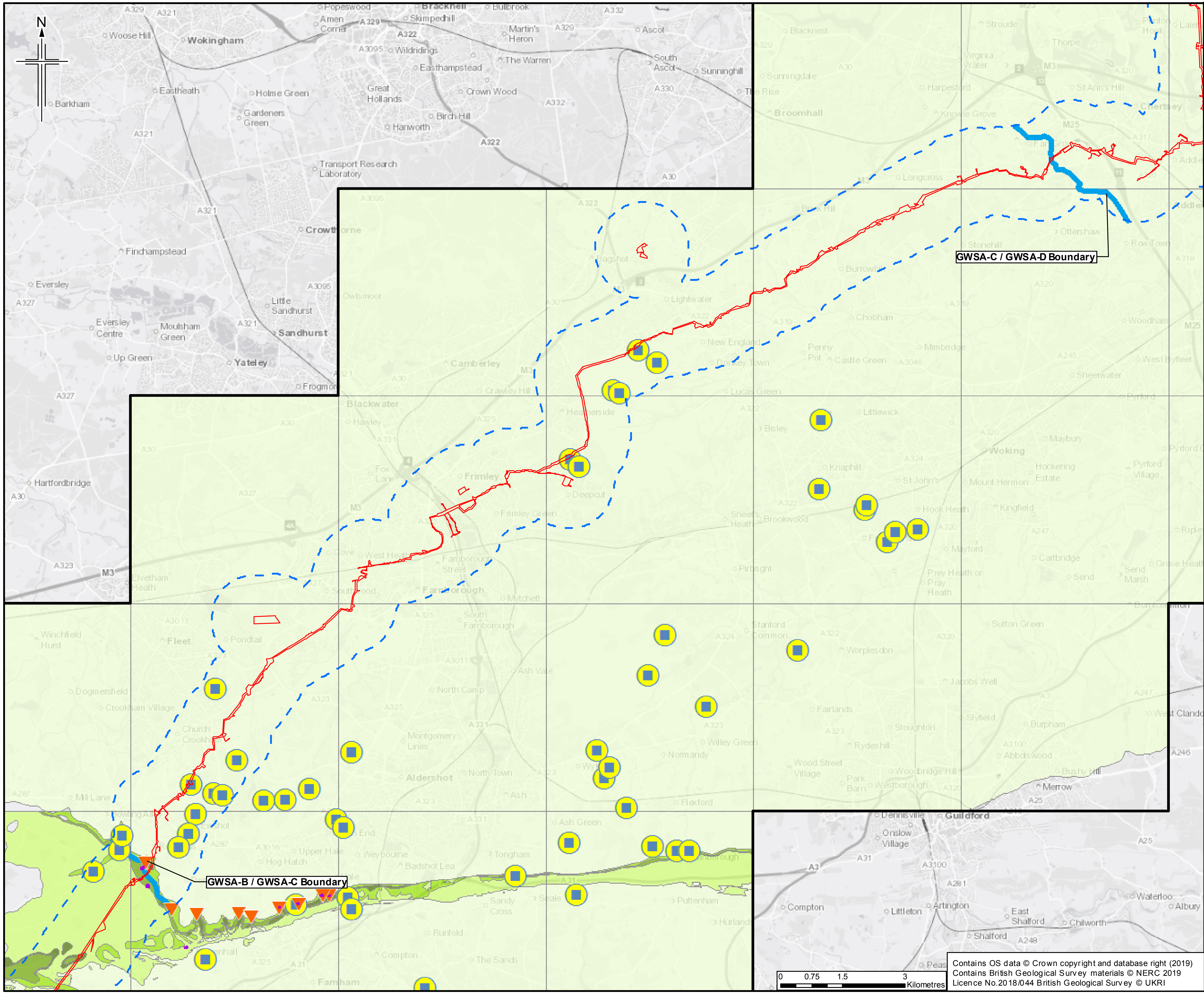
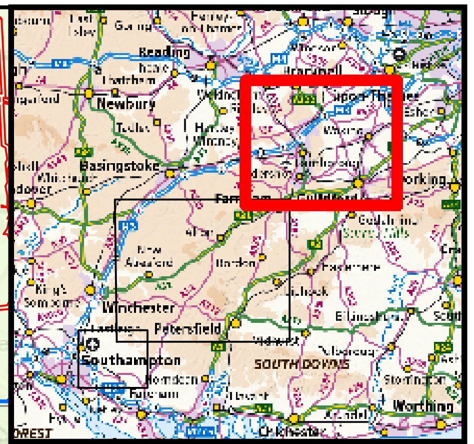
Drawing number	Figure A8.1.9 Sheet 2 of 3	Rev 0





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Sheet displays parts of Section C through to Section G

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Drawing number	Figure A8.1.9 Sheet 3 of 3	Rev 0