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A525 TRENCHLESS CROSSING WORKS (HDD)

Groundwater Risk Assessment

Prepared for: Awel y Môr Offshore Wind Farm Limited

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CONTENTS

DOCUMENT REFERENCES

FIGURES

APPENDICES

1.0 Introduction

This groundwater risk assessment assesses the potential impact of the trenchless crossing works that will be used to install cables beneath the A525 as part of the onshore arrangements for Awel y Môr Offshore Wind Farm (AyM OWF).

This report has been prepared in response to feedback received from Natural Resources Wales (NRW) following statutory consultation, under Section 42 of the Planning Act 2008, which ran from 31 August to 11 October 2021. Within its response to statutory consultation NRW requested that a groundwater risk assessment should be completed for each major Horizontal Directional Drilling (HDD) crossing associated with the onshore elements of AyM to ensure that all risks are assessed, and any mitigation measures are outlined and implemented during construction and operation. The Major HDD crossings proposed for the onshore elements of AyM are:

- The crossing at landfall required to pass beneath the North Wales Main Line railway, Robin Hood Bay Caravan Park, Rhyl Golf Club and the proposed East Rhyl Coastal Defence scheme (The Landfall HDD crossing);
- The crossing of the A525
- The crossing of the Afon Clwyd
- The crossing of the A55

This report provides the groundwater Risk Assessment for the crossing of the A525 using HDD. The indicative maximum depth for the HDD would be 20m below ground level.

Further details on the Project infrastructure, installation methodologies and programme can be found in Volume 3, Chapter 1: Onshore Project Description (application ref: 6.3.1) of the Environmental Statement (ES).

This report has been informed by the following ES chapters and technical reports:

- Volume 3, Chapter 1: Onshore Project Description (application ref: 6.3.1);
- Volume 3, Chapter 5: Onshore Biodiversity and Nature Conservation (application ref: 6.3.5);
- Volume 3, Chapter 6: Ground Conditions and Land Use (application ref: 6.3.6);
- Volume 3, Chapter 7: Hydrology, Hydrogeology and Flood Risk (application ref: 6.3.7);
- Volume 4, Annex 3.1: Water Framework Directive Assessment (application ref: 6.4.3.1);
- Volume 8, Document 13.1 Outline Code of Construction Practice (application ref: 8.13.1).

This groundwater risk assessment:

- Describes the existing baseline established from desk studies, dedicated surveys and consultation;
- Outlines the potential environmental effects on groundwater receptors arising from the HDD process including groundwater abstractions, groundwater dependent ecological sites and groundwater fed surface water features;
- Highlights any necessary monitoring and/or mitigation measures which could prevent, minimise, reduce or offset the possible environmental impact.

The effects considered in this chapter include those on the hydrological and hydrogeological receptors that form part of the surrounding environment.

2.0 Study Area, Baseline Data and Methodology

2.1 Study area

The study area for the A525 crossing HDD crossing is shown on Figure 1. The HDD works for this location is c.250 m northwards of Rhuddlan. Buffer zones of 250 – 500 m from the Order Limits boundary that encompasses the A525 crossing works have been considered appropriate for data collection taking into account the nature of the development and likely zone of influence on hydrological and hydrogeological receptors whilst also allowing for refinement in final location and alignments of onshore infrastructure following detailed design (post consent).

2.2 Baseline data

Baseline data with respect to hydrogeology, hydrology and ecology has been taken from publicly available information and opensource data from a range of sources. The data review includes assessing the following:

- Lle Geo-Portal, Welsh Government and Natural Resources Wales (NRW):
  - Main Rivers;
  - Historic and active landfill sites;
  - Statutory and non-statutory environmental designations;
  - Water Framework Directive (WFD) surface water and groundwater classification data; and
  - Groundwater Source Protection Zones (SPZ).
- British Geological Survey (BGS) GeoIndex mapping:
  - Geology – artificial ground, mining, superficial deposits, bedrock;
  - Borehole data; and
  - Aquifer designation and groundwater vulnerability.
- Department for Environment, Food and Rural Affairs (DEFRA) MAGIC website:
  - Statutory and non-statutory environmental designations.
- Cranfield Soil and Agrifood Institute Soilscapes map viewer:
  - Soil type and character.
- North West and North Wales Coastal Group:
  - North West England and North Wales Shoreline Management Plan SMP2; and
  - Denbighshire County Council (DCC): Local Development Plan.

Third party data from bodies such as DCC and NRW has been used to characterise the sensitivity of water features and identify any water dependent designated areas.

Preparation of the groundwater risk assessment has also included data requests and consultation with a number of stakeholders and regulatory bodies that were performed for the production of the Hydrology and Hydrogeology ES chapter. The information and data requested includes:

- NRW - Licenced abstractions, surface water quality, WFD classification data, permitted activities and recorded pollution events.
- DCC - Registered private water supplies in proximity to the onshore Export Cable Corridor (ECC).

2.3 Methodology

This groundwater risk assessment has been developed in accordance with relevant Environment Agency (EA)/NRW guidance on completion of groundwater risk assessments[1] and Hydrogeological Impact Appraisals (HIA)[2] and includes the following stages:

- Section 3 provides a baseline assessment of the site. This includes a summary of the site geology and hydrogeology including information on ground conditions, groundwater levels and flows, groundwater quality and the location of potential receptors which could be impacted as a result of construction activities at the site. In addition, a Conceptual Site Model (CSM) of the current hydrogeological regime is provided.
- Section 4 provides an assessment of the potential impact that the A525 crossing HDD works could have upon the identified receptors and regional hydrogeology and hydrology. Appropriate mitigation measures are outlined where required.
- Section 5 provides a summary of the overall impact that the A525 crossing HDD works could have upon the local hydrogeology and any identified receptors.

A qualitative risk assessment methodology has been used to assess the potential significance of impact associated with the A525 crossing HDD works. Two factors are considered using this approach: the sensitivity of the receiving environment and the magnitude of any potential impact. This approach provides a mechanism for identifying whether additional mitigation measures are potentially required to reduce the risk to groundwater or hydraulically connected surface water receptors.

3.0 Conceptual Site Model

The geological, hydrogeological and hydrological regime in the vicinity of the A525 crossing HDD works area is considered under the following headings: location and topography, geological setting and hydrogeological setting, all of which have been used to develop the CSM.

3.1 Site Context

The proposed A525 crossing HDD works are located c.250 m northwards of Rhuddlan and c.500 m southwards of Rhyl, both of which are relatively densely populated towns. A roundabout connecting the A525 to the A547 and A55 is present immediately southwards of the proposed crossing. A shopping centre is found immediately southwards of Rhyl. A caravan park is located immediately south of this shopping centre and is within 100 m of the proposed HDD crossing. The extent of the proposed crossing is between the proposed trenchless crossing compounds to the east and west of the A525 respectively.

Although the land directly between Rhyl and Rhuddlan is predominantly urbanised, the land extending outwards away from the A525 is predominately agricultural, low-lying land with a network of drainage ditches both westwards and eastwards. Hedgerows and woodland are relatively scarce and limited to field boundaries, although there is a small area of woodland and swamp eastwards of the shopping centre on the east side of the A525.

A site context plan is provided as Figure 1.

[1] Natural Resources Wales / Guidance on water discharges
[2] Environment Agency (April 2007) Hydrogeological Impact Appraisal for Dewatering Abstractions, Science Report – SC040020/SR1

3.2 Geology

3.2.1 Soil and Superficial Deposits

The Cranfield Soil and Agrifood Institute Soilscapes online mapping service indicates that the proposed A525 crossing HDD works are underlain by freely draining slightly acid sandy soils, which are typically expected to drain to groundwater. However, this mapping service does suggest that there are loamy and clayey soils of coastal flats with naturally high groundwater in close proximity westwards of the proposed crossing and slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils in close proximity northwards. Due to the variability in soil types within the study area there is a degree of uncertainty regarding soils that may be encountered during the HDD works.

From examination of both the geological map (Geological Survey of Great Britain (1973 and 1985) 1:50,000 Series Solid and Drift Geology Map England and Wales, Sheet 107 – Denbigh, the following deposits are evident.

The proposed HDD is entirely underlain by Devensian till (diamicton). Till is typically described as an *unsorted and unstratified drift typically comprising of a heterogenous mixture of clay, sand, gravel and boulders*.

The till is overlain by Devensian glaciofluvial sheet sand and gravel deposits and/ or tidal flat deposits to the west and east of the HDD crossing area but these are not indicated to be present beneath the development area.

Small, disconnected outcrops of clay and silt lacustrine deposits are also found northwards of the proposed HDD crossing and alluvial deposits are present beneath watercourses but are not present within the working area.

Historic BGS borehole records, as presented in Appendix 1, within the vicinity of the proposed A525 crossing HDD works indicate that glacial deposits are widespread locally and clayey alluvial deposits are present within the vicinity of watercourses. Superficial deposits are indicated to be variable; glacial silts, sands and gravels appear to intermittently layer clayey till deposits. Sand and gravel deposits are variable in extent, ranging from minimal to several metres in thickness. Sand and gravel deposits appear to directly overly bedrock deposits.

Although the depth of local historic borehole logs is typically limited there are indications in historic BGS borehole logs SJ07NW13 and SJ07NW1, located to the north-west, indicate that local superficial deposits are present to depths of over 25 m below ground level.

Superficial deposits are further presented as Figure 2.

3.2.2 Bedrock

Bedrock at the proposed location for the A525 crossing HDD works is mapped by the BGS as the Kinnerton Sandstone Formation. This Sandstone Formation of dominantly aeolian origin is described as typically *'red-brown to yellow, generally pebble free, fine- to medium grained, and cross-stratified'*.

Historic BGS borehole logs indicate that the Sandstone underlying the proposed A525 crossing HDD installation is likely to be in excess of 100 m in thickness.

The geological setting of the AyM onshore infrastructure and ground conditions is further described within ES Volume 3, Chapter 6: Ground Conditions and Land Use (application ref: 6.3.6).

Bedrock geology is further presented as Figure 3.

3.3 Hydrogeology

3.3.1 Recharge

Met Office Climate Averages (1991-2020) for Rhyl (53.259, -3.509) indicate that the study area has a moderately high average annual rainfall value of 828 mm. Monthly and annual climate averages are provided in Tale 3-1-.

Table 3-1-
Rhyl Climate Averages (1991-2020)

Month	Maximum temperature (°C)	Minimum temperature (°C)	Rainfall (mm)	Days of rainfall ≥1 mm (days)
January	8.05	2.85	74.17	14.50
February	8.39	2.90	61.68	11.83
March	10.14	3.86	52.20	11.14
April	12.63	5.34	49.06	10.27
May	15.62	7.70	52.16	9.77
June	18.16	10.50	60.26	9.60
July	19.84	12.47	62.96	11.17
August	19.50	12.41	68.90	11.83
September	17.48	10.58	72.92	11.10
October	14.17	8.06	89.31	13.57
November	10.83	5.40	88.23	15.97
December	8.57	3.25	96.60	16.17
Annual	**13.64**	**7.13**	**828.45**	**146.92**

Based on the soils and superficial deposits present beneath the proposed A525 crossing HDD route recharge rates are likely to be relatively high where the soils are classified freely draining slightly acid sandy soils.

Recharge may be impeded by poorly draining clayey soils northwards and westwards of the proposed HDD works and also by the typically low permeability till deposits. These soils may promote surface water run-off to nearby watercourses and drains.

3.3.2 Hydrogeological Setting

The aquifer characteristics and BGS/NRW aquifer designation of the strata within the immediate vicinity of the works are summarised in Table 3-2-.

Table 3-2-
Aquifer Designations

Deposit Type	Formation	Aquifer Designation
Superficial	Alluvium	Secondary A
	Devensian Glaciofluvial Sheet Sand and Gravel	
	Tidal Flat Deposits	Secondary (Undifferentiated)
	Diamicton Till	
	Lacustrine Deposits	Unproductive

Deposit Type	Formation	Aquifer Designation
Bedrock	Kinnerton (Triassic) Sandstone Formation	Principal

The various classifications are described by NRW as follows:

- Principal Aquifer: layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale.
- Secondary A Aquifer: permeable layers that can support local water supplies, and may form an important source of base flow to rivers.
- Secondary B Aquifer: lower permeability layers that may store and yield limited amounts of groundwater through characteristics like thin fissures and opening or eroded layers.
- Secondary (undifferentiated): where it is not possible to apply either a Secondary A or B definition because of the variable characteristics of the rock type. These have only a minor value.
- Unproductive Strata: strata that are largely unable to provide usable water supplies and are unlikely to have surface water and wetlands ecosystems dependent on them.

The superficial deposits present at the HDD crossing area are all classified as secondary aquifers. However, it is considered that the clayey diamicton deposits will typically act as a barrier to significant groundwater flow.

Where sand and gravel are deposits are extensive there is the potential for moderate levels of groundwater flow. Historic BGS logs indicate minor seepages from superficial deposits. Perched groundwater within superficial deposits is typically, likely to be discontinuous and limited in extent and as such have limited groundwater potential. However, sand and gravel deposits overlying the sandstone may be in a degree of hydraulic connection with the underlying sandstone bedrock owing to their higher permeabilities.

Groundwater beneath the study area for this groundwater risk assessment is present within the Principal bedrock aquifer of the Kinnerton Sandstone Formation. It is expected that the sandstone has moderately high transmissivity and groundwater hydraulic conductivity values.

The closest BGS log with groundwater level information is BGS borehole SJ07NW95, located approximately 750 m to the north-west of the A525 crossing HDD works which indicated that resting groundwater level was approximately 10 m below ground level (c. -4 mAOD), suggesting that the sandstone is being confined by the overlying till, and also that the gravels at the base of the till are in hydraulic continuity with the sandstone aquifer.

The Kinnerton Sandstone Formation forms part of the Clwyd Permo-Triassic Sandstone WFD groundwater body.

3.3.3 Abstractions

NRW has confirmed that the closest licensed abstraction to the A525 crossing HDD works is located approximately 1 km to the north-west. It is detailed further below in Table 3-3-.

Table 3-3-
Licensed Abstractions

Abstraction Type	National Grid Reference	License No.	Usage	Source
Borehole	SJ 0133 7950	24/66/7/0029	General Farming & Domestic	Groundwater (undefined)

The source of groundwater for this licensed abstraction is undefined, but it is most likely to be drawing from the sandstone bedrock.

There are no further licensed abstractions within a 2 km radius of the site.

DCC has also confirmed that there are no private water supplies within a 2 km radius of the A525 crossing HDD works.

No groundwater Source Protection Zones (SPZs) are noted within the study area.

3.4 Hydrology

3.4.1 Hydrological Setting

The proposed crossing works do not pass beneath any surface watercourses or surface water features. Watercourses within a 500 m radius of the A525 crossing HDD works are presented on Figure 4.

The A525 crossing HDD works fall within the catchment of the Afon Clwyd, an NRW main river with an up-stream catchment of over 700 km^2 upstream of the point where the onshore ECC crosses the Afon Clwyd, approximately 1.2 km to the south-west.

The main tributary of the Afon Clwyd in the vicinity of the A525 crossing is the Afon Ffyddion (Glanffyddion Cut) and its associated tributaries. The Afon Ffyddion flows in a westerly/ south-westerly direction approximately 160 m to the south-east of the crossing at its closest. The river is fed by several minor tributaries to the east and south-east and the Cwybrmawr Drain immediately to the north-west.

This drain begins directly west of the shopping centre found to the northwest of the proposed HDD crossing. It ultimately flows into a series of drains adjacent to the Afon Clwyd. It is located c.150 m northwest of the proposed HDD works at its closest point.

These watercourses are generally underlain by alluvium or glaciofluvial sheet deposits which overlie the till. It is therefore likely that the watercourses will receive some baseflow from the underlying alluvium or glaciofluvial deposits, however given the clayey nature of the near surface till there is unlikely to be significant hydraulic connection with any groundwater within the till.

To the west of the A525 crossing and adjacent to the Afon Clwyd are a series of drains which includes the Clwyd Embankment Drain North and South, the Pont Gwynda drain and numerous minor field drains. These are drainage channels to the northeast and southwest of the Afon Clwyd channel and which operate as collector drains on the landward side of respective flood defences serving the Afon Clwyd. The drains both flow to the northwest, parallel to the Afon Clwyd, and ultimately discharge into the Afon Clwyd downstream (Clwyd Embankment Drain North via Rhyl Cut and Clwyd Embankment Drain South via the Afon Gele). These drains are all located on low permeability tidal flat deposits and are therefore unlikely to be in continuity with any groundwater present within the till.

As outlined in Section 3.2.1 the superficial deposits are locally in excess of 25 m in thickness and the groundwater table for the underlying sandstone aquifer is c.10 m below ground level. There will therefore be no hydraulic connection between the nearby watercourses and the sandstone aquifer.

3.4.2 Water Quality

Surface water quality is measured as part of the WFD classifications for main rivers. The WFD Cycle 2 (2018 Interim) Status of waterbody catchments within the study area for the onshore elements of AyM are presented in Table 3-4-.

The A525 crossing HDD works do not fall within an assessed WFD Cycle 2 (2018 Interim) river waterbody area. However, the Glanffyddion Cut Waterbody Catchment is c.100 m southwards of the proposed crossing location.

Table 3-4-
WFD Cycle 2 (2018 Interim) River Waterbody Catchment Statuses

River Waterbody Catchment	WFD Cycle 2 (2018 Interim) Status		
	Ecological	Chemical	Overall
Glanffyddion Cut	Moderate	Good	Moderate

The A525 crossing HDD works are located within the Clwyd Permo-Triassic Sandstone WFD groundwater unit. This was assessed in 2015 as having a good overall, quantitative and chemical status.

There are no recorded 'significant' pollution incidents within the study area.

3.5 Ecologically Designated sites

As presented on Figure 4 there are two designated ecological sites within a 500 m radius of the proposed HDD crossing; the Bryn Cwnin Wetland Local Wildlife Site (LWS) and The Clwyd Estuary and Adjacent Fields LWS.

The Bryn Cwnin Wetland (LWS is a swamp habitat c.150 m northeast of the proposed crossing that is likely to support a range of important invertebrate and plant species. The presence of slowly permeable loamy and clayey soils and low permeability superficial deposits underlying and adjacent to this site indicates that it is unlikely to be dependent and fed from groundwater underlying the proposed HDD crossing.

The Clwyd Estuary and Adjacent Fields LWS encompasses the river and network of drains associated with the Afon Clwyd and Clwyd Embankment Drain discussed in section 3.4.1. As discussed these watercourses are all located on low permeability tidal flat deposits and area not considered to be in hydraulic connection with groundwater underlying the proposed HDD works.

3.6 Conceptual Site Model Summary

The assessment of the baseline conditions of the A525 crossing HDD crossing works indicate that the proposed crossing area is underlain by a Principal aquifer, the Kinnerton Sandstone Formation, which has the potential to provide significant groundwater flows for abstractions or baseflow to watercourses.

Within the vicinity of the trenchless crossing works the sandstone bedrock is, however, expected to be overlain by circa. 25 m of variable superficial deposits, with lower permeability clays likely acting to confine groundwater flow within higher permeability sands and gravels, and potentially the underlying sandstone.

It is noted that nearby BGS logs suggest that the base of the till, immediately overlying the sandstone bedrock, comprises more sands and gravels. If sands and gravels are encountered, these will potentially be in hydraulic continuity with the underlying sandstone aquifer.

The proposed works will drill to a maximum depth of 20 m below ground level, suggesting that works are unlikely to encounter the bedrock aquifer, although they will potentially encounter the overlying sands and gravels and therefore a connection to the underlying aquifer cannot be ruled out.

The superficial deposits have the potential for limited groundwater flow within any sandy and gravel horizons, however these tend to be variable and unconnected and are therefore unlikely to provide significant flows for either abstractions or for surface water baseflow.

No abstractions or groundwater dependent ecological sites are identified to be in hydraulic connection with groundwater at the proposed HDD crossing.

4.0 Hydrogeological and Hydrological Impact Assessment

4.1 Proposed Development

A description of the proposed HDD activity at the A525 crossing area is provided in the ES, Volume 3, Chapter 1: Onshore Project Description (application ref: 6.3.1).

The potential impact of the proposed HDD trenchless crossing on groundwater receptors are outlined below using qualitative risk assessment methodology based on the sensitivity of the receptor and likelihood of impact occurring. Impacts assessed as moderate or high are considered to require further assessment or mitigation.

4.1.1 Potential Effects

Without appropriate design and controls, construction works have the potential to impair the local hydrology (water quality) and hydrogeology (groundwater levels, flow and quality), from the following:

- The use of machinery and the movement of soils has the potential to generate suspended solids in run-off and/ or introduce oils or hydrocarbons to the water environment;
- The use of bentonite drilling muds has the potential to impact on water quality;
- Existing groundwater flow paths could be disturbed or altered, impacting nearby groundwater abstractions.

Standard construction techniques and best practices will be used to avoid or reduce these potential impacts with outline control measures set out in the Outline Code of Construction Practice (CoCP) (application ref: 8.13). Details are given in the following section.

4.1.2 Receptor Sensitivity

Based on the review of the baseline conditions and the CSM as developed in the previous section it is considered that the primary receptor in the vicinity of the development site is the underlying Principal bedrock aquifer. The superficial deposits are also considered a potential receptor however given the limited groundwater potential of these deposits, they are not considered to be highly sensitive as there are no associated abstractions and are unlikely to provide flow to either surface water or ecological receptors.

For the purpose of this assessment the sensitivity of the bedrock aquifer is assessed as High whilst the superficial deposits are assessed as Low.

4.1.3 Embedded Mitigation

As part of the design for the onshore works careful routing of the onshore ECC and design of key crossing points (sea defence structures, main rivers, non-main and ordinary watercourses, roads) has been undertaken to avoid key areas of sensitivity.

Best practice construction techniques and procedures will be followed during any works, and these are outlined within the outline CoCP and accompanying appendices that provide a series of management plans which will be agreed with NRW and DCC prior to any development taking place. These include:

- A Pollution Prevention and Emergency Incident Response Plan (PPEIRP) is being developed for the works, an outline version of which is provided in the outline CoCP Appendix 6: Pollution Prevention and Emergency Incident Response Plan (application ref 8.13.6) that sets out the principles to be followed when the final PPEIRP is finalised. The outline PPEIRP sets out the pollution prevention measures, and

emergency incident responses, which may be implemented by the Applicant and its contractors during construction;

- An Outline Soil Management Plan (SMP) is provided as Appendix 4 to the outline CoCP (application ref: 8.13.4). The SMP provides details of mitigation measures and best practice handling techniques to safeguard soil resources by ensuring their protection, conservation and appropriate reinstatement during the construction of the onshore works. These measures will include guidance on earthworks and stockpiling in order to minimise potential entrainment of sediments to surface water features or increase in nitrogen loading to groundwater through infiltration.

The construction works will also be undertaken in accordance with good practice guidance within the following documents:

- CIRIA SP156 Control of Water Pollution from Construction Sites - Guide to Good Practice, 2002;
- CIRIA C502 Environmental Good Practice on Site C741, CIRIA 2015;

The Pollution Prevention Guidelines (PPGs) (which are progressively being replaced with Guidance for Pollution Prevention (GPPs)) provide environmental good practice for the whole of the UK and environmental regulatory guidance for Wales. Relevant PPGs/GPPs will be followed, including:

- GPP01: Understanding your environmental responsibilities – good environmental practices (Oct 2020)
- GPP02: Above Ground Oil Storage Tanks (Jan 2018);
- GPP04: Treatment and Disposal of wastewater where there is no connection to the public sewer (Nov 2017);
- PPG6: Working at construction and demolition sites (2012);
- GPP08: Safe storage and disposal of used oils (July 2017);
- GPP13: Vehicle Washing and Cleansing (April 2017);
- PPG18: Managing fire water and major spillages (June 2000);
- GPP21: Pollution incident response planning (June 2021);
- GPP22: Dealing with Spills (Oct 2018).

4.1.4 Impact on groundwater quality from construction activities

Measures outlined within the outline CoCP, SMP and PPEIRP will minimise the potential for any contaminants to be generated or released as part of the works and therefore minimise the potential impact on water quality.

The embedded mitigation measures include the implementation of spill procedures and use of spill kits. These measures together with appropriate drainage systems and containment will minimise the potential for any reduction in water quality associated with spills or leaks of stored oils/ fuels/ chemicals or other polluting substances migrating into nearby groundwater.

Whilst there is the potential for the construction of an entry/ exit pit relating to the HDD cable installation to introduce a pathway for contaminants, the low permeability of the underlying strata is likely to limit the migration of potential contaminants.

In the event that groundwater within the Kinnerton sandstone is encountered this could be sensitive to accidental spillages and runoff from the HDD works as the drilling will create a preferential pathway to the underlying sandstone. Measures in the outline CoCP to control the storage and use of materials and chemicals would be implemented, which would limit the magnitude of impact.

The above embedded mitigation measures will ensure that the risk to both shallow perched groundwater within the superficial deposits and groundwater within the deeper Kinnerton sandstone aquifer is low.

4.1.5 Impact on groundwater quality from drilling mud

Drilling mud is used as part of the HDD process and is pumped into the works to stabilise the drilled bore, recover drilling cuttings and ensure it does not collapse. Bentonite is the most commonly used drilling mud.

Bentonite is a naturally occurring swelling clay with sodium bentonite and calcium bentonite the most widely used in industry. The primary water quality concerns from the use of bentonite drilling muds are related to increased turbidity of the aquifer, or the release of elevated pH, sodium or calcium concentrations.

Bentonite clays have very fine particle sizes which in certain conditions, such as within fissured aquifers, has the potential to migrate from the drilling hole where voids in the aquifer are connected via the drilling. Drilling will however primarily take place through the superficial till deposits, which are dominated by clays and silts which will limit the potential for any migration of bentonite away from the drill hole.

The Kinnerton sandstone is described as a *'fine to medium grained sandstone'* therefore the potential for significant migration of bentonite drilling muds is considered to be very low. Any impact to water quality would therefore be highly localised to the immediate vicinity of the drilling works. As outlined above there are no sensitive abstractions or ecological sites within the immediate vicinity of the works which could be impacted. Given the significant aquifer thickness in comparison to the small diameter of the open hole and the small volume of bentonite used in the process, the potential for the bentonite to adversely impact water quality is considered to be very low.

It should also be noted that the use of bentonite as a drilling mud is a common approach in borehole drilling (both HDD and conventional well drilling) and is generally considered to be low risk to groundwaters. Good management and disposal practices of excess bentonite will apply to ensure further protection to superficial and bedrock aquifers.

The above assessment therefore indicates that the risk from the use of drilling muds is low. To ensure that the risk is controlled careful monitoring of the drilling mud used will be undertaken to ensure that any losses to the aquifer which could indicate migration away from the drill hole are identified as early as possible and allow for appropriate mitigation to be put into place in the highly unlikely event of this occurring.

4.1.6 Impact on Surface Water Quality

The CSM indicates that the watercourses within the vicinity of the proposed crossing are considered to receive limited groundwater baseflow from the study area due to the low permeability of the till deposits likely acting to limit the rate and volume of groundwater flow within superficial deposits. Therefore, it is considered highly unlikely that any impact from the HDD works would migrate to surface water. This along with the measures outlined above to protect groundwater will ensure that the potential impact on surface water quality is negligible.

4.1.7 Impact on Groundwater Levels and Flows

As outlined in Section 3.3.2 groundwater is considered to be present within the underlying bedrock at a depth of approximately 10 m below ground level at the HDD crossing point. There is therefore the potential that the HDD crossing will encounter the underling bedrock aquifer, either directly or via sands and gravels at the base of the till in continuity with the underlying aquifer, although it is noted that the majority of drilling will take place within the overlying clay dominant superficial deposits.

Some perched groundwater is potentially present within the superficial deposits however given typical low permeability of the till deposits mean that these are unlikely to provide a significant resource.

The method of working will minimise the size of the opening and therefore ensure that any dewatering which does occur as a result of the tunnelling is kept to a minimum. This could have a moderate impact on any groundwater encountered within the superficial deposits as it will likely locally alter the flows, however given the lack of any associated receptors and the low sensitivity of the aquifer, the magnitude of impact is considered to be low and acceptable.

In the event that the HDD works encounter the bedrock aquifer, the overall impact on flows is likely to be low owing to the very small size of the opening in relation to the significant aquifer thickness (in excess of 100 m) and the lack of any nearby significant receptors which could be impacted by what would be a very localised radius of influence. Following installation, the presence of the cables within the aquifer will potentially result in a very minor alteration in flows but given the minor development extent in relation to the aquifer the overall significance of impact is assessed as minor and no further mitigation above that embedded in the design is considered necessary.

4.1.8 Impact on Groundwater Abstractions and Ecological Sites

Given that is the limited impact that the proposals will have on the bedrock aquifer and the significant distance to the nearest licensed abstraction (c.1 km to the north-west), the potential impact to the abstraction is assessed as negligible. Similarly, ecological sites of interest are not considered to be in hydraulic connection with groundwater at the site and the potential for adversely impacting these sites is assessed as negligible.

5.0 Conclusions

A groundwater risk assessment has been undertaken to assess the potential impact of the proposed A525 crossing HDD Crossing Works on groundwater receptors.

The assessment has indicated that the primary potential receptor of concern relates to groundwater within the underlying Kinnerton sandstone aquifer.

The various watercourses in the vicinity of the development area are not considered to be groundwater dependent due to the low permeability of the overlying superficial deposits which act as a confining layer above the sandstone aquifer and any groundwater baseflow will be from localised alluvial deposits which do not extend beneath the works extent.

An assessment of the potential impact of the works on groundwater levels, flow and quality and surface water quality has been undertaken and confirms that the potential impact on levels and flows is considered to be negligible or low. The risk to both groundwater and surface water quality will be managed through the implementation of best practice measures in accordance with a series of management plans developed for the works and ensure that the risk to groundwater quality is low. The lack of any hydraulic continuity between groundwater and surface water ensures that the risk to surface water quality is negligible.

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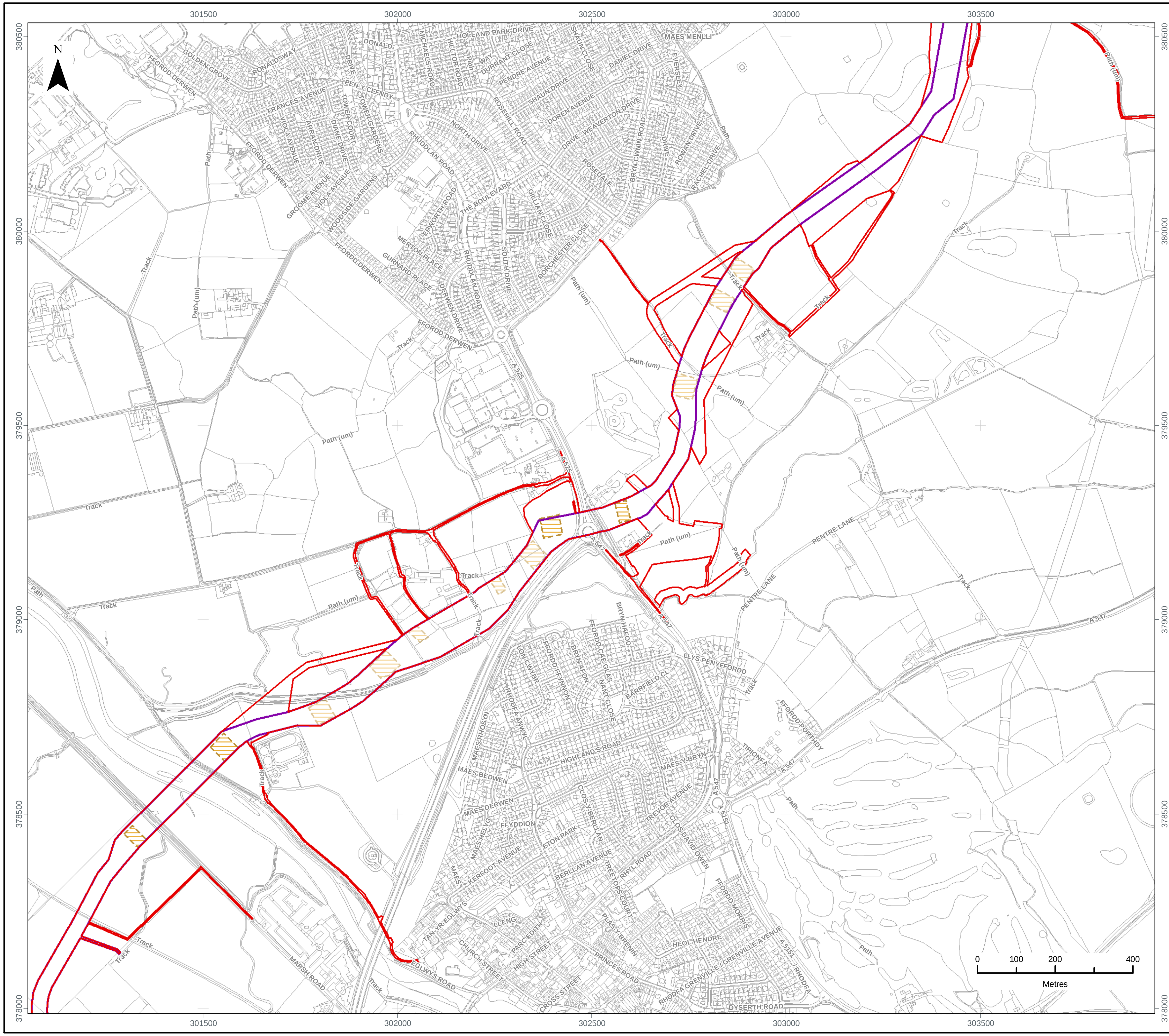

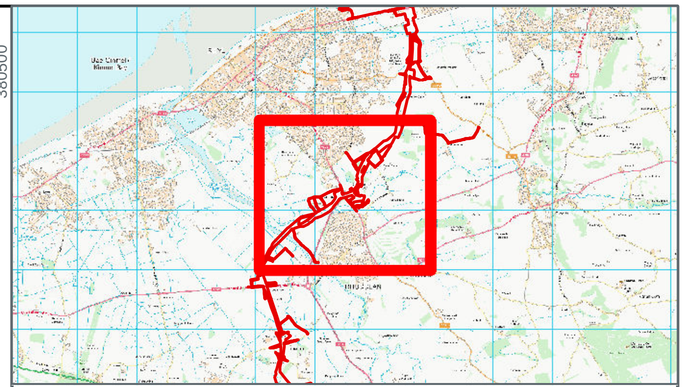

LEGEND

- Order Limits
- Proposed Onshore Export Cable Corridor
- Proposed Trenchless Crossing Compound

Data Source:
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PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

A525 Trenchless Crossing Works (HDD):
Hydrogeological Risk Assessment

FIGURE TITLE:

SITE CONTEXT

VER	DATE	REMARKS	Drawn	Checked
1	08/02/2022	First Issue	PW	SM

FIGURE NUMBER:

FIGURE 1

SCALE:	PLOT SIZE:	DATUM:	COORDINATE SYSTEM:
1:10,000	A3	ODN	British National Grid

Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

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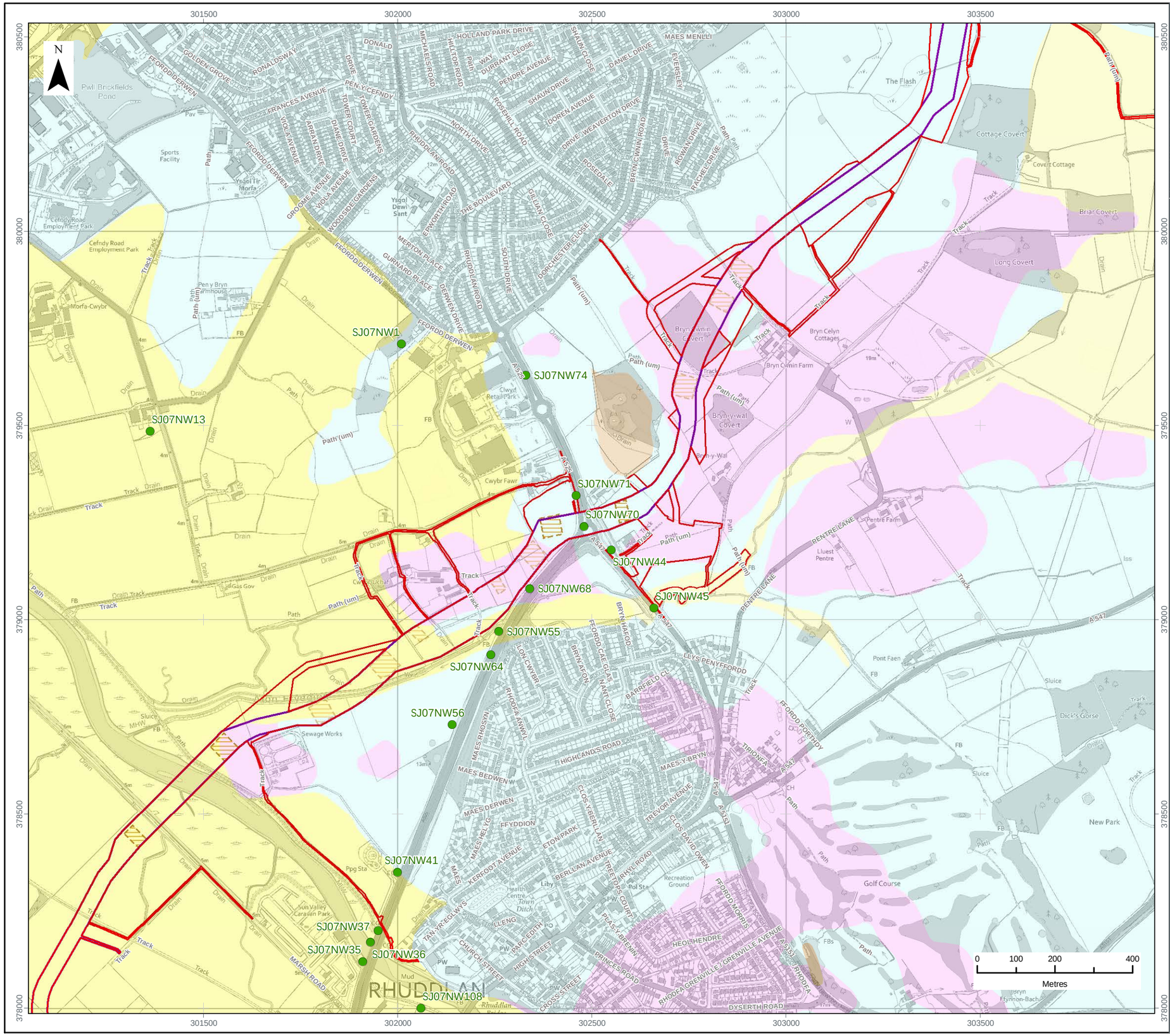

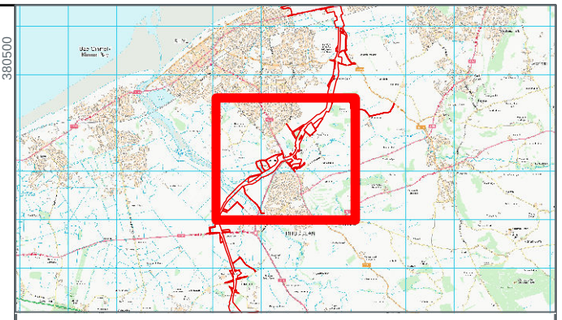

LEGEND

- Order Limits
- Proposed Onshore Export Cable Corridor
- Proposed Trenchless Crossing Compound

Superficial Geology

- Alluvium - Clay, Silt, Sand And Gravel
- Peat
- Tidal Flat Deposits - Clay, Silt And Sand
- Till, Devensian - Diamicton
- Glaciofluvial Sheet Deposits, Devensian - Sand And Gravel
- Lacustrine Deposits - Clay And Silt
- Historic BGS Borehole

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

A525 Trenchless Crossing Works (HDD):
Hydrogeological Risk Assessment

FIGURE TITLE:

SUPERFICIAL DEPOSITS

VER	DATE	REMARKS	Drawn	Checked
1	08/02/2022	First Issue	PW	SM

FIGURE NUMBER:

FIGURE 2

SCALE:	PLOT SIZE:	DATUM:	COORDINATE SYSTEM:
1:10,000	A3	ODN	British National Grid

Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

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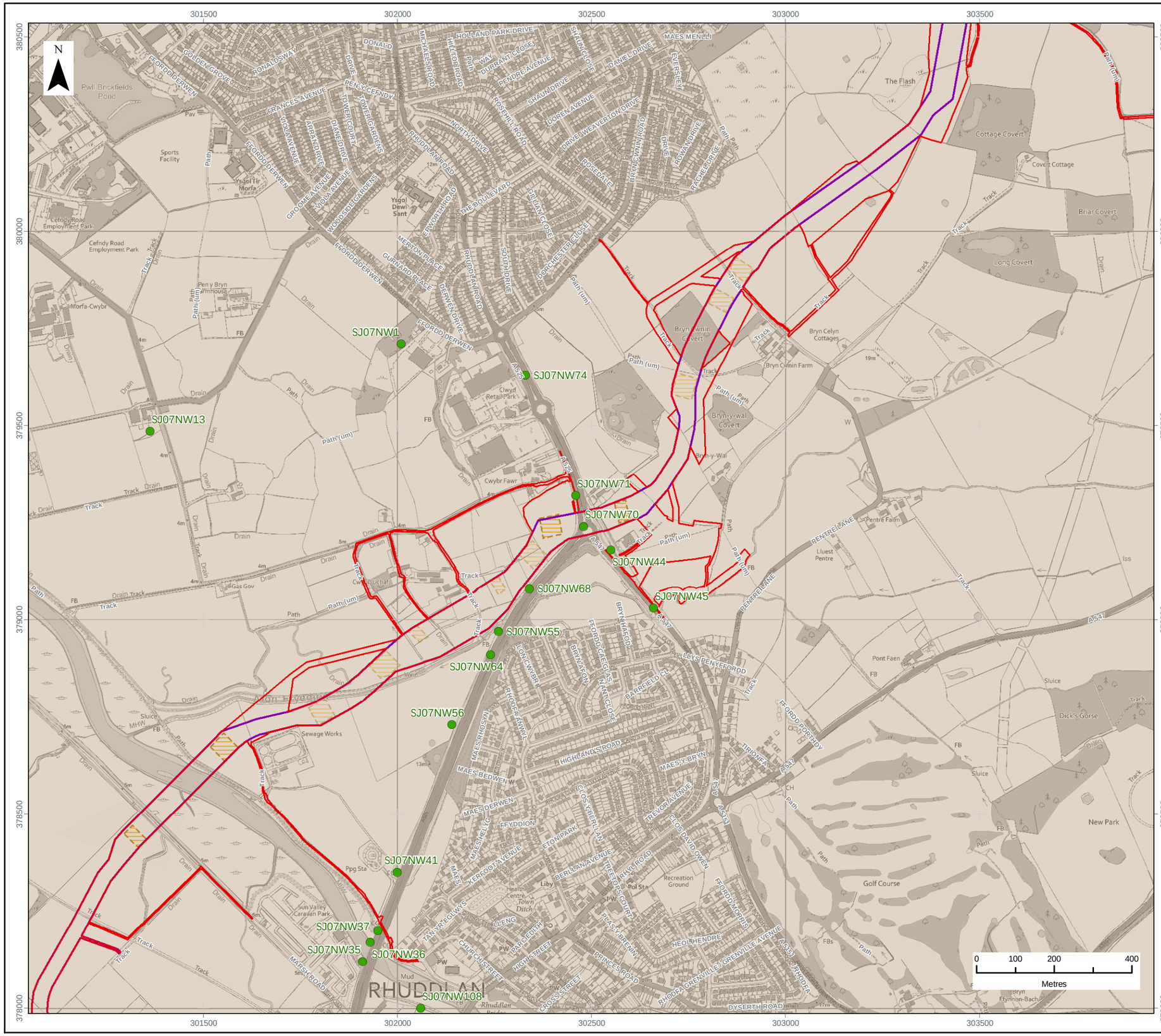

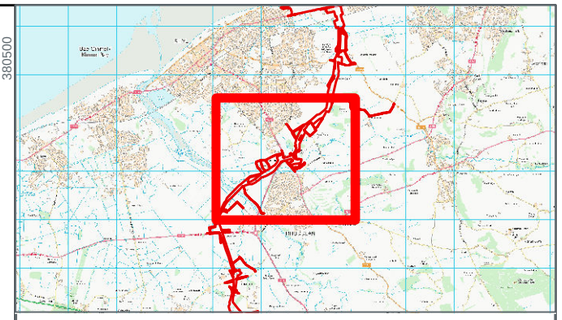

LEGEND

- Order Limits
- Proposed Onshore Export Cable Corridor
- Proposed Trenchless Crossing Compound

Bedrock Geology

- Kinnerton Sandstone Formation - Sandstone (Triassic)
- Historic BGS Borehole

Data Source:
© Crown copyright [and database rights] (2022) OS OpenData.
Contains British Geological Survey Materials © NERC 2019
Historic BGS Boreholes based upon records provided by British Geological Survey (UKRI)

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

A525 Trenchless Crossing Works (HDD):
Hydrogeological Risk Assessment

FIGURE TITLE:

BEDROCK GEOLOGY

VER	DATE	REMARKS	Drawn	Checked
1	08/02/2022	First Issue	PW	SM

FIGURE NUMBER:

FIGURE 3

SCALE:	PLOT SIZE:	DATUM:	COORDINATE SYSTEM:
1:10,000	A3	ODN	British National Grid

Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

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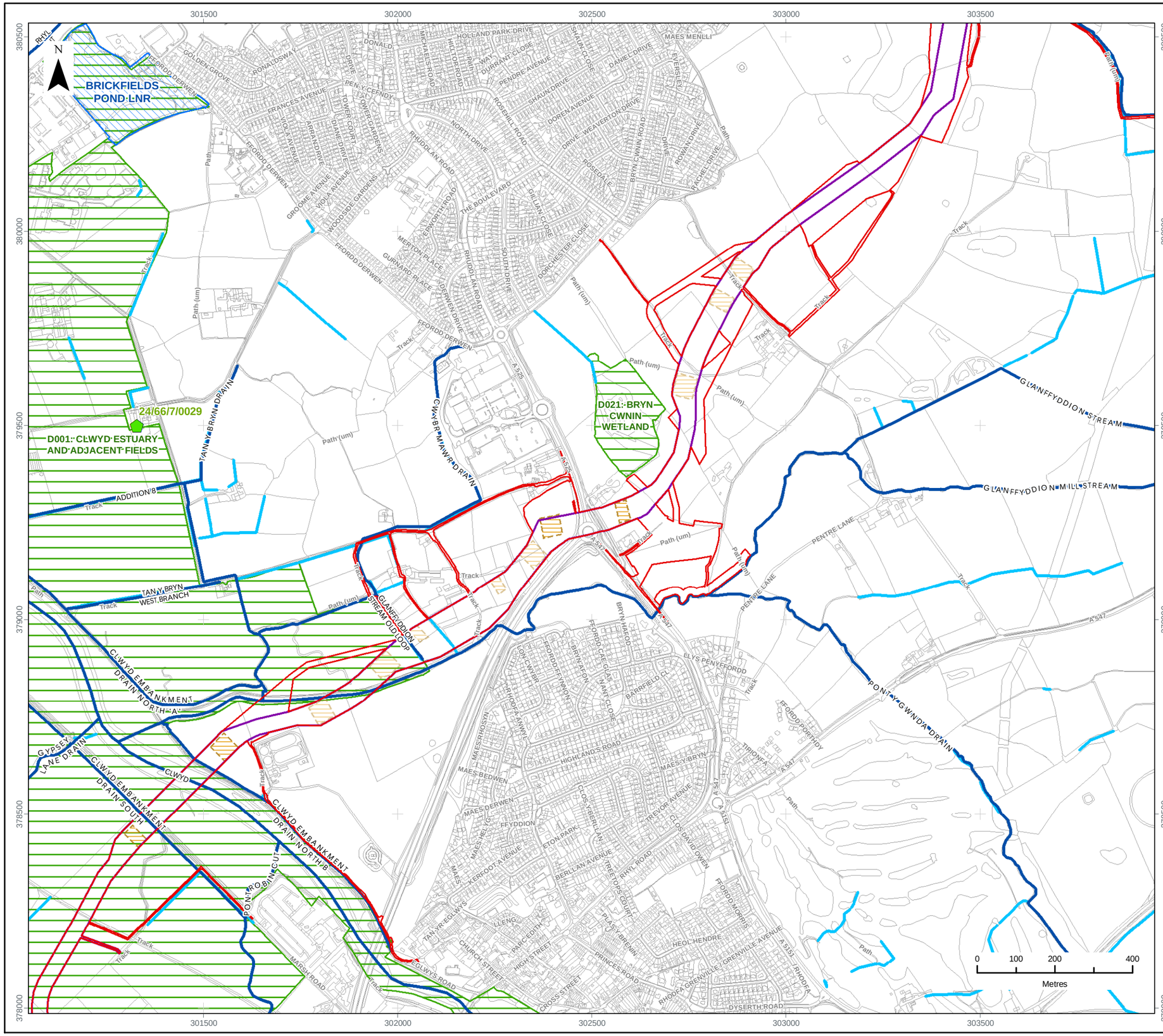

LEGEND

- Order Limits
- Proposed Onshore Export Cable Corridor
- Proposed Trenchless Crossing Compound
- Local Nature Reserve (LNR)
- Local Wildlife Site
- NRW Main River
- Ordinary Watercourse
- Licensed Groundwater Abstractions

Note: There are no Source Protection Zones within the Displayed Area

PROJECT TITLE:
AWEL Y MÔR OFFSHORE WINDFARM
A525 Trenchless Crossing Works (HDD):
Hydrogeological Risk Assessment

FIGURE TITLE:
GROUNDWATER SPZs, WATERCOURSES, ABSTRACTIONS AND ECOLOGICAL SITES

VER	DATE	REMARKS	Drawn	Checked
1	08/02/2022	First Issue	PW	SM

FIGURE NUMBER:

FIGURE 4

SCALE:	PLOT SIZE:	DATUM:	COORDINATE SYSTEM:
1:10,000	A3	ODN	British National Grid

Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

P:\05356 - GoBe Consultants Ltd\00009 Awel y Mor\Tech\GIS\Dwgs\Wking\202201 HRA\05356.00009.0297.0 HDD Groundwater SPZ.mxd

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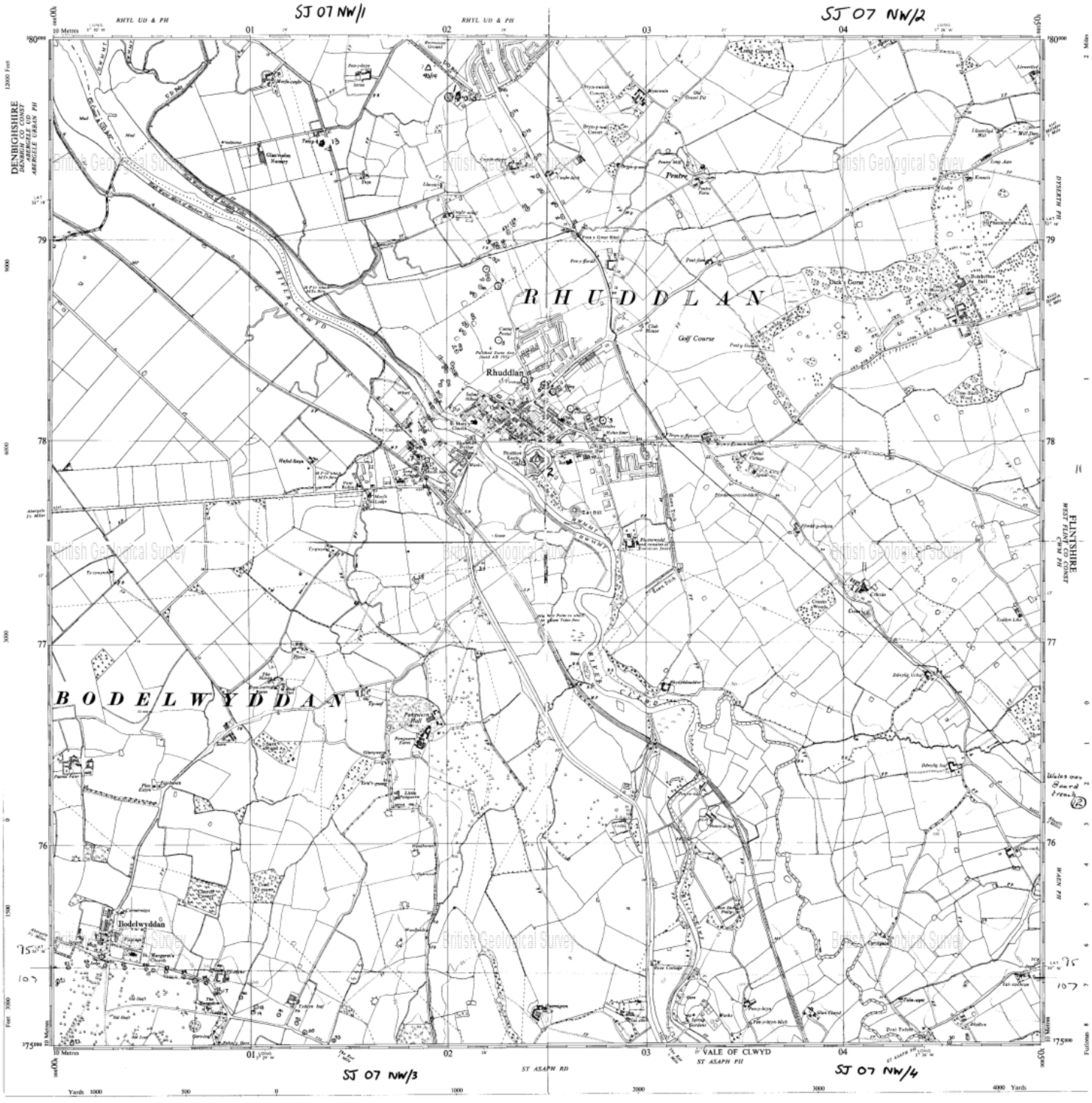
Northing: 379710
Date: 1954
Length: 76.81m


SJ 07 NW/1
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Bodelwyddan
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Glan-yr-afon Nursery
Dick Corner
Dobshill Fm
Dobshill Fm Dell
Pwll-y-Gaer Rifle Range
Pwll-y-Gaer Stone Axe Hoard AD 1951
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Parkwern Fm
Glanywern
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SJ 07 NW/1

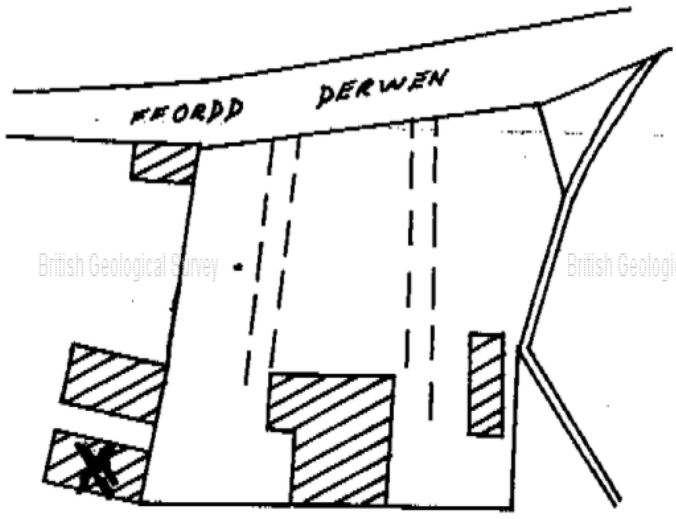
Rhuddlan Creamery [SJ 07NW/1] Sheet 95

Surface level approx. +4~~0~~m; National Grid ref. 0201 7971.
Drilled 1954 on behalf of C.W.S. Logged by contractor.

Description of strata	Thickness m	Depth m
DRIFT		
Alluvium		
Clay	0.91	0.91
Sand and gravel/ with clay towards base	5.18	6.09
Boulder Clay with Glacial Sand and Gravel		
Clay, sandy in parts, with stones and gravel	8.69	14.78
Sand with pebbles	2.44	17.22
Sand, red, running	0.45	17.67
Gravel, fine, with stones and sand	9.00	26.67
PERMO-TRIASSIC		
Lower Mottled Sandstone		
Sandstone, red ..... to bottom of hole	50.14	76.81

SJ 02 01/1971 4

SJ 07 NW 1



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ADDITIONAL INFORMATION 95/10 SJ07/6

WELSH NATIONAL WATER DEVELOPMENT AUTHORITY

DEE AND CLWYD RIVER DIVISION

SJ07/6

DETAILED HYDROGEOLOGICAL RECORD SHEET : INDIVIDUAL SITE RECORD

SJ07NE

NAME FFORDD DERWEN CREAMERY (1982 - Martin's cash & carry) N.G.R. 0202 7969

EXACT SITE KNOWN YES/~~NO~~ LOCATION SKETCH ~~YES~~/NO

HEIGHT A.O.D. .k:l..... METRES ESTIMATED FROM MAP/~~SURVEY~~

REFERENCE POINT NONE/~~DETAILS~~/~~SKETCH~~

LOG YES/~~NO~~ LOCATION OF LOG HERE/~~I.G.S.~~

SUMMARY OF LOG DRIFT TO 87½ FT

SST TO, 252½ FT

Rockhead -20·6mAOD.

WATER QUALITY INFORMATION ~~YES~~/NO

WATER LEVEL INFORMATION

ABSTRACTION YES/~~NO/OCCASIONALLY/NOT KNOWN/STAND-BY~~

LICENCE No. 66/7/~~36~~ 31~~4~~ } 31·822m³/HOUR 109·104m³/DAY 40·914ML/YEAR LICENSED ABSTRACTION

↳ revoked June 1982

Source no longer licensed or used.

PUMPING TEST YES/~~NO~~ DATE 1954

LOCATION OF DATA WITH LOG, HERE

WATER LEVELS RECORDED ~~NONE~~/ISOLATED READINGS/~~MONTHLY/AUTOGRAPHIC~~

LOCATION OF RECORDS RWL 2½' DATE ?

ACCESS ... site visit sheet

6_4.TIF

95/10

CWS Creamery borehole 1954. SJ07/6

(Hereford Borough) [0200 7970]

	Clayey soil	to 1'
glacial drift: Boulder Clay, Sandy Boulder clay and Glacial Sand & Gravel	Clay	to 3'
	Sand & gravel	to 15½'
	Sand, clay & gravel	to 48½'
	Sand & gravel	to 87½
Permo-Triassic Lower Mottled Sandstone.	Red Sandstone	to 252

Licenced to abstract 80,000 galls/day

Actual abstraction 2·3 million galls/month.

[redacted]

24/2/77

6-2. TIF

INDEX No. 22

S 107/6

T [redacted] 061—736 1614 Telegrams ARTESIAN MANCHESTER, 6

THOMAS MATTHEWS (Pumps) LTD.

Submersible Pump Specialists

Withington Street
Pendleton
Salford 6

This is my Postcode
Please add it as the last line
of my address when replying
M6 5BR

OUR REF. TAS/LEL.

YOUR REF.

DATE 18th October 1968.

Dee and Clwyd River Authority,
2, Vicar's Lane,
Chester.
CH1 1QT.

Dear sirs,

We are in receipt of your letter regarding the borehole at the C.W.S. Creamery at Rhuddlan which was drilled by Thomas Matthews Ltd., in 1954.

The borer's log is as follows:-

Clay.	Surface to 4' - 6"
Sand and Gravel	4' - 6" to 15' - 6"
Hard Clay and Stones	15' - 6" to 20' - 0"
Sandy Clay and Gravel	20' - 0" to 46' - 0"
Sand and Gravel	46' - 0" to 87' - 6"
Red Sandstone	87' - 6" to 252' - 6" total depth.

The borehole is lined from surface to 90' - 8" with 12" i/d Tubes cemented in.

On completion the boring was tested for 144 hours continuously at 10,000 g.p.h. with the water level at 33ft from surface.

We trust this is the information you require, but should there be any further details please do not hesitate to ask.

Yours faithfully,
THOMAS MATTHEWS (PUMPS) LIMITED.,

[redacted]

T.A. Steer.
Secretary.

6-5.TIF

SHEET NO. 1

WELSH WATER AUTHORITY
DEE AND CLWYD DIVISION

95/10
SJ07/6

HYDROGEOLOGY SECTION

Ground Water Level Information

SJ07/6

Name of Site.....Ffordd Derwen...Creamery.....

D.C.D. Ref. No.....[illegible]..... N.G.R.....

Reference Point.....

Date	Time G.M.T.	Observer	Datum m.A.O.D.	Water Level			Comments
				Depth to (m)	Approx	m.A.O.D.	
1954		T. Matthews		2.5' (0.76m)			Drillers information (Rest)
1954		T. Matthews		33' (10.1m)			6 days at 10000 gph
7.12.71	1555	WCW		1.165			Rest level
7.12.71	1600	WCW		7.540			taken after two minutes pumping at c.7000 gph
1972		K.B.E.		8.06			pumping
14.9.82	1515	psn		1.102			rest level
7.1.76	1630	?		1.218			rest level

6-6.TIF

95/10

Sheet No. 1

WELSH WATER AUTHORITY
DEE AND CLWYD DIVISION
HYDROGEOLOGY SECTION
GROUND WATER QUALITY ANALYSES

SJ07/6 SJ07/6

Name of Site ...Ffordd Derwen Creamery

D.C.D. Ref. No. .....[redacted]..... N.G.R. .....

Analysis Group: Group 'A'

Sampling Location and Other Details

Date	7·1·76					
Time G.M.T.						
Water Level (m.A.O.D.)						
Flow (g.p.h.)						
Temperature						
pH	6·9					
Specific Conductivity	578					
Total Dissolved Solids						
Sodium						
Potassium						
Calcium (as $CaCO_3$)	206					
Magnesium (as $CaCO_3$)	97					
Chlorides	35					
Sulphates	12					
Carbonates						
Bicarbonates						
Nitrates	1·19					
Nitrites	0·002					
Tot. Ox. Nitrogen	1·192					
Ammoniacal Nitrogen	<0·005					
Silicates	9·8					
Orthophosphates						
Suspended Solids						
Alkalinity (Total)	265					
Iron (Total)	0·035					
Manganese (Total)	<0·01					
Total Hardness	303					
Temp "	265					
Permanent "	38					
Lead (Total)	<0·01					
Zinc (Total)	0·066					

Comments:

6_10.TIF SJ07 NW 11 95 N.6038

THE UNIVERSITY OF LIVERPOOL

TELEPHONE: ROYAL 6022

THE JAN
LABORATORI

[redacted]

Map ref. 020797, O.S. Sheet 108. 21st October, 194.

SJ07/6

Dr. F. H. Trotter,
Geological Survey Office,
102, High Street,
MANCHESTER, 19.

SJ 020 7970

Dear Dr. Trotter,

6" Flint & NE/W.

A bore-hole has just been sunk near Rhyl (Map ref. 020797, O.S. Sheet 108), and Professor Shackleton has suggested that I mention the fact to you, in case the drillers (Matthews of Pendleton) fail to report it to H. M. Survey, which so often happens.

I went to the site yesterday, and have not spoken to the drillers, but have seen the manager of the Co-operative Wholesale Society Ltd., (address: Creamery, Ffordd Derwen Road, Rhuddlan, Nr. Rhyl), for whom the job was done, and I have also inspected the cores, thereby piecing together the following information:-

Depth of hole - 293 ft.
Log:- approximate thickness of drift 100 ft.
Remainder - dark red Trias sandstone, cored throughout the length, with about 70% recovery, there being about 190 ft. of cores laid out on the ground nearby.
Diameter:- 9½" throughout.
Description of rock from cursory inspection of cores:-
Soft, friable sandstone, fairly course, very little mica, no pebbles.
Top 55 ft. poorly bedded.
Next 18 ft. well bedded. There is no evidence of current bedding in any single core, but the apparent dip varies from 10° to about 45°, with one or two cores showing nearly vertical bedding, so the rock is current bedded on a large scale.
Remainder, poorly bedded.

I have brought back five cores, well spaced for depth, but the rest are lying exposed near the hole, and likely to disappear soon for use as garden ornaments etc., or get otherwise lost or displaced; therefore I have lost no time in writing to you.

6-11. TIF

SJ07/6

The bore-hole is for water supply, and 10,000 g.p.h. has already been obtained on trial.

Yours sincerely,

[redacted]

DR. G. D. V. WILSON.

BGS BOREHOLE REFERENCE: SJ07NW13

Easting: 301363
Northing: 379485
Date: 1965
Length: 110.34m

SS07NW 13

(For Institute use only) Geological Classification	NATURE OF STRATA If measurements start below ground surface, state how far.	Thickness Feet	Inches	Metres	Depth Feet	Inches	Metre
	Black soil	0	2	0.35	1	2	0.36 0.35
	Brown Marl	1	4	1.46	6	—	1.82
	Soft Blue Marl	1	5	1.52	11	—	3.35
	Brown Peat	2	9	2.74	20	—	6.09
	Brown Silt	0	3	0.91	23	—	7.01
	Blue Marl	1	5	1.52	28	—	8.53
Sand, Gravel	Brown Sea Sand with Stones	9	31	9.44	59	—	17.98
	Brown Loam.	0	3	0.91	62	—	18.89
	Brown Sea Sand	3	12	3.65	74	—	22.55
	Yellow Stony Marl	3	11	3.35	85	—	25.90
	Buff Sea Sand.	0	11	0.30	86	—	26.21
	Soft Red Sandstone	5	17	5.18	103	—	31.39
Lower Mottled Sst. Permo Trias	Hard Red Sandstone	78	259	78.94	362	—	110.34

SJ 07 NW/13

Tan y bryn [SJ 07NW/13] Sheet 95

Surface level approx. +4[illegible] m; National Grid ref. 0136 7949.
Drilled 1965 for water. Logged by contractor.

Description of strata	Thickness m	Depth m
DRIFT		
Marine and Estuarine Alluvium		
Marl [sic], brown to blue	3.35	3.35
Peat	2.74	6.09
Sand, silt/ and marl [sic]	20.12	26.21
PERMO-TRIASSIC		
Lower Mottled Sandstone		
Sandstone, soft, red	5.18	31.39
Sandstone, hard, red ..... to bottom of hole	78.95	110.34

35_1.TIF

RECORD OF WELL

For Institute use only Licence No. N. 13097

9 5 SJ07/35

SJ07 NW13 25

EXACT SITE OF WELL

At TAN-Y-BRYN.

RHYL

Town or Village RHYL.

County DENBIGHSHIRE.

Six-inch County Sheet S NW/E.

Six-inch National Grid sheet and reference SJ 0135 7948

For MR. EVANS.

State whether owner, tenant, builder, contractor, consultant, etc.:— .....

Address (if different from above) Dee & Clwyd R.A. HA:66 S/C 7

Level of ground surface above sea level (O.D.) ..... ft (..... m)

*DELETE AS NECESSARY

If well top is not at ground level, state how far above:* below: ..... ft (..... m)

SHAFT..... ft (..... m); diameter..... ft (..... m);

HEADINGS (please attach details—dimensions and directions)

BORE 362 ft (110·34 m); diameter: at top 8 in (203·2 mm); at bottom 6 3/4 in (171·4 mm)

Full details of permanent lining tubes (position, length, diameter, plain, slotted, etc.)

8" BLACK TUBE FROM 1 FT BELOW SURFACE TO 129'; 7" BLACK TUBE FROM 114' TO 154'

(203·2 mm black tube 0·30 — 39·31 m bs; 177·8 mm [redacted] black tube from 34·74 — 46·93 m bs)

TEST CONDITIONS

Water struck at depths of 151' 4" ft (47·03 m) below ~~well top~~ surface

Rest level of water 6" ft (0·15 m) ~~above~~ below ~~well top~~. ~~Suction~~ Surface 3" Airlift at 160 ft (48·76 m)

Yield on 40 ~~days~~ hours'* test pumping at 12,000 galls (15·154 m³) per hour with

depression to 22 ft (6·70 m) below ~~well top~~ surface. Recovery to rest level in 4 ~~hours~~ mins*

Capacity of ~~pump~~ airlift 12,000 g.p.h. (15·154 m³/h)

Date of measurements 28/5/65 – 30/5/65

NORMAL CONDITIONS

DESCRIPTION OF PERMANENT PUMPING EQUIPMENT:

Make and/or type..... Motive power.....

Capacity..... galls (..... m³) per hour. Suction at..... ft (..... m)

below well top. Amount pumped..... galls (..... m³) per day. Estimated

consumption..... galls (..... m³) per week

Well made by [redacted] Date of sinking 1965

ADDITIONAL NOTES ANALYSIS (please attach copy if available)

Licence 24/66/7/29/G: 10,000 gph, 136000 gpd. 6·164 m.g.a.

LOG OF STRATA OVERLEAF

Received from .....

.....

.....

Date .....

Observation well .....

Recorder.....

E.R. log .....

Site marked on

1" map .....

6" map .....

(use symbol)

Copy to .....

.....

Date .....

INSTITUTE OF GEOLOGICAL SCIENCES,
WATER DEPARTMENT,
SOUTH KENSINGTON,
LONDON, S.W.7.

35-2.TIF

(For Institute use only) GEOLOGICAL CLASSIFICATION	NATURE OF STRATA If measurements start below ground surface, state how far.	THICKNESS Feet	Inches	Metres	DEPTH Feet	Inches	Metre
	Black soil	1	2	0·35	1	2	0·35
	Brown Marl	4	10	1·46	6	—	1·82
	Soft Blue Marl.	5	—	1·52	11	—	3·35
Sand &	Brown Peat	9	—	2·74	20	—	6·09
Gravel	Brown Silt	3	—	0·91	23	—	7·01
	Blue Marl	5	—	1·52	28	—	8·53
(ESTUARINE ALLUVIUM?	Brown Sea Sand with Stones	31	—	9·44	59	—	17·98
ON BOULDER CLAY)	Brown Loam.	3	—	0·91	62	—	18·89
	Brown Sea Sand	12	—	3·65	74	—	22·55
	Yellow Stony Marl	11	—	3·35	85	—	25·90
	Buff Sea Sand.	1	—	0·30	86	—	26·21
Lower Moth. Ssh.	Soft Red Sandstone	17	—	5·18	103	—	31·39
Permo-Trias	Hard Red Sandstone	259	—	78·94	362	—	110·34

Nov 70.

Agreed
D.T. LOWE
24/2/77

Licenced Abstraction 136.000 gpd
Max. annual abstraction 2 Million galls.

Used for Spray irrigation.

35_3.TIF

RECORD OF WELL

For Institute use only Licence No.

N .....

SJ07/35

95/25

EXACT SITE OF WELL

At Tan-y-bryn Farm .....

.....

Town or Village ... Rhyl .....

County ..... Flint .....

Six-inch National Grid sheet and reference ..... SJ 014 795 .....

For ..... R. Evans & Co. .....

State whether owner, tenant, builder, contractor, consultant, etc.: ..... owner .....

Address (if different from above) .....

.....

Level of ground surface above sea level (O.D.) ..... ft (..... m)

*DELETE AS NECESSARY

If well top is not at ground level state how far above:* below: ..... ft (..... m)

SHAFT ..... ft (..... m); diameter ..... ft (..... m);

HEADINGS (please attach details—dimensions and directions)

BORE .... 360 ..... ft (..... m); diameter: at top ..... 8 ..... in (..... mm);

at bottom ..... in (..... mm)

Full details of permanent lining tubes (position, length, inner and outer diameters, plain slotted etc.):

.. nk .....

.....

.....

.....

Water struck at depths of ..... ft (..... m) below well top

TEST CONDITIONS

Rest level of water ..... ft (..... m) above* below well top. Suction at ..... ft (..... m)

Yield on ..... hours'* days' test pumping at ..... galls per ..... (..... l/s) with

depression to ..... ft (..... m) below well top. Recovery to rest level in ..... mins* hours

Capacity of pump ..... g.p.h. (..... l/s)

Date of measurements .....

NORMAL CONDITIONS

DESCRIPTION OF PERMANENT PUMPING EQUIPMENT:

Make and/or type ..... Motive power .....

Capacity ..... galls (..... m^3) per hour. Suction at ..... ft (..... m)

below well top. Amount pumped ..... galls (..... m^3) per day. Estimated

consumption ..... galls (..... m^3) per week

Well made by .... nk ..... Date of sinking. .... nk .....

ADDITIONAL NOTES ANALYSIS (please attach copy if available)

LOG OF STRATA OVERLEAF

Access for dipping by threaded plug in cover plate.
Licence No. 24/66/7/296 for 10 000 gph, 136000 gpd, 6·164 mga.

Received from .. Dee & Clwyd RA .....

.....

.....

Date ... 5-8-68 .....

Observation well .....

Recorder .....

ER log .....

Site marked on

1" map .....

6" map—Grid Sheet .....

(use symbol)

Copy to .....

.....

Date .....

INSTITUTE OF GEOLOGICAL SCIENCES
HYDROGEOLOGY UNIT
EXHIBITION ROAD
LONDON SW7 2DE

IGS 2494 10 000 7/79

35-4. TIF

For Institute use only

Geological Classification	Nature of Strata *If measurements start below ground surface, state how far.*	Thickness Feet	Inches	Metres	Depth Feet	Inches	Metres
Drift	Black soil	1	2		1	2	
	Brown marl	4	10		6	–	
	Soft blue marl	5	–		11	–	
	Brown peat	9	–		20	–	
	Brown silt	3	–		23	–	
	Blue marl	5	–		28	–	
	Brown sea sand with stones	31	–		59	–	
	Brown loam	3	–		62	–	
	Brown sea sand	12	–		74	–	
	Yellow stoney marl	11	–		85	–	
– – – – –	Buff sea sand	1	–		86	–	
Lower Mottled Sandstone.	Soft red sandstone	17	–		103	–	
	Hard red sandstone	257	–		360	–	

35-5.TIF

INDEX No 33

Tan-y-Bryn Farm, SJ07/ER 55
Rhyl,
Flintshire.

WKS/MR/ 1174

12th October, 1968.

E.H.Crann, B.Sc., PH.D., M.I.C.E., M.I.W.E.
Chief Officer,
Dee & Clwyd River Authority,
2, Vicar's Lane,
Chester.

Dear Sir,

Borehole at Tan-y-Bryn, Farm, Rhyl (N.G.R. 014795).

In reply to your letter dated 25th September, I offer the following information.

Strata Nature

Black Soil	0 to 1ft. 2ins.
Brown Marl	1ft. 2ins. to 6ft.
Soft Blue Marl	6ft. to 11ft.
Brown Peat	11ft. to 20ft.
Brown Silt	20ft. to 23ft.
Blue Marl	23ft. to 28ft.
Brown sea Sand with Stones	28ft. to 59ft.
Brown Loam	59ft. to 62ft.
Brown Sea Sand	62ft. to 74ft.
Yellow Stony Marl	74ft. to 85ft.
Buff Sea Sand	85ft. to 86ft.
Soft Red Sand Stone	86ft. to 103ft.
Hard Red Sand Stone	103ft. to 360ft.

The above was compiled by the Drill Operator and may not be entirely accurate in soil type.

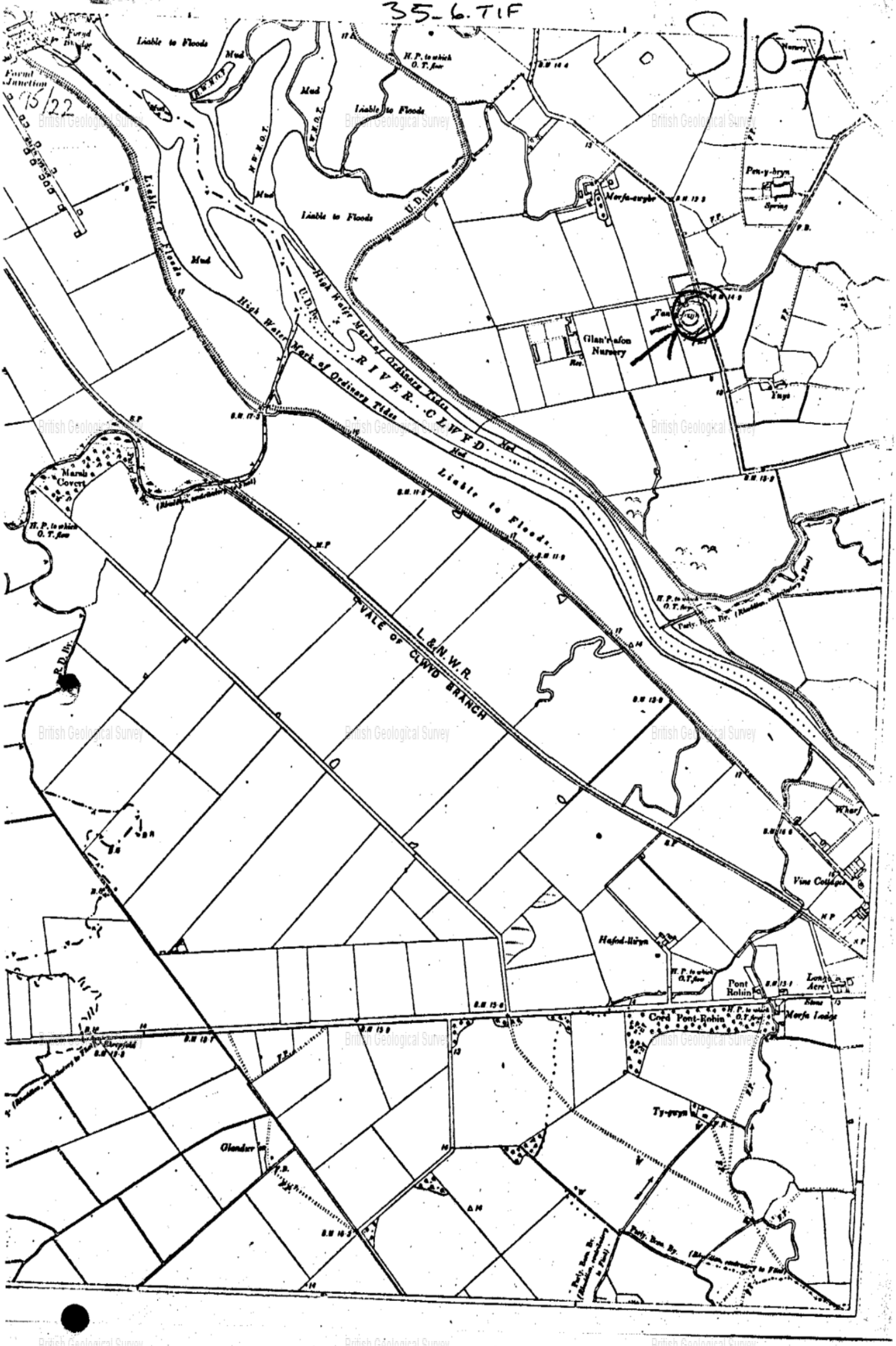
It is possible to measure the water level by removing a threaded plug on the top of the bore hole lining, and I shall be pleased to offer any assistance required.

If you require any further information please let me know.

Yours faithfully

[redacted]

(R.P.W. Evans)
p.p. R.Evans & Co.


35-6.TIF
SJ07
Liable to Floods
Mud
H.W.O.T.
H.P. to which O.T. flow
Liable to Floods
Mud
U.D.Dr.
Liable to Floods
Morfa-surgeon
Pen-y-bryn
Spring
Glan'r-afon Nursery
Res.
Tan
Twgs
High Water Mark of Ordinary Tides
RIVER CLWYD
Mud
Liable to Floods
Marsh Covert
H.P. to which O.T. flow
VALE OF CLWYD BRANCH
L.&N.W.R.
R.D.Dr.
Wharf
Vine Cottages
Hafod-lliryn
Pont Robin
Morfa Lodge
Cred Pont-Robin
Ty-gwyn
Glandwr
Path from Dr. (Boundary to Field)

BGS BOREHOLE REFERENCE: SJ07NW44

Easting: 302550
Northing: 379180
Date: 1992
Length: 5.80m

Norwest Holst Soil Engineering Ltd.

Borehole No. 24

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass Stage II
Client Clwyd County Council
Method of Boring Cable Percussion
Diameter of Borehole 150mm

0255, 7918
SJ 07 NW 44.

Sheet 1 of 1
Co-ords 8914E 21198N
Ground Level 12.04 m.A.O.D.
Date 17/2/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
TOPSOIL		0.40	11.64		0.40		
Stiff dark brown sandy silty CLAY (Glacial Till) at 0.40m: clayey silty fine to medium sand with some to much angular rounded fine to coarse gravel.		0.95	11.09	NIL	0.50-0.95	U(60)	
		1.10	10.94		0.95		
				NIL	1.05-1.50 c	"11"	
Greyish and reddish brown silty SAND and subrounded to rounded fine to coarse GRAVEL, including sandstone, siltstone. (Glacial Sand and Gravel)		2.25	9.79	1.50	1.10 1.50-1.90 1.90 2.00 2.25	U(53)	
Firm reddish-brown silty CLAY with very occasional rounded fine to coarse gravel. (Glacial Till) 2.00-2.25m: firm and sandy		3.80	8.24	2.00 3.30	2.30-2.75 s 3.05 3.35-3.80 s	"11" "10"	
Medium dense brown silty fine SAND with some pockets of soft and firm reddish brown slightly sandy silty clay. (Glacial Sand and Gravel)				3.65	3.80-4.25 s	"9"	
Loose brown silty fine to medium SAND with some pockets of firm reddish brown laminated silty clay. (Glacial Sand and Gravel)		5.15	6.89	4.60	4.80 5.15 5.20-5.65 5.65	U(100)	17/2
		5.80	6.24				
Firm to stiff reddish brown laminated silty CLAY. (Laminated Clay) 5.65-5.80m: with some sand and rounded fine to coarse gravel.							
Borehole complete at 5.80m							

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.) () U100 blows

150mm diameter casing inserted from GL to 4.60m

Groundwater not encountered

Borehole backfilled with bentonite/cement grout

Water levels are subject to seasonal or tidal variations and should not be taken as constant

BGS BOREHOLE REFERENCE: SJ07NW45

Easting: 302660
Northing: 379030
Date: 1992
Length: 5.00m

Norwest Holst Soil Engineering Ltd.

Borehole No. 25

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass
Client Clwyd County Council
Method of Boring Cable Percussion
Diameter of Borehole 150mm

0266, 7903
SJ07NW 45

Sheet 1 of 1
Co-ords 9087E 21258N
Ground Level 8.45 m.A.O.D.
Date 23/3/92 - 24/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
MADE GROUND: Topsoil with some fine to coarse angular gravel, cobbles and ceramic fragments.		0.60	7.85		G.L.		23/3
					0.60		
Stiff reddish brown very silty sandy CLAY with some fine and medium sub-angular gravel of assorted lithologies (GLACIAL TILL)		1.40	7.05	1.50	1.40		
					1.50-1.95	"25"	
					c		
Medium dense brownish grey fine and medium slightly clayey silty SAND and some fine to coarse angular to subrounded gravel. (GLACIAL SANDS AND GRAVELS)		2.30	6.15		2.30		
				2.50	2.50-2.95	"4"	
					s		23/3
Loose grey and reddish brown clayey very silty SAND and very sandy CLAY with some fine and medium subangular to subrounded gravel. (GLACIAL SANDS AND GRAVELS)							24/3
				3.50	3.50-3.95	"5"	
					s		
		4.20	4.25		4.20		
Soft to firm grey very silty very sandy CLAY with much organic detritus.				4.50	4.50-5.00	(28)	
		4.90	3.55				
		5.00	3.45		5.00		24/3
Grey fine to coarse clayey silty SAND with some organic material.							
Borehole Complete at 5.00m.							

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.) ( ) U100 blows

Groundwater encountered at 5.00m, rising to 2.50m after 20 mins
Inspection pit excavated to 1.40m.
Standpipe piezometer installed with tip at 4.80m, sand filter from 4.00 to 5.00m.

Water levels are subject to seasonal or tidal variations and should not be taken as constant

BGS BOREHOLE REFERENCE: SJ07NW55

Easting: 302260
Northing: 378970
Date: 1992
Length: 5.35m

Norwest Holst Soil Engineering Ltd.

Borehole No. 38

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass, Stage II
Client Clwyd County Council
Method of Boring Cable Percussion
Diameter of Borehole 150mm

0226,7897
SJ 07 NW 55

Sheet 1 of 1
Co-ords 9022E 20866N
Ground Level 5.26 m.A.O.D.
Date 18/2/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Grass over TOPSOIL		0.05	5.21		0.05		
Brown silty SAND and subangular to rounded fine to coarse GRAVEL with occasional pockets of firm reddish brown silty clay. Occasional metal wire. (Made Ground)		0.50	4.76		0.50		
		0.95	4.31		1.00-1.45	U(36)	
					1.45	*	
Dark brown clayey silty fine to medium SAND. (Made Ground)		1.85	3.41		1.70-2.15	U(32)	
Soft brown and grey slightly sandy silty CLAY. (Alluvium) 1.70-1.85m: sandy		2.15	3.11		2.15		
					2.20-2.65	U(70)	
					2.65		
Brown silty SAND and GRAVEL with some soft brown clay.							
Stiff brown fissured silty CLAY with occasional partings of soft silt and fine sand and very occasional rounded fine gravel. (Glacial Till)					3.25-3.70	U(60)	
					3.70		
					4.00		
					4.30-4.75	U(38)	
Loose brown clayey very silty fine SAND. 4.90-5.20m: firm brown very silty clay.		4.75	0.51		4.75		
		5.20	-0.06		4.90-5.35	"9"	
		5.35	-0.09		s 5.00		18/2
Stiff brown sandy silty CLAY with some clayey very silty fine sand.							
Borehole complete at 5.35m							

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.) () U100 blows * - No recovery

150mm diameter casing inserted GL - 4.50m
Groundwater struck at 1.80m, level rose to 1.70m after 20 mins. casing to 1.50m, sealed off at 2.00m. Second strike at 5.00m level rose to 3.20m after 20 mins. sealed off at 4.00m

Piezometer installed at 5.00m (see details)

Water levels are subject to seasonal or tidal variations and should not be taken as constant

BGS BOREHOLE REFERENCE: SJ07NW64

Easting: 302240
Northing: 378910
Date: 1992
Length: 4.20m

Norwest Holst Soil Engineering Ltd.

Trial Pit No. **14**

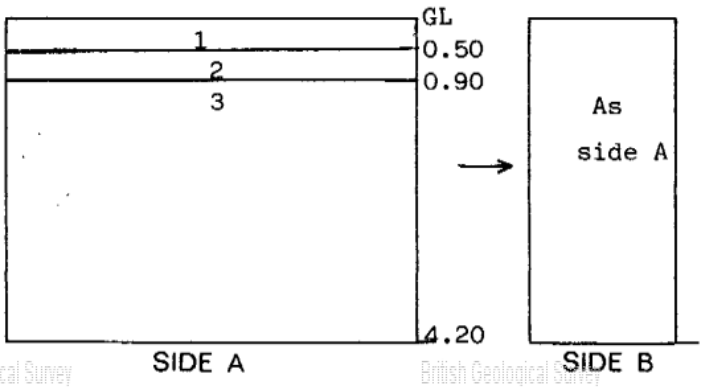
TRIAL PIT LOG

Contract No. F9440
Location A525 Rhuddlan Bypass. Stage II
Client Clwyd County Council
Excavation Plant Ford 655
Dimensions (l x b x h) 4.00 x 1.00 x 4.20m

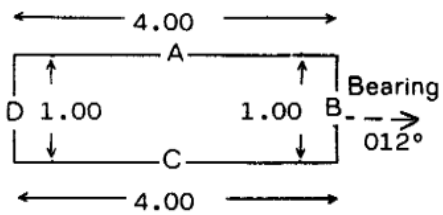
0224, 7891
SJ 07 NW
64

Co-ords 9069E 20822N
Ground Level 8.25 m.A.O.D.
Date 19/2/92

ELEVATIONS:—



PLAN (Not to scale)



SAMPLES

No. & Type	Depth m.
D1	0.50
B2	0.50 - 0.90
D3	0.90
B4	0.90 - 1.80
D5	1.80
B6	1.80 - 2.50
D7	2.70
B8	2.80 - 3.20
D9	3.20
B10	3.20 - 4.20

No.	Depth m.	STRATA DESCRIPTION	Cv kN/m²
1	GL 0.50	Grass over TOPSOIL with gravel and rootlets.	
2	0.50 0.90	Firm, brown very silty sandy CLAY with much fine to coarse gravel of quartz, siltstone and sandstone and occasional cobbles. (Glacial Till)	
3	0.90 4.20	Stiff brown very silty sandy CLAY. ...from 1.80m: mottled grey fissured with grey silt on partings and occasional fine to coarse gravel with occasional cobbles and a little fibrous organic material. (Glacial Till)	1.00 114,120 124 1.90 94 121 128
		Trial Pit complete at 4.20m	

NOTES Cv/Cp: Approximate value of undrained shear strength from hand vane/penetrometer
Groundwater: Minor seepage from gravel at 0.90m
Pumping: None
Supports/Stability: None/Minor fall from gravel at 0.90m

BGS BOREHOLE REFERENCE: SJ07NW68

Easting: 302340
Northing: 379080
Date: 1992
Length: 4.00m

Norwest Holst Soil Engineering Ltd.

Trial Pit No. **18**

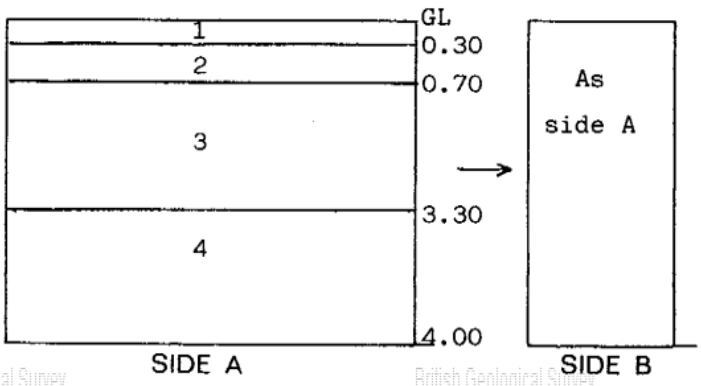
TRIAL PIT LOG

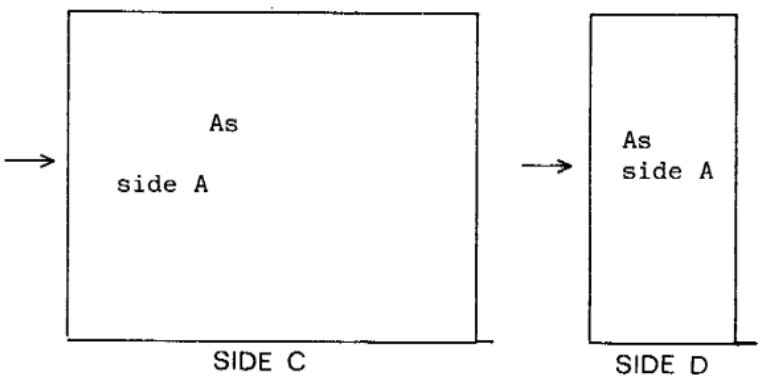
Contract No. F9440
Location A525 Rhuddlan Bypass - Stage II
Client Clwyd County Council
Excavation Plant Ford 655
Dimensions (l x b x h) 3.50 x 1.00 x 4.00m

0234, 7908
SJ 07 NW
68

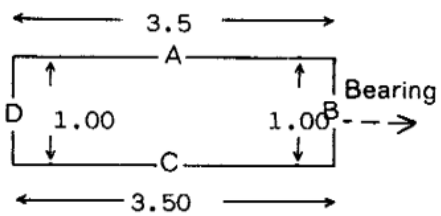
Co-ords 8939E 20977N
Ground Level 7.12 m.A.O.D.
Date 17/2/92

ELEVATIONS:—





PLAN (Not to scale)



SAMPLES

No. & Type	Depth m.
D1	0.20
D2	0.30
B3	0.30 - 0.70
D4	0.70
B5	0.70 - 1.70
D6	1.50
D7	2.00
B8	1.70 - 2.70
D9	3.30
B10	3.30 - 3.80
D11	4.00
B13	3.80 - 4.00

No.	Depth m.	STRATA DESCRIPTION	Cv kN/m²
1	GL 0.30	Grass over TOPSOIL with rootlets and occasional medium gravel of quartz.	
2	0.30 0.70	Firm brown slightly silty very sandy CLAY with a little medium gravel of quartz and occasional rootlets. (Alluvium)	0.40 175,148 108
3	0.70 3.30	Brown clayey SILT with occasional medium gravel sized pockets of dark brown fine sand. (Alluvium) from 1.50m: becoming silty from 2.00m: sand content	
4	3.30 4.00	Firm brown silty slightly sandy CLAY with occasional fine gravel of quartz and siltstone and igneous. at 3.80m: with medium gravel pockets of sand. (Alluvium)	3.30 88,88, 94
		Trial Pit complete at 4.00m	

NOTES Cv/Cp: Approximate value of undrained shear strength from hand vane/penetrometer
Groundwater: Dry
Pumping: None
Supports/Stability: Stable

BGS BOREHOLE REFERENCE: SJ07NW70

Easting: 302480
Northing: 379240
Date: 1992
Length: 4.20m

Norwest Holst Soil Engineering Ltd.

Trial Pit No. 20

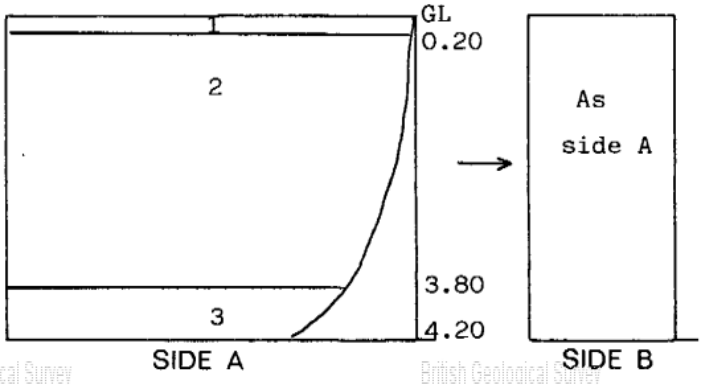
TRIAL PIT LOG

Contract No. F9440
Location A525 Rhuddlan Bypass, Stage II
Client Clwyd County Council
Excavation Plant Ford 655
Dimensions (l x b x h) 5.0 x 1.0 x 4.20m

0248, 7924
SJ07 NW
70

Co-ords 8834E 21160N
Ground Level 9.63 m.A.O.D.
Date 18/2/92

ELEVATIONS:—



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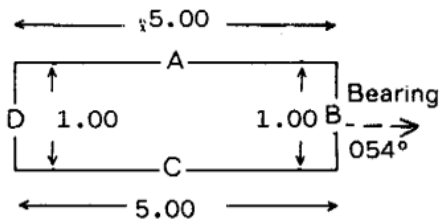


SAMPLES

No. & Type	Depth m.
D1	0.20
B2	0.20 - 1.10
D3	1.10
B4	1.10 - 1.50
D5	1.50
B6	1.50 - 2.00
D7	2.00
B8	2.00 - 3.00
D9	3.80
B10	3.00 - 3.80
B11	3.80 - 4.20

No.	Depth m.	STRATA DESCRIPTION	Cv kN/m²
1	GL 0.20	Grass over sandy TOPSOIL with occasional gravel and rootlets. Gradational Boundary	
2	0.20 3.80	Firm brown silty sandy CLAY with occasional fine to medium gravel of quartz, siltstone and sandstone. ...from 1.10m: becoming reddish brown very sandy ...from 1.50m: losing sand content, locally friable, losing gravel content, becoming very silty. ...from 2.00m: becoming stiff cohesive with occasional black amorphous organic material and occasional cobbles. (Glacial Till)	0.60 74, 74 81
3	3.80 4.20	Soft to firm brown clayey SILT with occasional cobble pockets of sand with occasional shell fragments. (Glacial Till)	3.80 54 40 94
		Trial Pit complete at 4.20m	

NOTES Cv/Cp: Approximate value of undrained shear strength from hand vane/penetrometer
Groundwater: Dry
Pumping: None
Supports/Stability: Stable

BGS BOREHOLE REFERENCE: SJ07NW71

Easting: 302460
Northing: 379320
Date: 1992
Length: 4.00m

Norwest Holst Soil Engineering Ltd.

Trial Pit No. **21**

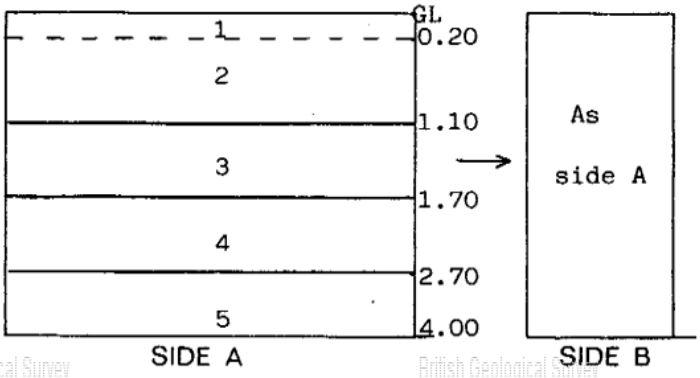
TRIAL PIT LOG

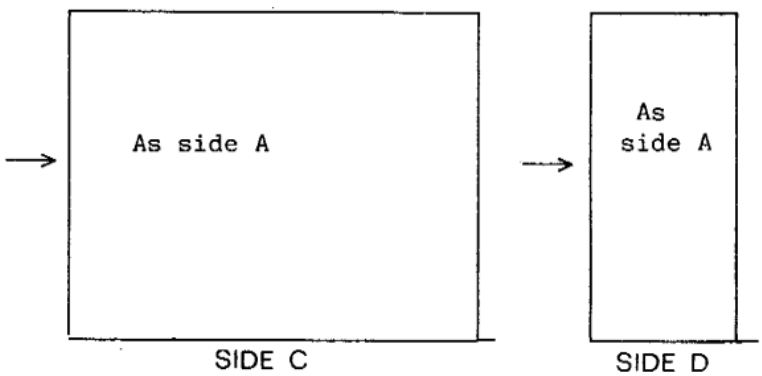
Contract No. F9440
Location A525 Rhuddlan Bypass
Client Clwyd County Council
Excavation Plant Ford 655
Dimensions (l x b x h) 3.50 x 1.00 x 4.00m

0246, 7932
SJ 07 NW
71

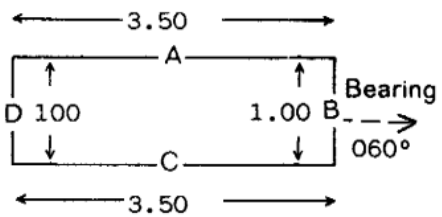
Co-ords 8754E 21167N
Ground Level 7.66 m.A.O.D.
Date 18/2/92

ELEVATIONS:—





PLAN (Not to scale)



SAMPLES

No. & Type	Depth m.
D1	0.20
B2	0.20 - 1.10
D3	1.10
B4	1.10 - 1.70
D5	1.20
D6	1.70
B7	1.70 - 2.70
D8	2.70
B9	2.70 - 2.90
D10	2.90
B11	2.90 - 3.90
D12	3.90
D13	4.00

No.	Depth m.	STRATA DESCRIPTION	Cv kN/m²
1	GL 0.20	Grass over TOPSOIL	
2	0.20 1.10	Soft to firm brown, silty sandy CLAY with occasional fine and medium gravel of quartz and occasional fine and medium gravel of quartz and occasional rootlets. from 0.40m: locally friable, with occasional coarse gravel. (Alluvium)	0.50 60, 67, 60
3	1.10 1.70	Light brown sandy very silty CLAY with occasional fine to medium gravel of quartz. from 1.20m: becoming reddish brown very sandy (Alluvium)	
4	1.70 2.70	Firm reddish brown mottled grey silty, sandy CLAY with occasional cobble sized pockets of coarse sand. (Alluvium)	1.70 162, 121, 121
5	2.70 4.00	Reddish brown very silty fine SAND with occasional black amorphous organic material and gravel of quartz. (Alluvium) at 3.10m: locally coarse sand. Trial Pit complete at 4.00m	

NOTES Cv/Cp: Approximate value of undrained shear strength from hand vane/penetrometer
Groundwater: Seepage from 1.60m and 2.40m
Pumping: None
Supports/Stability: Slight collapse from 2.70 to base

BGS BOREHOLE REFERENCE: SJ07NW74

Easting: 302330
Northing: 379630
Date: 1992
Length: 4.00m

Norwest Holst Soil Engineering Ltd.

Trial Pit No. 24

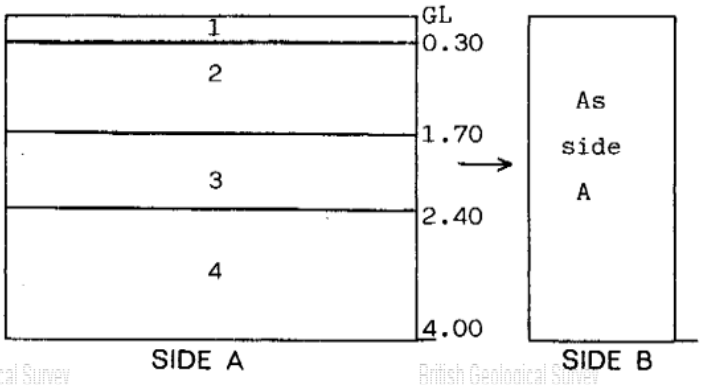
TRIAL PIT LOG

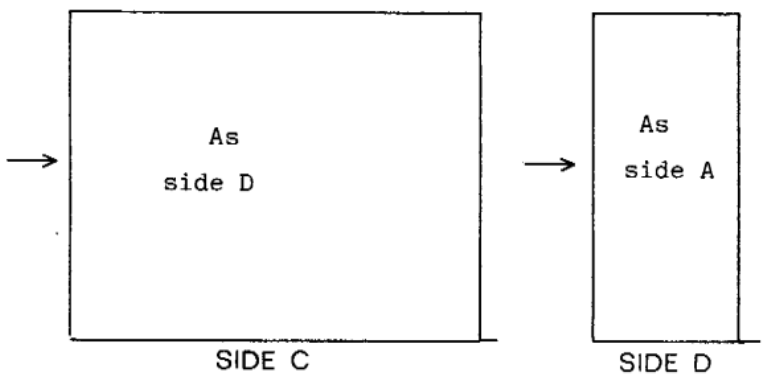
Contract No. F9440
Location A525 Rhuddlan Bypass, Stage II
Client Clwyd County Council
Excavation Plant Ford 655
Dimensions (l x b x h) 4.00 x 1.00 x 4.00m

0233,7963
SJ 07 NW
74

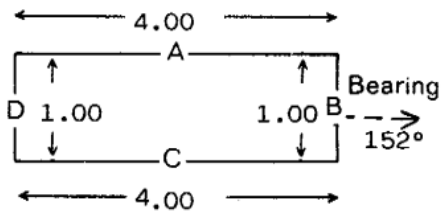
Co-ords 8416E 21142N
Ground Level 6.79 m.A.O.D.
Date 20/2/92

ELEVATIONS:—





PLAN (Not to scale)



SAMPLES

No. & Type	Depth m.
1 D	0.50
2 B	0.50 - 0.80
3 B	1.00 - 1.30
4 D	1.20
5 B	1.70 - 2.00
6 D	2.00
7 D	2.10
8 B	2.50 - 2.80
9 D	2.60
10 B	3.10
11 D	3.60

No.	Depth m.	STRATA DESCRIPTION	Cv kN/m²
1	GL-0.30	Grass over TOPSOIL with rootlets	0.50m 74, 78, 86
2	0.30-1.70	Firm brown friable very(fine) sandy very silty CLAY with pockets of light brown silty fine sand below 0.80m. Occasional rootlets. 0.30-0.80m: very occasional rounded gravel (Glacial Till)	1.00m 83, 92, 96 1.70m 101, 105, 92
3	1.70-2.40	Firm to stiff brown slightly sandy silty CLAY. (Glacial Till) at 2.10m: becoming sandy with pockets of brown fine to coarse sand.	2.50m 148 >188 175
4	2.40 4.00	Stiff brown fissured silty CLAY with blue grey gleying on fissure surfaces with occasional rounded fine to coarse gravel including mudstone, siltstone, quartz. (Glacial Till)	3.00m (3x>188) 4.00m (3 x>188)
		Trial Pit complete at 4.00m	

NOTES Cv/Cp: Approximate value of undrained shear strength from hand vane/penetrometer
Groundwater: Dry; minor seepage at 2.20m
Pumping: -
Supports/Stability: None/stable

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