HILLYBARN FARM

HYDROGEOLOGICAL & WATER NEUTRALITY ASSESSMENT

APRIL 2023

PROJECT NO. 22231014

B. A. Hydro Solutions Limited
3 & 4 The Sidings, Station Road, Shepreth, Royston, Herts, SG8 6PZ, 01763 26 27 26

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Hillybarn Farm
The Mount
Ifield
Crawley
RH11 0LF

Report researched and produced by B. A. Hydro Solutions Limited (BAHS Ltd) on the instruction of PROwe Planning Solutions.

t. +44 (0)1327 264622
w. www.britishdrillingassociation.co.uk

t. +44 (0)3302 23 43 02
w. www.gshp.org.uk

B. A. Hydro Solutions Limited
3&4 The Sidings
Station Road
Shepreth
Herts
SG8 6PZ

t. +44 (0)1763 26 27 26
e. info@bahsltd.com
w. www.bahsltd.com

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1 Introduction

B. A. Hydro Solutions Ltd. (BAHS Ltd.) has been commissioned to complete a desk study report on hydrogeological conditions present at the following site. There is a proposal to develop the site for residential purposes utilising an existing well. Due to the location within the Sussex North Water Resource Zone, there is a need to assess the water neutrality status of the proposal as only water neutral projects are acceptable to Natural England who are responsible for conservations site assessed to be at risk within the Zone.

The site location is illustrated in the following figure; for the purpose of considering geological strata and depths to each stratum, a mean site elevation has been adopted throughout this report, as listed below:

Site Address:	Hillybarn Farm			
	The Mount			
	Ifield			
Postcode:	RH11 0LF			
Drill position NGR:	TQ 23116 38251			
Elevation range:	96	to	98	maOD
Elevation adopted:	98			maOD

Table 1: Site details

2 Objectives

This Assessment seeks to fulfil the following objectives:

- Confirm the geological sequence.
- Define the hydrogeological setting.
- Consider where groundwater is present and hydraulic linkages.
- Consider the quantity and seasonality of groundwater present and recharge.
- Consider the potential and effects of groundwater abstraction.
- Consider the likely quality of water present.
- Report the regulatory conditions applicable.
- Assess the potential impact on the Sussex North Water Resource Zone and whether the project would be water neutral.

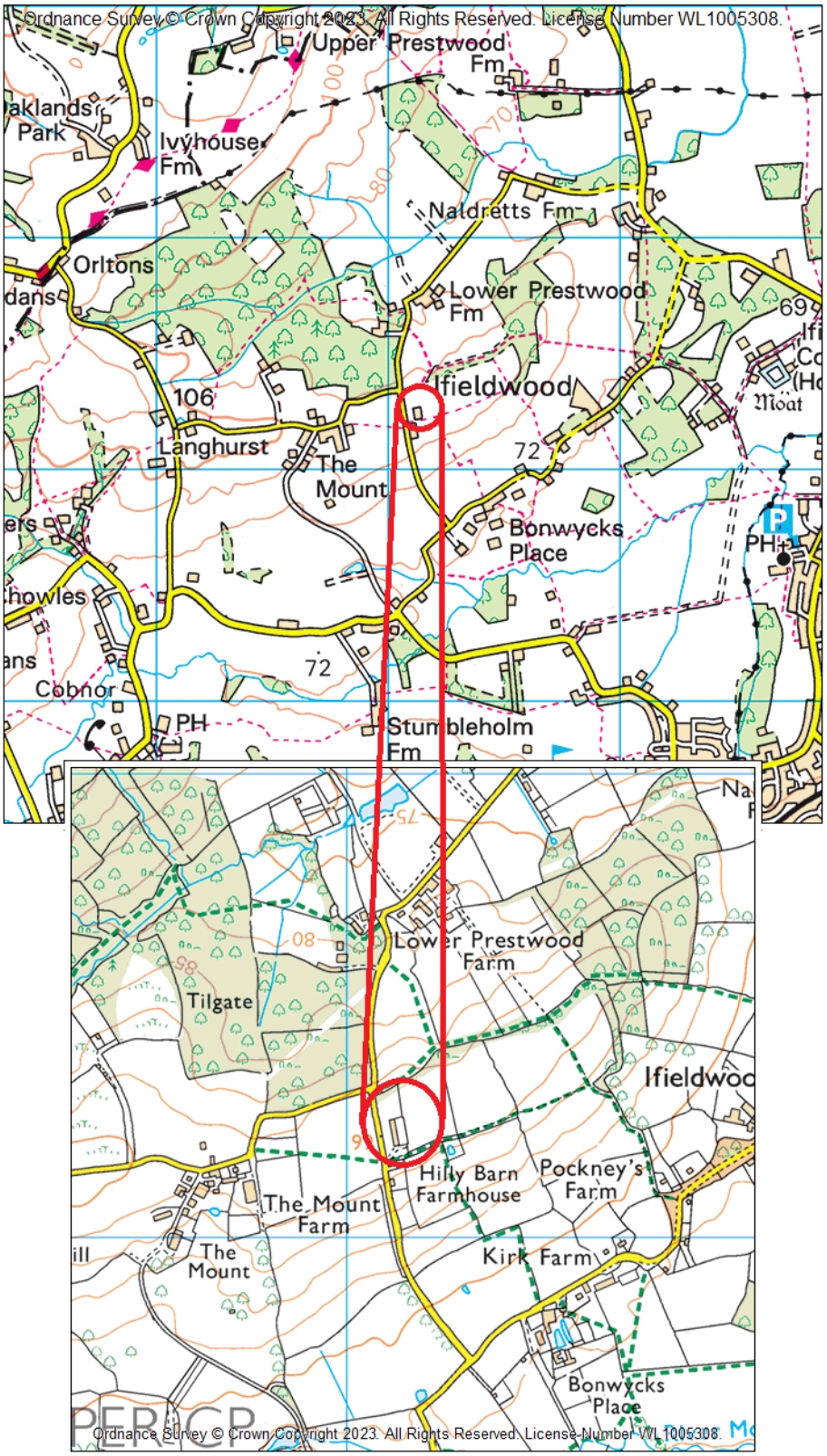

Figure 1: Location Map

3 Geological Setting

3.1 Geology

The following discussion of the geology beneath the site is based on a site-specific literature review and historical borehole records that have been obtained for the purpose of predicting the geological unit thickness, nature and depths. As geological units are not laterally continuous, vary in thickness and are not homogeneous, the predicted thickness and depths may differ slightly if or when investigated on site.

The geology and thicknesses reported are based on the position of the exiting well as advised by the client. The National Grid Reference (NGR) listed in Table 1 is marked on the geology map below.

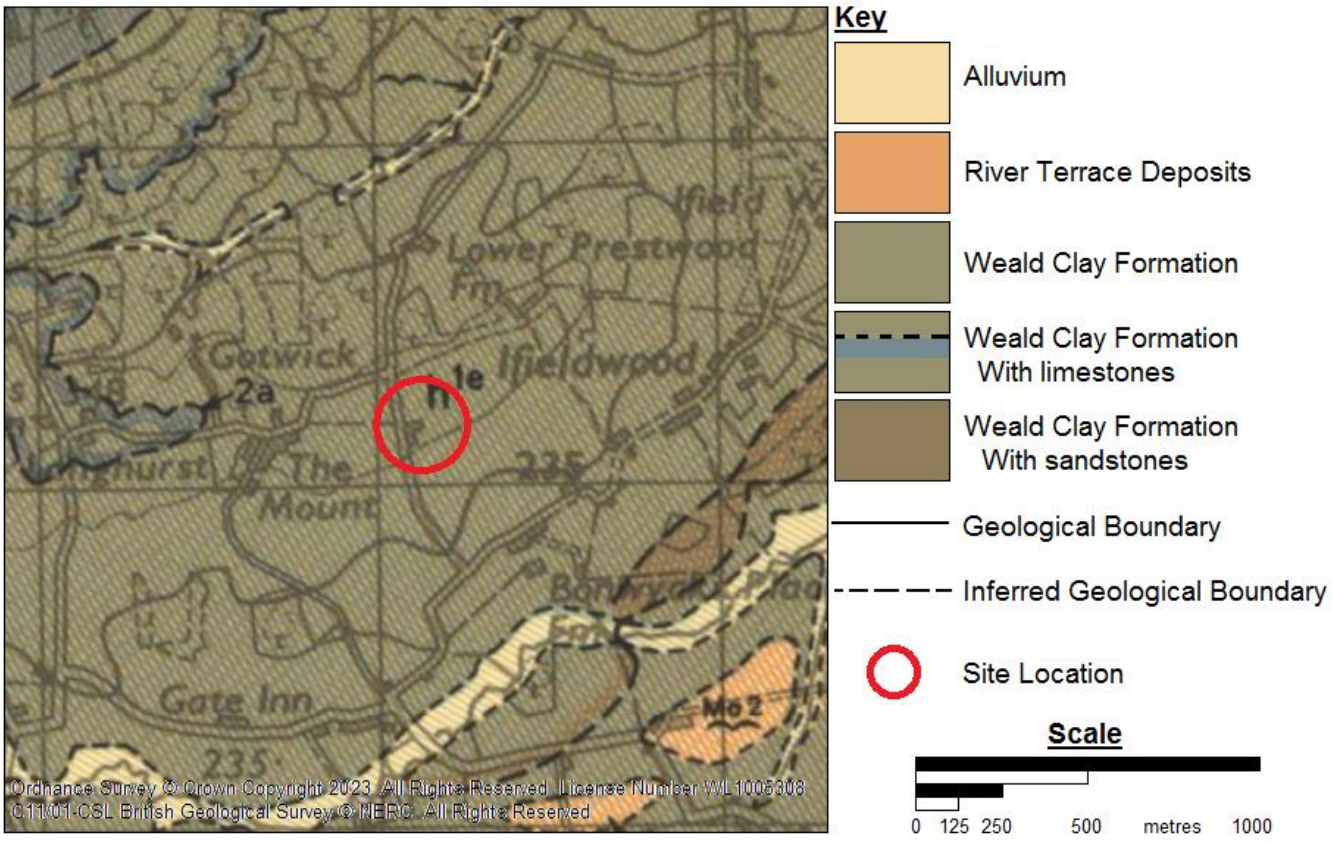

Figure 2: Geological Map

The geology mapped at ground level across the local area is illustrated in Figure 2; the location of the site is outlined in red, the following table summarises the

strata present, their names, lithological nature and range of thicknesses as seen regionally.

Geological Group	Geological Formation	Lithological Nature	Range of thickness (metres)
-	Soil & Drift	Loamy Soils	<2
Wealden Group	Weald Clay Formation	Mudstones & Siltstones with layers of sandstone and limestone	>450

Table 2: Summary of Geological Sequence

3.2 Structure

The main geological structures present and affecting the ground beneath the site are listed below. The tectonic events and the sequences leading to the resulting structures are not considered by this Assessment as such detail does not affect the conclusions drawn by this study.

- There are no faults in the vicinity of the site, minor faults may be present but are not anticipated to affect the presence or abundance of groundwater beneath the site.
- The strata considered by this Assessment have experienced minor tectonic deformation since their deposition, they have been gently folded/tilted and faulted.
- The strata dip to the west through to north-west at between 15 and 40 degrees from horizontal.

4 Lithological Characterisation

4.1 Drift

The soil is reported to be slowly permeable, seasonally wet, slightly acidic but base-rich loamy and clayey soil. The soil is expected to be 0.2 to 0.6 metres thick with no drift underlying it.

4.2 Weald Clay Formation

The rock head beneath this site is formed by the Weald Clay Formation. The rock head is expected to be weathered to a depth of 2 to 15 metres causing weakening of strata making it less able to stand without support during drilling.

The Weald Clay Formation is the top most unit of the Wealden Group and is typically formed of mudstones and shales with subordinate layers of siltstone, occasional layers of fine to medium grained sandstones, some of which are calcareous in nature. The mudstones, shales and siltstones form a series of thinly bedded sediments which tend to be a dark grey colour. A number of thicker sandstone and limestone horizons have been found to extend over some distance, whilst most are lensoidal with only limited lateral extents.

The Horsham Stone Member and the Paludina Limestones are examples of more traceable horizons within the Weald, which have more of a regional presence. Most of the more arenaceous deposits and limestones have such limited thicknesses and lateral extents that they have no hydraulic connection to ground level and thus contain isolated pockets of groundwater receiving very slow rates of recharge as water migrates downwards through the clay rich layers above.

Local boreholes have recorded layers of 'clay' and shale, the 'clays' can be geologically interpreted to be mudstones that have become broken down by the drilling process, possible weathered clays if within the first 2 to 10 metres below rock head. The shales represent the less weathered and less disturbed layers. Regionally, the mudstone and shale layers are noted as being grey to dark grey in colour. The local drilling logs do not make mention of the sandstone and limestone beds that are present regionally, these are/were present as the boreholes have encountered water which is only present in these layers. The Weald Clay Formation is anticipated to be over 100 metres thick beneath the site and the last geological unit considered by this Assessment within an ecomonic drill depth.

5 Hydrology and Hydrogeology

5.1 Hydrology

The following table summarises the nearest water features to the proposed borehole location and the potential impact of the proposal:

Water Feature	Direction (N/E/S/W)	Distance (Km)	Hydraulic Connection?	Potential Impact
Pond	SE	0.1	Perched - no link with groundwater	No Impact
Pond	SW	0.4	Perched - no link with groundwater	No Impact
Pond	SE	0.5	Perched - no link with groundwater	No Impact

Table 3: Hydrology Summary

The Environment Agency's flood designation for the site is summarised below, this Assessment is not, and cannot be used as part of a flood risk assessment.

Is there a risk of flooding?	Low Risk
Flood Risk Level	0.1 - 1 %
Nature of flood risk	Surface water

Table 4: Flood Designation

5.2 Hydrogeology

In this section the ground beneath the site is divided into hydrogeological units which are in turn considered in terms of the presence, abundance, movement and potential to sustain a new groundwater abstraction. Each unit is considered as it is reached with depth below the site. The preferred hydrogeological unit for a potential new groundwater abstraction is identified. The necessary drill depth, anticipated rest water level, along with the potential yield and necessary drawdown in water levels needed to sustain the predicted yield are set out in Table 5.

The study has considered the different strata present beneath the site in terms of their hydrogeological conditions to assess whether there may be a prospect of finding water. Where there are no boreholes or abstractions locally which can be used directly to judge the potential of the ground, BAHS Ltd use information

derived from representative abstractions completed into comparable hydrogeological settings.

Soil and Shallow Weald Clay Secondary (undifferentiated) Aquifer	The shallow ground seasonally contains water, however its limited thickness and/or seasonal fluctuation in water levels means it does not represent a viable target horizon for a new groundwater abstraction. Historically shallow wells may have drawn from this horizon, a modern borehole and pumping system could not be sustained by the volumes of water present.	Rest Water Level (maOD) N/A Transmissivity (m^2/day) N/A
Weald Clay Formation Secondary (undifferentiated) Aquifer	The low permeability mudstones and siltstones in this unit are unable to contain or transmit any measurable volume of water in their pore spaces. Small amounts of groundwater is present in the joints and fractures that cut through the limestone and sandstone rock layers within the unit. However, the density and connectivity of these joints and fractures decrease with depth (40 to 60 metres) due to the weight of the ground above, which restricts their development and propagation (if present).	Rest Water Level (maOD) 70 to 75 Transmissivity (m^2/day) 2 to 14

This Assessment concludes that the existing well on site must draw from the Weald Clay Formation Deposits and that these presented the only/most favourable horizon present. Based on water level and abstraction records from local boreholes passing through comparable ground; this Assessment estimates a Transmissivity (T) range in the local area of zero up to 2 to 14 m^2/day.

Using a conservative T value, a 10 metre drawdown in water levels in the well below a rest water level of 70 to 75 maOD; a yield of between 0.6 and 2.5 cubic metres per hour should be sustainable. The following table summarises the above values and the predicted yield:

Rest Water Level	23 to 28 mbgl	Or	70 to 75 maOD
Drawdown in water levels (m)	10		
Transmissivity Range (m^2/day)	2	To	14
Potential yield range (m^3/hour)	0.6	To	2.5
Estimated depth of well (m):	60	To	75

Table 5: Hydrogeological Properties

6 Water Quality

The quality of groundwater present beneath the site has been tested by B. A. Hydro Solutions Ltd., the results are listed below along with limits based on UK Drinking Water Standards. The values reported reflect measurements made on the sample collected on the 5th May 2022, the quality could vary over time.

Parameters	Local Range			UK Limit	Unit
Alkalinity	271	to	>320	-	mg/l
Calcium	2.5	to	138	-	mg/l
Chloride	15.9	to	280	250	mg/l
Chromium		<30		50	µg/l
Copper		<100		2000	µg/l
Cyanide		<10		50	µg/l
Fluoride		<150		1500	ug/l
Total Iron (FeII+FeIII)	289	to	20200	200	µg/l
Lead		<1		10	µg/l
Magnesium	2	to	6	-	mg/l
Manganese	13	to	690	50	µg/l
Nitrate	<5	to	17	50	mg/l
Nitrite	25	to	332	500	µg/l
Phosphate	0.2	to	0.6	-	mg/l
Potassium	15	to	32	-	mg/l
Sodium	6	to	490	200	mg/l
Sulphate	<150	to	266	250	mg/l
Sulphide		<0.1		-	mg/l
Zinc	<0.2	to	1.22	-	mg/l
Electrical Conductivity	692	to	2152	2500	µS/cm
Hardness, Total, as CaCO3	14	to	368	-	mg/l
pH	7.0	to	8.2	6.5-9.5	pH units
Total Dissolved Solids	337	to	1082	-	mg/l

Table 6: Indicative water quality

The quality of water is expected to be poor due to potentially elevated levels of chloride, iron, manganese, sodium and sulphate; these problematic parameters can be treated to make this a potable source of water.

7 Water Neutrality

7.1 Background & Definition

There are documented concerns that a number of conservation areas are at risk of deteriorating as a result of changes to the hydrogeological and hydrological environment. There is reason to believe the abstraction of water by the local water undertaker is having an adverse effect on the conservation areas. At present it cannot be demonstrated beyond doubt that the existing abstractions are having an effect, consequently Natural England advise that developments within this effected zone must not add to this impact.

Natural England conclude there can be no adverse effect on the integrity of;

- Arun Valley Special Area Conservation (SAC)
- Arun Valley Special Protection Area (SPA)
- Arun Valley Ramsar Site.

For a new development to not have an adverse effect it must be water neutral [quality and quantity]. The definition of water neutrality is the use of water in the supply area before the development is the same or lower after the development is in place (*Natural England's Position Statement for Applications within the Sussex North Water Supply Zone, September 2021 – Interim Approach*).

7.2 The Sussex North Water Resource Zone

The area of primary concern to Natural England is an area known as the Sussex North Water Resource Zone. The following figure illustrates the zone.

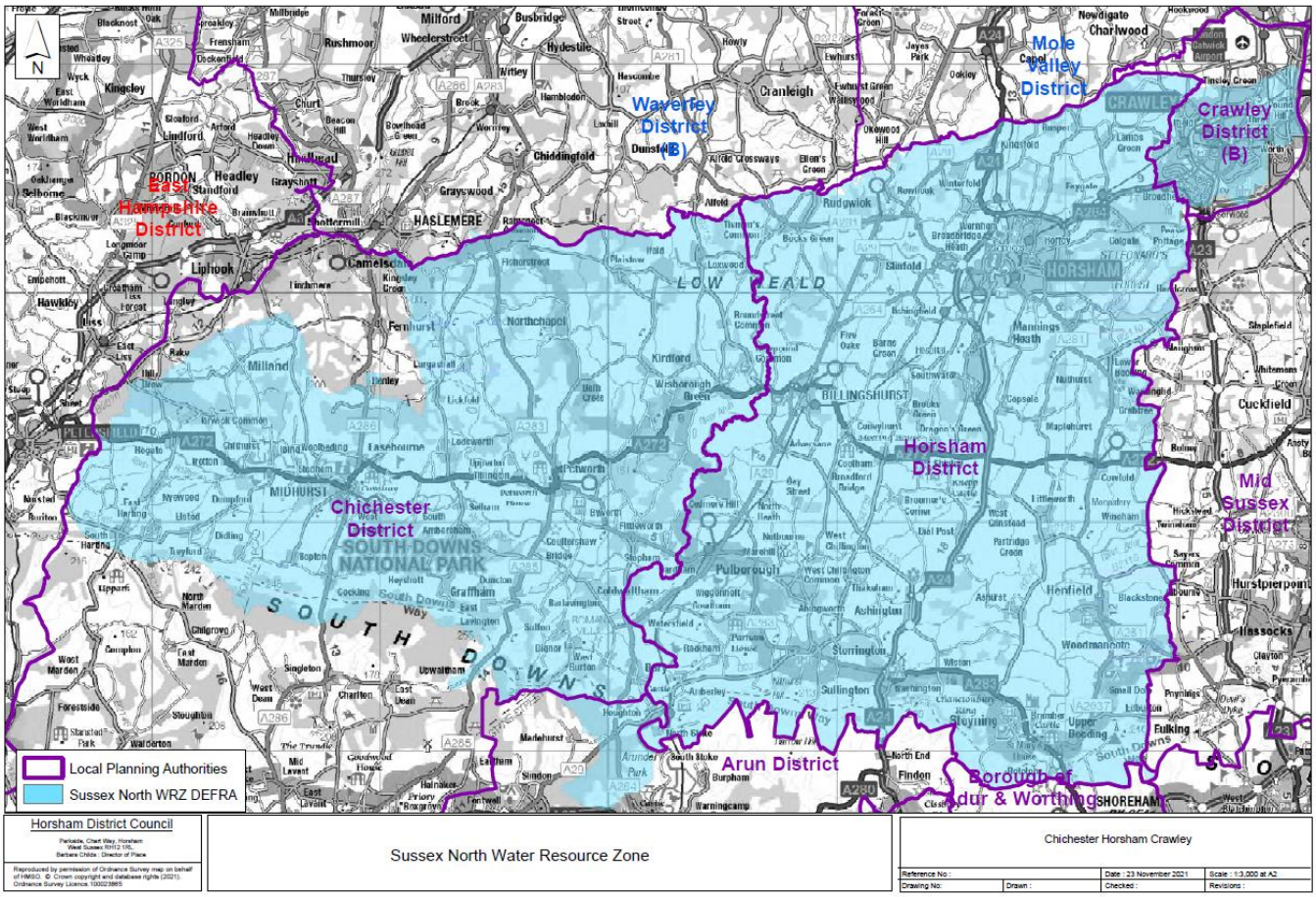

Figure 3: Sussex North Water Resource Zone

Any closed loop boreholes drilled at the site should be separated by an adequate distance to minimise thermal interaction over the lifetime operation of the ground source heating system. Where possible boreholes should also be configured to avoid shadowing as passing groundwater is chilled or warmed.

7.3 Source(s) of Water

In order for the abstraction of groundwater not to affect the water balance within the Sussex North Water Resource Zone (Zone) the water abstracted must not have otherwise ended up within the Zone being protected. In this part of the Assessment BAHS considers the groundwater body that may be drawn from and whether it is in hydraulic continuity with surface water or groundwater within the Zone. This section also considers whether the abstraction of groundwater from the proposed source horizon would adversely or positively

affect the quality of groundwater present, and whether there may have any effect on the protected Zone.

The Assessment has completed a review of the hydrogeological setting of this site in order to identify all surface water and groundwater links between the site and the three sites identified by Natural England. The following figure illustrates the site location in relation to the sites of concern and highlights the hydraulic linkages that could exist.

A new borehole at this site would draw from the Weald Clay Formation which has no hydraulic connnection with surface water, or groundwater that sustains or has hydraulic connection with, the water dependant habitats within the Water Neutrality Zone. A new abstraction from a borehole at this site could, therefore, have no direct or indirect impact on the water dependant habitats.

Due to the very low permeability, porosity and infiltration rate into the Weald Clay, an abstraction of groundwater from the unit cannot change the rate at which rainfall recharges the unit. The groundwater abstracted would be from tens of metres below ground level which would have no effect at ground level, thus not leaving a 'void' for rainwater to fill. Thus the rate at which rainfall enters the ground would be unchanged and therefore the abstraction would have no effect on runoff rates or infiltration rates from the site.

The proposed private water supply abstraction would therefore not be at the expense of surface water, groundwater or runoff on or off site. There could be no impact on the water resource status of the Water Neutrality Zone and therefore no effect on the water dependant habitats.

As a new abstraction would be drawing from deep pockets of groundwater which are very slowly recharged, at a rate not influenced or affected by abstraction itself, there could be no resulting effects on the quality of groundwater or surface water on or off site.

7.4 Groundwater Recharge

Natural England will consider proposed developments in terms of whether they might have an effect on the recharge to groundwater and groundwater fed environments. For example, might the development block pathways for groundwater recharge, change groundwater flow patterns, runoff and infiltration rates.

This section of the Assessment considers whether the development would change groundwater recharge potentials across the site and whether use of

soakaways and associated drainage systems could help to increase the water balance contribution. Finally the effect of any changes to natural groundwater recharge and any induced recharge is considered in terms of water quality.

7.4.1 Natural Groundwater Recharge

As already stated, the abstraction of groundwater would be from isolated, fracture dominated, horizons within the ground which are very slowly recharged from above as water moves downwards from the ground surface over time. The rate of infiltration from ground level cannot be influecned as the hydrostatic pressure difference induced by the removal of water rapidly returns to natural levels within a few metres above or below the source horizon(s) and thus cannot propagate to ground level.

7.4.2 Induced Recharge

The abstraction of groundwater cannot, therefore, cause recharge to become more rapid, rather the rate of abstraction would have to be adjusted to balance the natural rate of recharge.

7.4.3 Water Quality Impact

The proposed abstraction would not change the quality of groundwater present, already anticipated to be poor, due to the very slow rate at which groundwater moves through the ground and the time it has to take on the chemical signature of the natural ground. As there would be no hydraulic link between groundwater abstraction and surface water or the different groundwater body that sustains the water dependant habitats (Chalk, Hythe and Greensands) the abstraction cannot affect their water quality either.

8 Regulatory Information

In England the Environment Agency (EA), and Natural Resources Wales (NRW) in Wales, have assessed the available surface water and groundwater resources within each river and groundwater management unit (catchments). The status of each unit or catchment is documented in a corresponding Catchment Abstraction Management Strategy (CAMS). Some of the units have been assessed as having water available, which means that the EA or NRW will consider an application for a licence to abstract surface or groundwater, on a case by case basis, dependent on the effects of the new abstraction on other existing abstractors and the environment, in the vicinity.

Other units may be deemed as either over abstracted or over licensed, and there is an over-arching stance in these areas that applications for consumptive groundwater abstraction licences would be refused under these CAMS policies. There are however, some circumstances where licences may be granted for abstraction at certain times of the year, dependent on hydrological conditions, and possible restrictions imposed on the licences. Applications for licences for open loop ground source heating systems may be considered in all surface water and groundwater units providing the water will be returned to the source and there would be no detrimental effects arising from the proposal.

The following table (Table 7) details the relevant CAMS and resource status for this site. Please note that an abstraction of up to 20 m^3/day does not require a licence; this allows a cumulative abstraction up to this volume per day from any combination of springs, surface water, boreholes, well, etc., per relevant property deed.

Source Protection Zones (SPZs) indicate the presence of sensitive licensed groundwater abstractions from the underlying aquifer(s), often those used for public/private potable supply. The EA and NRW use these zones in conjunction with their Groundwater Protection Policy (GP3) to set up pollution prevention measures in areas which are at high risk, and to monitor the activities of potential polluters nearby that may result in contamination of these sources.

Relevant CAMS:	N/A: abstractions under 20 cubic metres a day are license exempt
Date CAMS last updated:	N/A: abstractions under 20 cubic metres a day are license exempt
Status of units relative to this site:	N/A: abstractions under 20 cubic metres a day are license exempt
Is site within a SPZ:	No
SPZ number:	N/A

Table 7: Regulatory information

9 Assessment Summary

B. A. Hydro Solutions Ltd. has been commissioned to complete a Hydrogeological & Water Neutrality Assessment to investigate the potential utilising a groundwater abstraction for a private water supply and to assess whether this would result in a change in the water balance status of the Sussex North Water Resource Zone. This study has collected and assessed all available information at the time of production.

Please refer to:

- Section 3 for geological & structural summary,
- Section 4 for discussion on the lithology beneath the site,
- Section 5 for discussion on the hydrological and hydrogeological setting,
- Section 6 covers water neutrality,
- Section 7 for discussion on the anticipated water quality, and
- Section 8 for relevant regulatory information.

The findings from this study are listed below:

Strata	Thickness (m)	Max Depth (m)
Soil & Drift	0.2 to 0.6	0.6
Weald Clay Formation	>100	>100.6
Target horizon of well:	Weald Clay Formation	
Estimated depth of well:	60 to 75	metres
Primary casing depth:	5	metre
Anticipated rest water level:	70 to 75	maOD
Anticipated transmissivity range:	2 to 14	m^2/day
Anticipated yield range:	0.6 to 2.5	m^3 per hour
Water Quality Summary:	Poor - Treatable	
Problematic water quality parameters:	Chloride, Iron, Manganese, Sodium & Sulphate	
Licensing status of catchment:	N/A: abstractions under 20 cubic metres a day are license exempt	
Direction of Groundwater Flow:	West to north-west	

Table 8: Summary table

A borehole drilled at this location should be plain cased to around 5 metres below ground level and grouted to provide a reliable sanitary seal. The hole should then be screened to its base to pick up all inflow horizons with depth. There is thus potential to develop a new potable water supply at this site which, while low yielding, could provide a reliable small scale supply. Only once a new borehole has been drilled and tested can the actual yield and quality be confirmed.

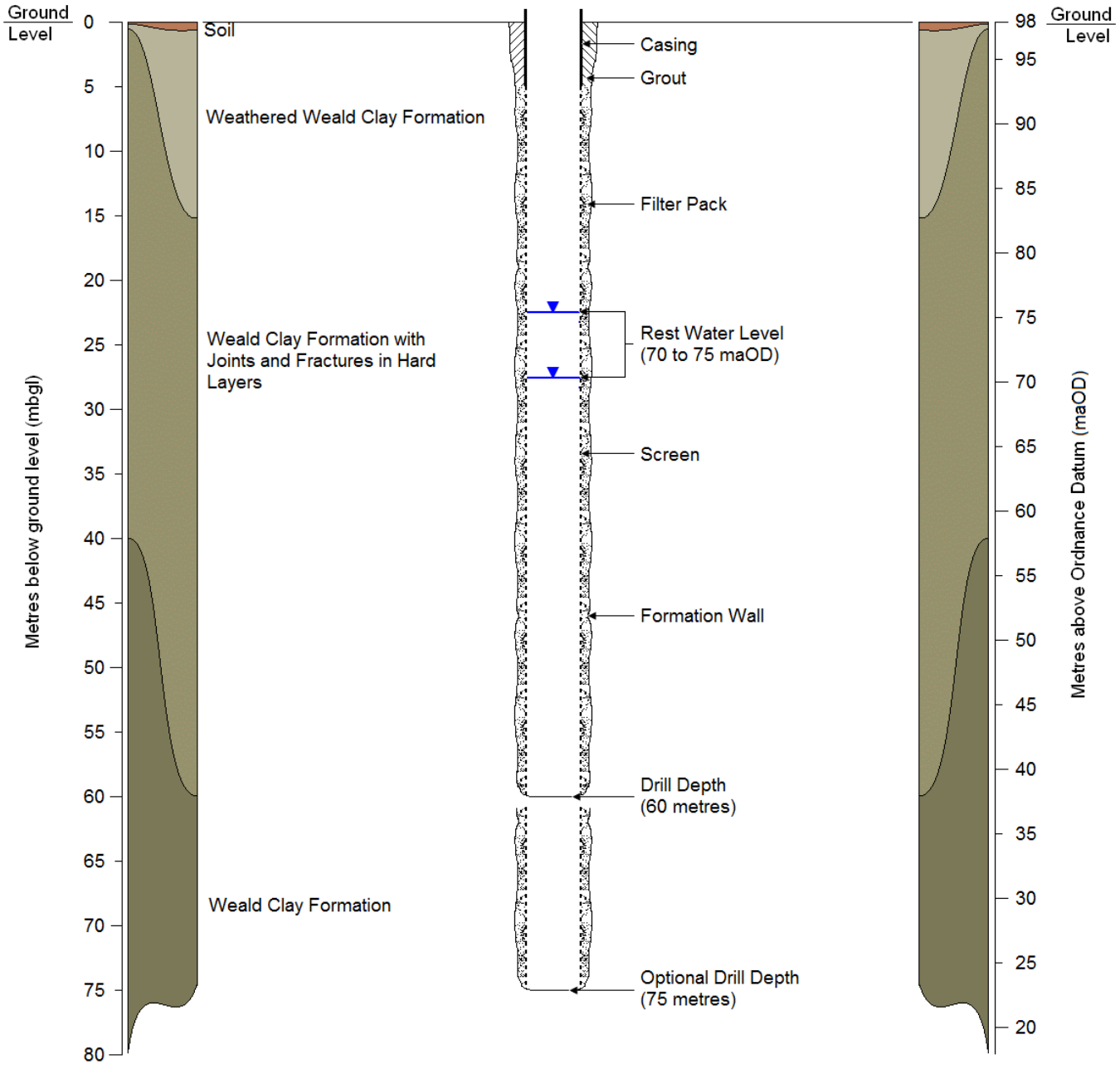

Figure 4: Outline borehole design

It is the professional opinion of BAHS that the proposed private water supply would be a new source that would make no difference to the water resource balance within the Water Neutrality Zone. The proposal would thus be water neutral and would not affect the water dependant habitats the Water Neutrality Zone has been established to protect and improve.

Disclaimer – Hillybarn Farm, The Mount, Ifield, Crawley, RH11 0LF

Information within this Hydrogeological Report has been gathered from all sources available to B. A. Hydro Solutions Ltd. Discussion and interpretation is the professional opinion of B. A. Hydro Solutions Ltd. based on information and data provided by the client plus the best available information collected specifically for this study.

If the client wishes to drill a borehole based on the information contained within this report B. A. Hydro Solutions Ltd. must stress no guarantee can ever be given that groundwater will be present, or that the quantity or quality of groundwater required will be available for abstraction. B. A. Hydro Solutions Ltd. cannot guarantee the ground conditions discussed/used (as drawn from research undertaken) are directly comparable to the ground beneath the site. Groundwater quantities/qualities, ground properties including thermal potentials can vary seasonally and as a result of external factors beyond our control and not foreseen by this study.

APRIL 2023

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Additional Information 1 – Licensing Restriction

BAHS Ltd. have been instructed to complete a Hydrogeological Assessment for use in the development of a proposed new groundwater borehole. A borehole for abstraction purposes requires an abstraction licence if quantities exceed 20 m^3/day.

Licences are awarded by the Environment Agency (EA) following a detailed review of the availability of the resource in the specific area. The country is divided into river catchments that are individually assessed to determine the total surface and groundwater resource that can be theoretically abstracted while maintaining sufficient levels or flows to protect or enhance the environment. Resources are then licensed up to the limit deemed sustainable by the Environment Agency.

Additional Information 2 – Hydrogeological Terms

The hydrogeological properties of strata and the ground as a whole is a function of its permeability and the ease at which water is able to move through the various strata. The ground can broadly be divided into three hydrogeological rock types, the aquifers which contain water, aquitards which can contain water but restrict the movement of water and aquicludes which do not contain water and act as a barrier to groundwater movement.

Groundwater moves through the ground via either pore spaces in the rocks, fractures and joints which dissect the strata or sometimes through solution features such as caves. The interconnectivity of the pores, joints, fractures and solutions features determines the amount of water which can accumulate and the ability of the ground to transmit.

The storage potential of the ground is described by its *storativity* [S] which is a dimensionless value ranging from zero up to one. The larger the number the greater the proportion of the saturated ground, in terms of total volume, which can be drained by lowering the water table. If the storativity was one it would be space entirely filled with water and no rock.

When the storativity is very low or zero there is no space in which water can accumulate or none of the water in the ground can be abstracted by lowering the water table. Due to the number of observations needed to quantify the storativity of the ground it is uncommon to be able to derive such values from historical data.

The grounds ability to transmit water is measured by its *transmissivity* [T], the larger the number the easier the water is able to move through the rocks. Theoretically there is no maximum T value, practically it is limited by the aquifer thickness, the volume of water in the aquifer and the capacity of the borehole and pump used to test the ground conditions.

The productivity of boreholes is simplistically measured by its *specific yield* [Sy] which is a measure of the sustainable yield a borehole can deliver per day per metre the water table is lowered. This can easily be derived from measurements recorded during pump tests or reported steady state yield and drawdown values.