



Borehole Prognosis Report



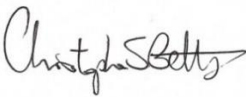

Ty'r-Ywen Farm

Abergavenny, NP7 7EN

On behalf of

Mr Feakins

Quality Management

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Data Sources

Data Sources

- Ordnance Survey (OS) maps for the site;
- BGS Geological Map, Abergavenny, Sheet 232, 1:50,000, Bedrock and Superficial Geology (1990);
- BGS Hydrogeological Map, Sheet 17, South Wales (1986);
- The physical properties of minor aquifers in England and Wales, Technical Report WD/00/04, BGS and Environment Agency (1997);
- Usk Catchment Area Management Strategy (CAMS), Environment Agency (2017);
- BGS Borehole Records (online);
- Environment Agency Catchment Data Explorer (online).

Disclaimer

Hydrogeo Ltd has undertaken a groundwater abstraction prognosis on behalf of Mr Feakins (the client). A desk study review of available information has been carried out by an experienced hydrogeologist and the results of this work are displayed in this report. No responsibility can be accepted for the local conditions which alter the interpretation and predictions of the published data.

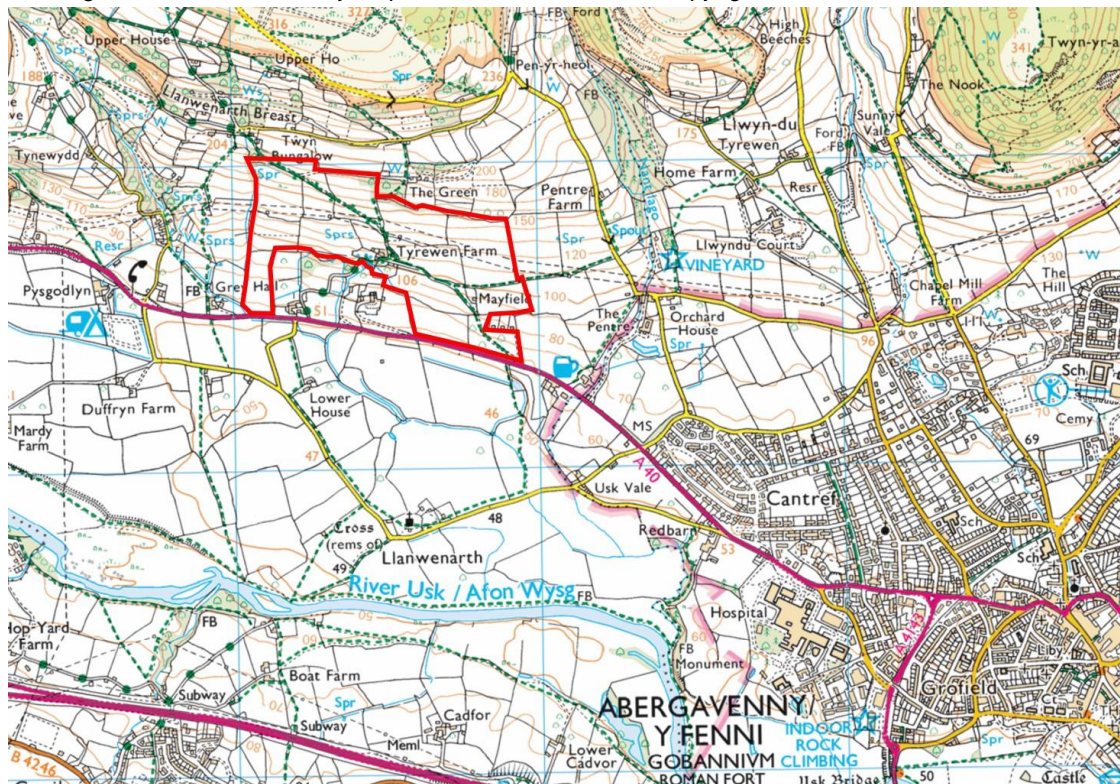
It is the responsibility of the contractor to check for buried services and underground obstructions prior to drilling.

Site Location, Surroundings and Surface Water Courses

- The site is occupied by Ty'r-Ywen Farm, as residential dwelling hereafter referred to as "the Site". The national grid reference for the site is 327534, 215695; the site postcode is NP7 7EN.
- The site is located 2.7km north-west of Abergavenny town centre. The site is accessed off Brecon Road (A40) and is located within a rural area.
- The Site requires an approximate borehole yield of 100m³/day in order to supply the future development plans.
- The site is situated upon the lower southern flank of the Sugarloaf and is set across elevations from approximately 190mAOD (metres above ordnance datum) to the northwest to approximately 60mAOD in the southeast.
- The closest named watercourse to the site is the River Usk, which is located approximately 900m to the south of the site.
- The site is located within the Usk Catchment Area. The site is not situated within Natural Resources Wales (NRW) Source Protection Zone (SPZ). However, according to a plan provided by the Client, several springs present across the Site provide private water supplies for domestic purposes for residential properties to the south and east of the Site. The positions of these spring abstractions are indicated in Figure 3 & Drawing 1

Site Location Map

Figure 1- Ordnance Survey Map of Site Location. Crown copyright reserved, Licence No. 100047852



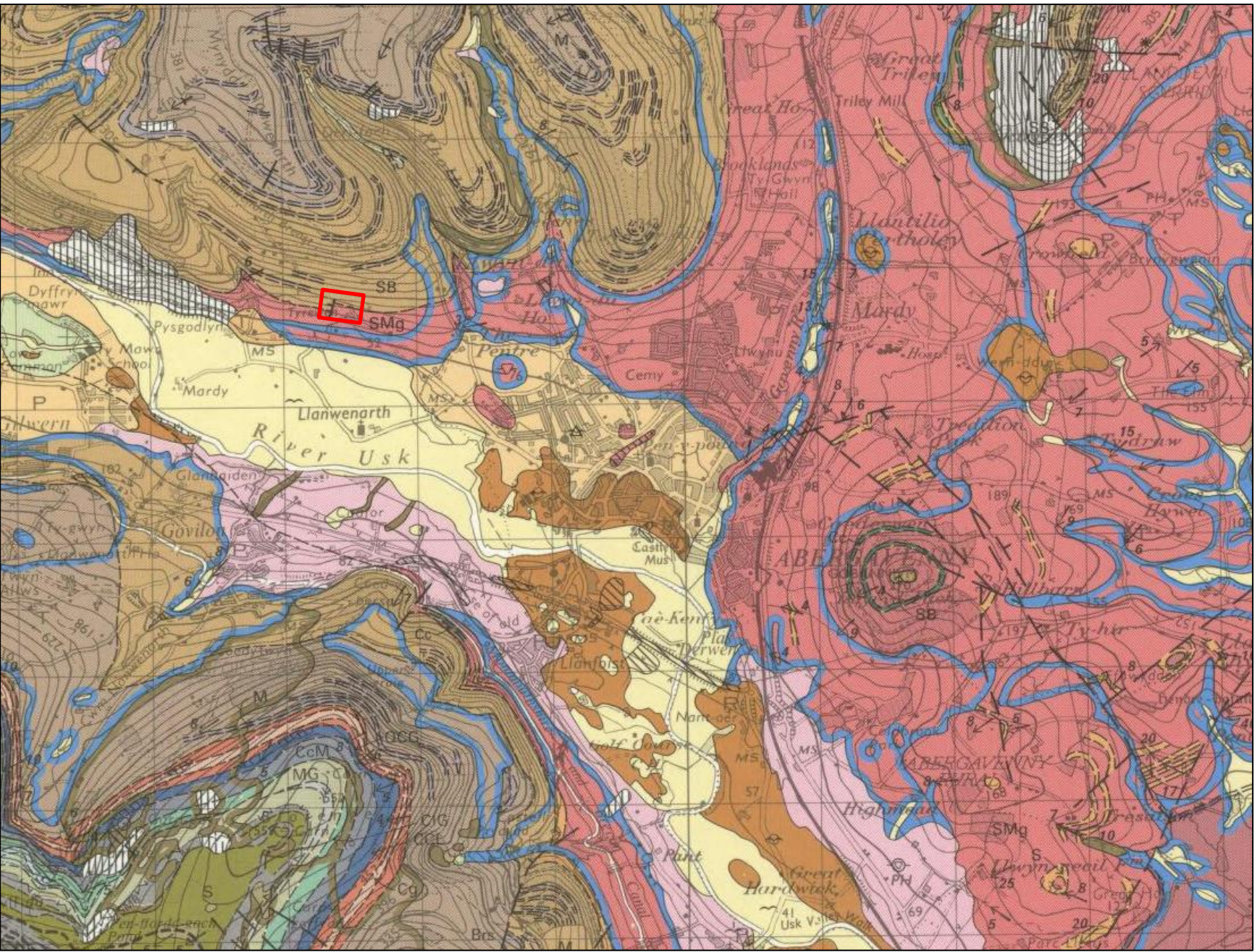
Water Availability and CAMS (Catchment Area Management Strategy)

- As the required groundwater abstraction is greater than 20 m³/per day, an abstraction licence is required.
- The proposed borehole location is situated within the Usk catchment abstraction management strategies (CAMS) area as defined by Natural Resources Wales, July 2017.
- If a borehole is drilled on the site and used as a domestic supply (≤ 20 m³/per day), the borehole should be registered with the Monmouthshire County Council's Environmental Health Department as a Private Water Supply. This will ensure that the borehole conforms to Private Water Supply Regulations (Wales) 2017, and that records are available to ensure the well is protected from harm.
- The local authority is normally not required to assess private water supplies which serve only one property; however, the owner can request testing of the supply, for which there is normally a charge.
- More information can be found on the Council's website: [Monmouthshire County Council – Private Water Supplies \(hyperlink\)](#).
- There is no separate groundwater licencing policy within the Usk catchment. Licences will only be granted if it can be demonstrated that the abstractions will have “no adverse effect” on nearby licensed / private water supplies and springs and the integrity of the River Usk SAC.
- Any application for a new groundwater abstraction licence will be treated on a case-by-case basis.
- Applications will be assessed as to their impact upon on designated sites such as wetlands, water course and other groundwater users.
- Abstraction restrictions would be dependant aspects such as aquifer type. The depth of the borehole, proximity to surface water courses and designated sites and the proposed use.
- The surface water resource availability for the site is classed as ‘Water available for licensing’.
- Any application for a new groundwater abstraction licence will be treated on a case by case basis. Applications will be assessed as to their impact upon on designated sites such as wetlands, water course and other groundwater users. Abstraction restrictions would be dependent aspects such as aquifer type, the depth of the borehole, proximity to surface water courses and designated sites and the proposed use.

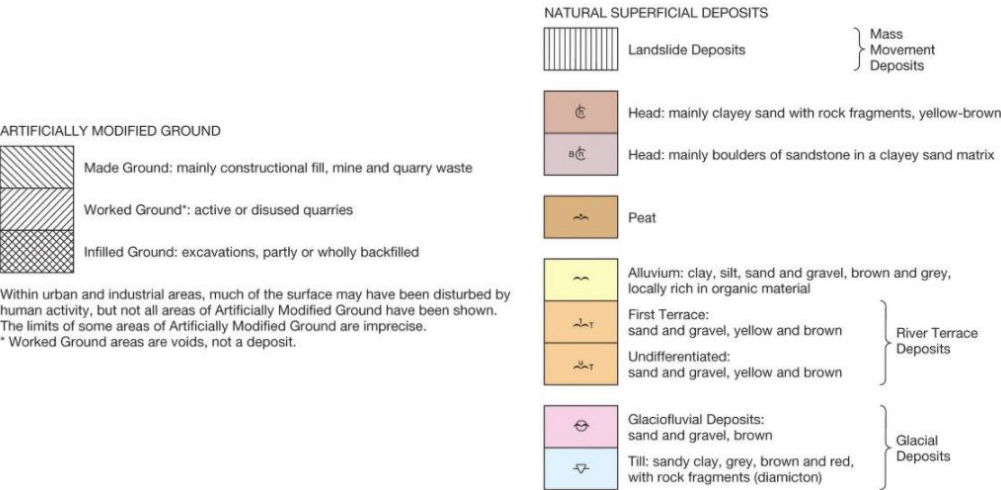
Geology
Artificial Ground
<ul style="list-style-type: none"> Artificial ground consists of any areas where ground conditions have been significantly modified by man. These include excavations, infilled ground and made-up ground. No artificial ground is shown to be present on BGS geological mapping.
Superficial Geology
<ul style="list-style-type: none"> Superficial Deposits consist of near surface unconsolidated (loose) sedimentary deposits which have not yet become solid rock. BGS mapping indicates that superficial deposits of Glacial Till deposits are present beneath the site along the southern portion of the Site from 90mAOD. From the Site's southern boundary, alluvium deposits associated with the River Usk are present, as shown in Figure 2.
Bedrock Geology
<ul style="list-style-type: none"> The bedrock geology beneath the site comprises the Lower Old Red Sandstone Group. The group consists of a coarsening-upwards succession of mudstones and sandstones, with common calcrete horizons. The Lower Old Red Sandstone Group is divided into two formations beneath the site, as show in Figure 2 & Figure 3. The Senni Formation, which consists of green and purplish grey sandstones with red mudstone interbeds. The base of the Senni Formation is indicated by a calcrete Limestone bed, as indicated on the BGS geological sheet. The lower boundary of the Senni Formation with the older St. Maughans Formation is indicated to be present across the Site, and is believed to be identified by the presence of the Springs as shown in Figure 3 & Drawing 1. The Senni Beds beneath the Site is believed to be potentially 20m to 80m thick. The boundary between the Senni Formation and the older St. Maughans Formation is located at 130mAOD to 110mAOD according to BGS mapping data; with the springs believed to represent the base of the Senni Formation position at approximately 100mAOD on the Ordnance Survey mapping. The Senni Formation is underlain by the St. Maughans Formation, which consists of red mudstones with purple, brown and green sandstones. The St. Maughans Formation contains a higher proportion of mudstone than the overlying Brownstones and Senni Formations. The St. Maughans Formation appears to be around at least 300m thick beneath the site. The regional dip of the geology beneath the site is towards the south-west. Nearby dip measurements on the BSG paper map indicates that the angle of dip is 6° within the Senni Formation, and the overlying Brownstones Formation is indicated as horizontal bedding.

- A small fault is present on-Site towards the centre of the Site, running approximately north-northeast to south-southwest. The BGS geological map sheet shows this fault to have been downthrown to the northwest.

Paper Geological Map Extract – Bedrock and Superficial Geology



ARTIFICIAL / SUPERFICIAL GEOLOGY



BEDROCK GEOLOGY

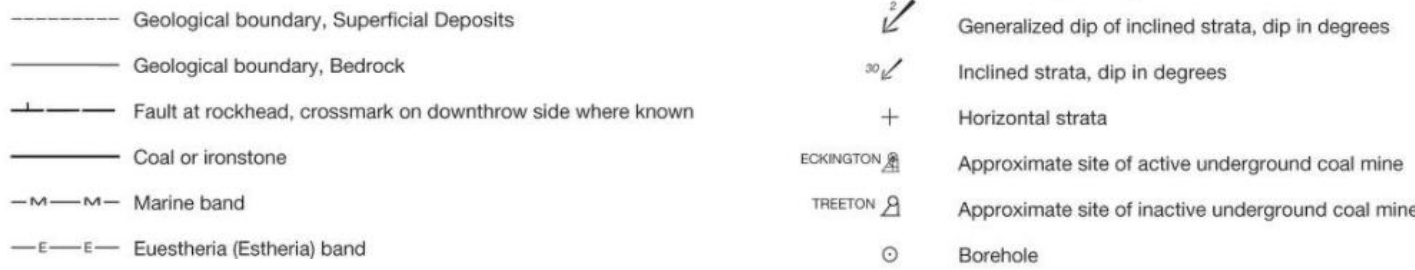
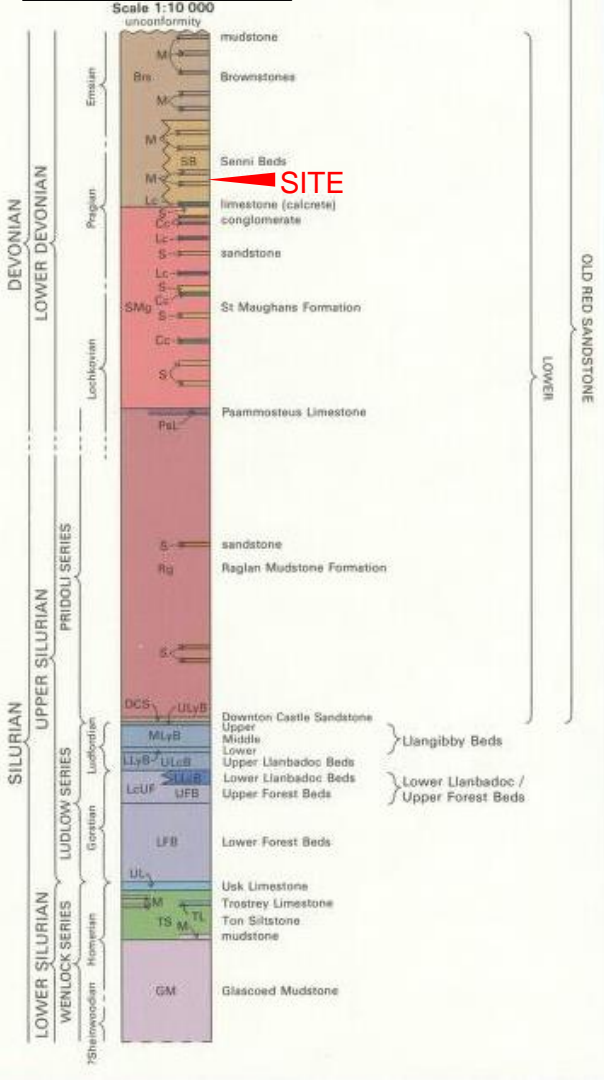


Figure 2 - British Geological Survey superficial geological map of site and surrounding area, Sheet 232, Abergavenny (2011). Licence number [C10/018-CSL] © NERC. All rights reserved.

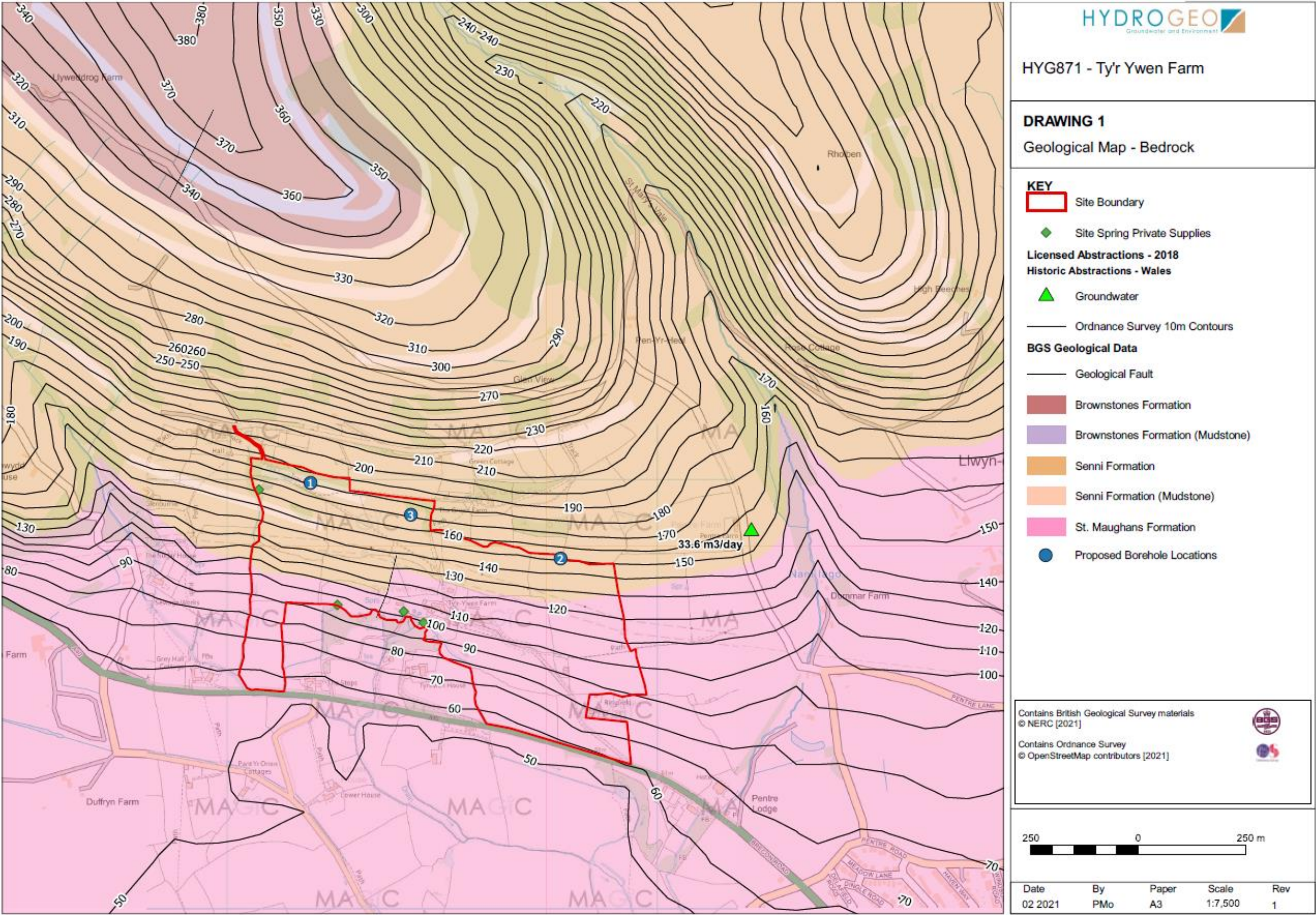


Figure 3 - Site Geological Plan with OS 10m (AOD) contours lines with current spring abstraction points and proposed borehole locations.

Resource Assessment

Old Red Sandstone - Secondary A Aquifer

- The Lower Old Red Sandstone groups present on site is classified as a Secondary A Aquifer. Secondary A Aquifers are permeable layers of rock capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.
- The Old Red Sandstone of Wales and the Welsh Borders attains great thicknesses, but has limited permeability. This is due in part to the variety of rocks present, with low permeability mudstones, marls, and siltstones interbedded with the higher permeability sandstones. Primary porosity is usually low, with few interconnected pores in the rock.
- The primary porosity in some horizons of the Old Red Sandstone, for example is so low that they have long been used as flagstones. Associated cementation filling pore spaces, both calcareous and siliceous, further decreases primary porosity. Instead, the predominant groundwater flow mechanism is through fractures.
- For a well to be successful, these groundwater bearing fractures need to be intercepted by a borehole. Failure to penetrate groundwater bearing fractures can result in a dry borehole.
- There is potential for increased fracturing of the bedrock beneath the Site associated with the small, on-Site fault, indicated as present by the BGS data. The fault and potential associated fracturing of the bedrock may have increased the secondary permeability of the local bedrock, allowing groundwater flow through fractures.
- Despite the low porosity, the Devonian-age Old Red Sandstone is arguably the most important aquifer in Wales due to its extent and thickness. The main outcrop of the aquifer contains at least 2650 abstractions (as of 2004) and over 80 per cent of these are licensed for groundwater abstractions (i.e. >20 m³/day), either boreholes or springs, the majority for domestic, agricultural and industrial supply.
- Additionally, there are over 2300 private water supplies from Old Red Sandstone strata that are registered with local government, although many small sources such as supplies to single dwellings remain unregistered. At least 50 per cent of the known private supplies are for domestic use only.
- The BGS Hydrogeological Map of South Wales states that borehole yields from the Old Red Sandstone generally average around 0.5 litres per second (43m³/day), but can achieve up to 15 litres per second (1296 m³/day) in rare cases.

Senni Formation - Secondary A Aquifer

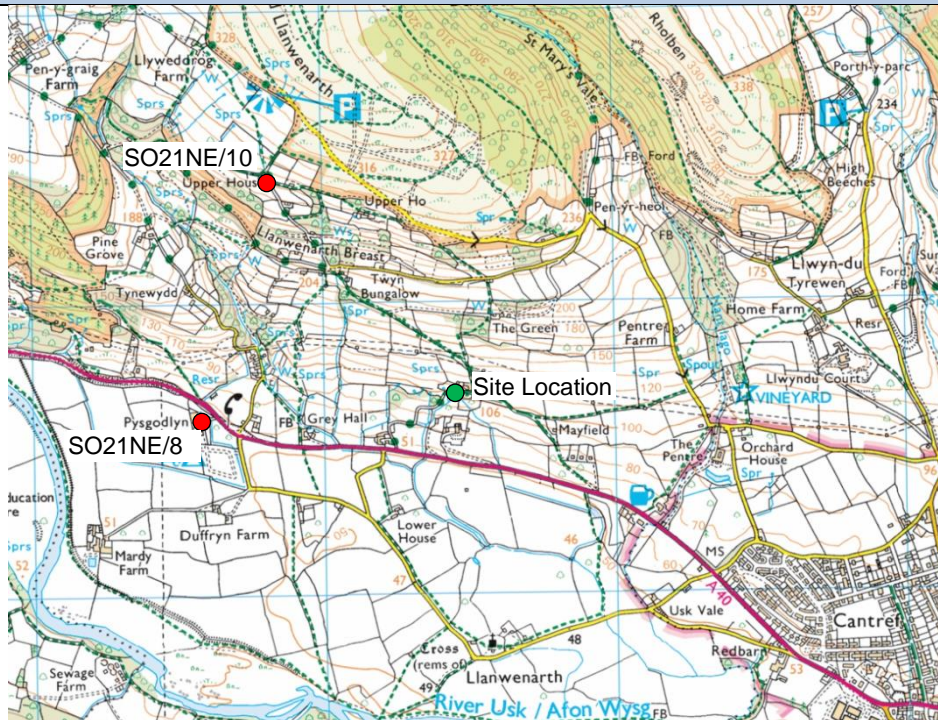
- Senni Formations is a locally-used aquifer.
- The NERC physical properties of minor aquifers technical report states that “*springs issuing from the base of the sandstones commonly yield <10m³/day but locally >50m³/day. One group of springs in Senni Beds yields >1000m³/day*”.
- According to a plan provided by the Client, several of the springs present across the Site are utilised for domestic purposes for residential properties to the south and east of the Site. The positions of these spring abstractions are indicated in Figure 3 & Drawing 1. The presence of these springs and their utilisation for domestic supply indicate the Senni Formation beneath the Site should be the primary target for abstraction.
- According to available abstraction licence data there are no active abstraction boreholes in the surrounding area of the Site. However, there is 1no. record of historic abstraction licence (20/56/31/0111) located at Sugarloaf Cottages approximated 650m to the northeast of the Site, situated on the Senni Formation. The licence pertains to a maximum daily abstraction of 33.6m³/day for water bottling purposes. The location of this historic abstraction licence record is shown in Figure 3 & Drawing 1.

St. Maughan's Formation - Secondary A Aquifer

- According to the NERC physical properties of minor aquifers technical report is a locally-used aquifer.
- The NERC physical properties of minor aquifers technical report states that there are few wells in the St Maughan Formation, with most yield <43m³/day.
- According to available abstraction licence data there are no active abstraction boreholes in the surrounding area of the Site targeting the St Maughan's Formation. The closest. record of historic abstraction licence (19/55/17/0487) located at Whitehouse Farm, Llanihangel approximated 8km to the northeast of the Site, situated on the St Maughan's Formation. The licence pertains to a maximum daily abstraction of 24m³/day for general domestic and farming purposes.

BGS Borehole Records

- BGS Borehole records have been reviewed. A selection of the closest boreholes to the site have been reviewed to determine the geological succession and records of groundwater abstractions.
- BGS Borehole Record locations can be viewed in Figure 4 and the details of the abstraction boreholes available are detailed below. All distances and direction are given from the site.

Figure 4 – BGS Borehole Records Map

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BGS Borehole Record Review

Borehole Record No. and Name	NGR, Distance (m) and Direction	Depth (mbgl) and date	Elevation (mAOD)	Stratigraphy	Install details	Yield	Rest water Level (mBGL)	Notes
SO21NE/8 Pyscodlyn Farm, Abergavenny	326600, 215500 ~0.9km southwest	36.6m 1995	~51.5m	GL to 1.52m <i>Overburden</i> 1.52m to 21.33m <i>Alluvial Fan</i> 21.33m to 36.6m <i>Old Red Sandstone</i>	103mm plain UPVC 0m to 30.40m; 103mm slotted UPVC 30.40m to 36.6m.	4000 gallons/day (18m ³ /day)	-	Groundwater strikes 6.09mBGL & 21.33mBGL.
SO21NE/10 Bronhafod, Abergavenny	326800, 216400 ~1km northwest	75m 2006	~278m	GL to 8m Soft red sands & gravels 8 to 13m Soft to medium red Marls & Sandstones 13 to 54m Medium to hard grey Sandstone 54 to 56m Fractured grey Sandstone 56 to 75m Medium to hard grey-brown Sandstone & Marls	103mm plain UPVC 0m to 52m; 103mm slotted UPVC 52m to 70m; 103mm plain UPVC 70m to 75m.	110 gallons/hour* (12m ³ /day)	54m	*Blow-out Yield

Summary of Anticipated Underlying Geology

- Geological maps and historical BGS borehole records for the area around the site were used to interpret the site geology.
- The anticipated sequence of geological units beneath the site is displayed in the table below and the availability of groundwater from each of these is discussed in the section 'Resource Availability'.
- Thicknesses of all geological formations have been estimated using available BGS borehole records and the Geological Map, 1:50,000 Scale. Sheet 232 - Abergavenny (1990).
- Thicknesses and depths are an approximation only. A best estimate has been made from the available data, but depths in the field may vary. The estimated thickness of the Senni Formation is presented as a range based upon the relative positions of proposed borehole location and the base of the Senni Formation as indicated by the BGS mapping, (at ~130mAOD in the east and ~110mAOD in the west); and as represented by the presence of the Springs on the OS mapping (~100mAOD).
- The depths to the base of each unit have been provided in mAOD for two potential borehole positions along the northern boundary of the Site. These positions should allow for the interception of the greatest thickness of Senni Formation beneath the Site.
- Additionally, a potential borehole position close to the indicative location of the on-Site fault, this borehole would likely encounter a reduced thickness of the Senni Formation, however the bedrock is likely to have increased fracturing that may result in an increased yield. This location should be deemed a third option, to be considered subsequent to drilling and testing of the two above proposed locations. It should be noted that targeting a Faultline for an abstraction boreholes can lead to difficulty drilling (drillhead deviation at depth); increased groundwater vulnerability to contamination; and the abstraction is may have a detrimental effect on the private abstraction from the on-Site springs.

Northwest Corner of the Site (~180mAOD)

Period	Group	Formation	Lithological Colour and Description	Estimated Thickness (m)	Depth to base (mbgl)	Elevation of Base (mAOD)
Devonian	Lower Old Red Sandstone	Senni Formation	Green and purplish-grey sandstones with red mudstone.	70-80	70-80	110-100
		St Maughans Formation	Red mudstone with purple, brown and green sandstones.	Up to 300	Up to 460	-

Northeast Corner of the Site (~150mAOD)						
Period	Group	Formation	Lithological Colour and Description	Estimated Thickness (m)	Depth to base (mbgl)	Elevation of Base (mAOD)
Devonian	Lower Old Red Sandstone	Senni Formation	Green and purplish-grey sandstones with red mudstone.	25-50	25-50	125-100
		St Maughans Formation	Red mudstone with purple, brown and green sandstones.	Up to 300	Up to 460	-
Northcentre of the Site (~170mAOD) Targeting indicated Faultline.						
Period	Group	Formation	Lithological Colour and Description	Estimated Thickness (m)	Depth to base (mbgl)	Elevation of Base (mAOD)
Devonian	Lower Old Red Sandstone	Senni Formation	Green and purplish-grey sandstones with red mudstone.	30-70	30-70	125-100
		St Maughans Formation	Red mudstone with purple, brown and green sandstones.	Up to 300	Up to 460	-

Water Quality

- Quality of groundwater from the Old Red Sandstone is typically good, but hard.
- Total hardness of groundwater from the Old Red Sandstones is usually 220mg/l, of which 200mg/l is calcium carbonate. This can vary – values as high as 500mg/l and low as 50mg/l have been recorded for total hardness.
- An electrical conductivity of 300µS/cm from the Ty-Y-Wern spring can be used as indicative for an abstraction from Site.
- Nitrates can exceed 45mg/l. Values will most likely be lower than this on site, as there is a relatively short distance to outcrop, and it is assumed that no fertilization takes place on the hillside which appears to mostly comprise pasture.
- An iron concentration of 0.025mg/l from the Ty-Y-Wern spring can be used as indicative for an abstraction from Site; however, iron concentrations within the Old Red Sandstone can occur up to 3.5mg/l.
- Groundwater in faults and fractures may be vulnerable to the rapid wash-in of surface pollutants such as microbes, organic carbon and turbidity. The risk of these contaminants being found in groundwater can be increased by improper siting of the borehole.

- The borehole should be kept upslope and as far away as is possible from any fuel storage or sewerage systems such as septic tanks and drainage fields which the site currently has in place.
- It is recommended that the locations of any septic tanks and soakaways associated with residential properties situated up-slope of the Site in order to avoid positioning proposed boreholes directly down-gradient of potential contaminative sources.
- The borehole should also be completed with a sanitary seal, and kept inaccessible to any livestock.
- Water treatment via filtration and ultraviolet systems are routinely adopted for domestic supplies, and are highly recommended.
- Overall, groundwater quality should be adequate for the intended domestic use, but some treatment may be required to improve quality.

Conclusions and Recommendations

- Hydrogeo Limited (Hydrogeo) has been commissioned by Mr. Feakins (the client) to undertake a water supply feasibility study for a total abstraction of 100m³/day.
- The feasibility of the water supply was reviewed in terms of the ability of the bedrock beneath the site to provide the yield and quality of water required at the site.
- As the required abstraction is over 20 m³/day, an abstraction licence will be required. Water is available for licensing beneath the site. Natural Resources Wales should be contacted to determine if it would be possible for a licence to be granted at the earliest opportunity. Hydrogeo can assist with regulatory liaison and licencing.
- The Site is underlain by sandstones and mudstones of the Devonian Old Red Sandstone. The Old Red Sandstone is divided three formations beneath the site, which consist mainly of sandstone and mudstone; the mudstone content tends to increase with depth. A table of the predicted geology is included in the report.
- The Old Red Sandstone is classified by the Environment Agency as a Secondary A Aquifer.
- The multiple springs, as identified by Ordnance Survey mapping, are believed to represent the base of the Senni Formation; and indicate the Senni Formation to be water bearing.
- The records provided by the Client of private abstractions from several of the springs across the Site for domestic properties off-site indicate that the Senni Formation should be consider the primary target for abstraction.
- For a well to provide a successful yield, these groundwater bearing fractures need to be intercepted by a borehole. Failure to penetrate groundwater bearing fractures can result in a dry borehole. The small fault present towards the centre of the Site may have induced additional fracturing in the local bedrock, thereby increasing the secondary permeability of the bedrock and allowing groundwater flow through fractures.
- The 2no. BGS boreholes records present in the surrounding area to the Site, so it is known that a groundwater resource is available from the Old Red Sandstone. Based on the indicated blowout yields and pump rates from the borehole records (12 to 18m³/day) for individual boreholes, multiple boreholes may ultimately be required to provide 100m³/d.
- The historic abstraction licence in the surrounding area, approximately 650m to the northeast, targeting the Senni Formation, pertained to the maximum daily abstraction of 33.6m³/day for water bottling purposes.
- Drilling a larger diameter hole (200mm) is likely to increase the potential of intercepting groundwater bearing fractures.
- Given the evidence of limited yield from a single borehole abstraction targeting the Senni Formation, it is expected that multiple borehole abstractions are considered to ensure the target yield of 100m³/day is achieved.
- In order to intercept the greatest thickness of the Senni Formation as possible, the abstraction boreholes should be positioned close to the northern boundary of the Site. Though the presence of

the private abstractions from the on-Site springs should be taken into consideration when positioning the boreholes.

- Abstraction boreholes along the northern boundary of the Site could potentially intercept a thickness of 25-50m and 70-80m of the Senni Formation in the northeast and northwest of the Site respectively.
- It is recommended that the proposed boreholes are progressed one at time, starting in the northwest corner; drilling targeting the base of the Senni formation; installing the borehole; and testing the borehole yield. Once the northwest borehole has been completed and tested, if the required yield has not been achieved then the proposed borehole in the northeast corner should be progressed.
- Drilling through the Senni Formation into the underlying St. Maughans Formation is not recommended.
- An alternative borehole targeting the on-Site fault is likely to intercept a reduced thickness of the Senni Formation, ~30-70m; however, the likely increased fracturing of the bedrock associated with the fault may result in an increased secondary permeability of the bedrock and therefore a greater yield.
- A borehole targeting the on-Site Faultline should be deemed a tertiary option following the drilling and testing of the proposed boreholes in the northwest and northeast corners. It should be noted that targeting a Faultline for an abstraction boreholes can lead to difficulty drilling (drillhead deviation at depth); increased groundwater vulnerability to contamination; and the abstraction is may have a detrimental effect on the private abstraction from the on-Site springs.
- It is difficult to estimate the rest water level for groundwater beneath the site due to the steeply sloping topography.
- Groundwater quality in the Devonian Sandstones is typically good, but hard. Quality should be sufficient for the required use as pond top-up water. Filtration and UV treatment is recommended to bring the water up to potable standards.
- The borehole should be sited as far away as possible (and uphill) from any existing sewerage systems or fuel storage. The borehole should be kept inaccessible to livestock, and should constructed with a properly sealed headworks chamber to prevent the wash in of surface contamination.
- It is advised that borehole be routinely inspected and maintained on a regular basis to ensure the longevity of the abstraction borehole.
- Hydrogeo can assist with pump test analysis and construction & design of the abstraction borehole.
- Any abstraction boreholes should take into account the private abstractions from the on-Site Springs, to ensure that the proposed abstraction boreholes do not affect the flow rate and volumes from the springs.