Garnswllt WWTW

Hydrological Impact Assessment

01/07/2021

300392-DEL-XXX-RP-00002 P01

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Document control

Revision History

Rev	Date	Purpose / Status	Preparer	Checker	Approver	Comments
P01	01/07/2021	First Issue	N Hill	C Holt	P Trafford	None

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1 Introduction

1.1 General

This Hydrological Impact Assessment (HIA) is to report the findings for the assessed impact on water features due to the proposed dewatering temporary works at Garnswllt Waste Water Treatment Works (Garnswllt WWTW). It has been prepared for use by Welsh Water Capital Delivery Alliance with respect to the specific project in question. The HIA key principles and methodology are applied to develop a hydrological concept model to assess the impact of the proposed scheme. The proposed temporary works requires dewatering and temporary lowering of the water table to protect two settlement tanks from ground heave during maintenance works.

Garnswllt WWTW is located on the River Loughor river flood plain. Hydrologically, the site area is bounded by the River Loughor to the west, River Cathan to the north and the Garnswllt Hillside to the east. The River Terrace Deposits and Alluvium are classified as Secondary B Aquifers that according to EA definition are predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.

A site visit as part of this Desk Study was conducted on 16/06/2021

1.2 Limitations

Morgan Sindall Engineering Solutions takes no responsibility over the accuracy or completeness of the third-party published information and third-party ground investigation data used in this desk study report.

2 Sources of information

2.1 Sources of Information

The following sources were consulted to prepare this Report.

- Dŵr Cymru Welsh Water Drawing: Garnswllt WWTW Site Plan - Unnumbered (Appendix A)
- Dŵr Cymru Welsh Water Drawing: Garnswllt WWTW Site Plan and inflows/outflows - Unnumbered (Appendix A)
- Historical OS Maps (1:10,000 and 1:2,500), National Library of Scotland Map Images Database (https://maps.nls.uk/)
- Online borehole information and Geological maps from the British Geological Survey (BGS) (www.bgs.ac.uk)
- Magic maps (https://magic.defra.gov.uk/MagicMap.aspx)
- Google Earth, (earth.google.com/web/)

- Hydrogeological Map of South Wales, http://www.largeimages.bgs.ac.uk/iip/hydromaps.html?id=south-wales.jp2
- Natural Resources Wales Interactive Map Viewer https://maps.cyfoethnaturiolcymru.gov.uk/Html5Viewer210/Index.html?configBase=https://maps.cyfoethnaturiolcymru.gov.uk/Geocortex/Essentials/REST/sites/External_Map_Browser/viewers/EMB_Address/virtualdirectory/Resources/Config/Default&locale=en-gb
- CAMS, The Carmarthen Bay Abstraction Licensing Strategy May 2014, Natural Resources Wales
- BGS Geology of Britain Viewer (http://mapapps.bgs.ac.uk/geologyofbritain/home.html))
- BGS GeoIndex Onshore database (http://mapapps2.bgs.ac.uk/geoindex/home.html).
- Geological Survey of England and Wales 1:63,360/1:50,000 geological map series, New Series, Sheet 229, Carmarthen, Solid
- Geological Survey of England and Wales 1:63,360/1:50,000 geological map series, New Series, Sheet 229, Carmarthen, Drift

2.2 Ground information

- Report 106289 – Factual Report on Ground Investigation at Amman Valley CSO Strategy Ammanford September 2001. Report No 10629
- 300392-DEL-GRN01-CA-00002 C01, Garnswllt De-watering Preliminary Assessment.
- 300392-DEL-XXX-RP-00001 P01.3 Water Features Survey Report

2.3 References and Standards

- Preene, M, Roberts, T O L and Powrie, W (2016) Groundwater control: design and practice, second edition, C750, CIRIA, London, UK
- Preene, M, Roberts, T O L, Rowrie, W and Dyer, M R (2000) Groundwater control: design and practice, C515, CIRIA, London, UK

No other sources of information were consulted during the preparation of this report.

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3 Site location and proposed development

3.1 Site location

The site is located between the banks of Afon LLwchwr / River Loughor and the Llanelly & Llandilo Railway line as depicted in the Dwr Cymru Welsh Water Drawing Garnswllt WWTW. Coordinates of the area to be dewatered are provided in Table 1.

Location information	Western side	Eastern side
Grid Reference	SN 62112 09855 SN 62110 09827	SN 62167 09822 SN 62168 09850
Address (near) :	Lonyfelin, Garage, Lon y Felin, Garnswllt, Ammonford, SA18 2RH	Lonyfelin, Garage, Lon y Felin, Garnswllt, Ammonford, SA18 2RH

Table 1 Location information

3.2 Proposed Works

The following information is summarised from the MSES De-watering Preliminary Assessment

The tanks in question are indicated in Figure 1 below.

Site have requested that the groundwater is to be modelled at ground level (16.764mAOD) and reduced to the top of the base slab for the tank (13.259m). The required drawdown would be 3.505m.

Based on the Ground Information (Report 106289), the De-watering Preliminary Assessment (Report 300392-DEL-GRN01-CA-00002 C01), processes required by CIRIA C750 Groundwater Control, and the ground water levels identified (Figure 2 and Figure 3)

The approximate volume of water to be removed from the ground to achieve the required water level is based on:

- Based on the Ground Information (Report 106289),
- De-watering Preliminary Assessment (Report 300392-DEL-GRN01-CA-00002 C01), processes - CIRIA C750 Groundwater Control,
- Ground water levels identified (Figure 2 and Figure 3)

The preliminary volume of ground water extraction estimated is shown in table 1

Figure 2 shows the locations of the tanks and boreholes

The long section in figure 3 below shows the geology of all three boreholes. Borehole logs have been included in the appendix.

Figure 1. Location of tanks in question

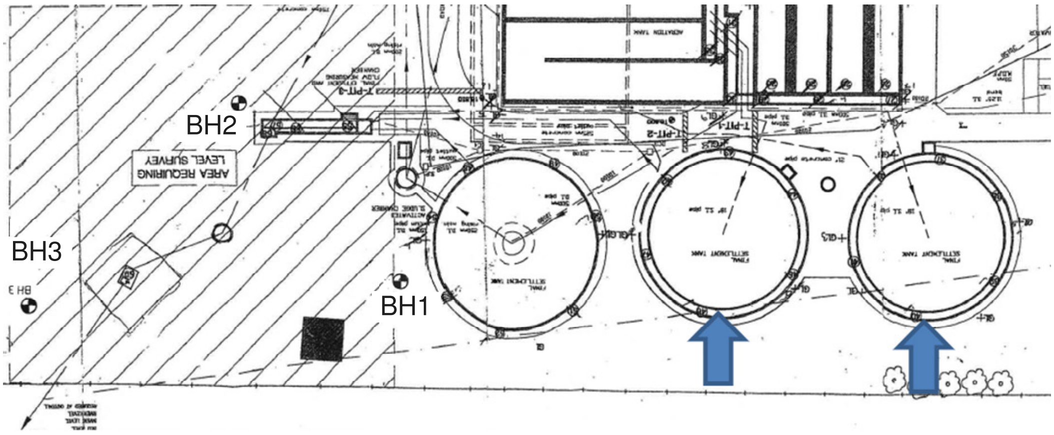

Figure 2. Tank and boreholes

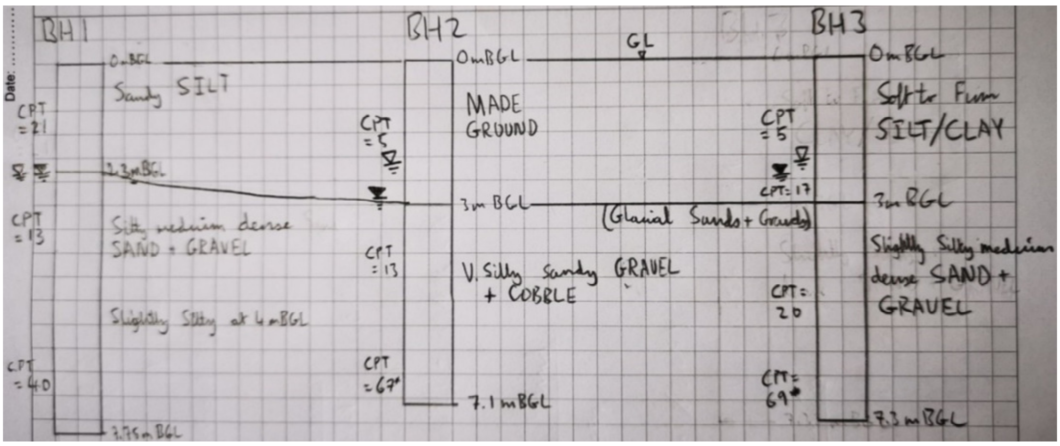

Figure 3. Long Section showing BH1, BH2 and BH3

Assumptions made for the assessment include:

Groundwater level – 16.764mAOD

Drawdown level – 13.259mAOD, estimated depth to the top of the base slab at 3.5m bgl

Target Reduced Ground Water Level – 11.759mAOD, 1.5m below the top of the base slab.

Base of aquifer – 9.014mAOD, As the base of the aquifer is unknown it has been taken as the base of the borehole (7.75mBGL).

Permeability of k = 10^{-5}m/s to 10^{-4}m/s on the basis of soil grading.

Findings from this preliminary assessment are:

- For 3.5m of drawdown of the water table (assuming ground water at surface level), a single stage wellpoint system will be required to be installed around the two FST.
- Estimated discharge calculated to be approximately 2 l/s – 8.5 l/s
- Ground permeability estimated from soil descriptions only
- Wellpoints expected to be installed to approximately 6m depth at 1.5m spacings at a minimum distance of 1.5m from the tanks.

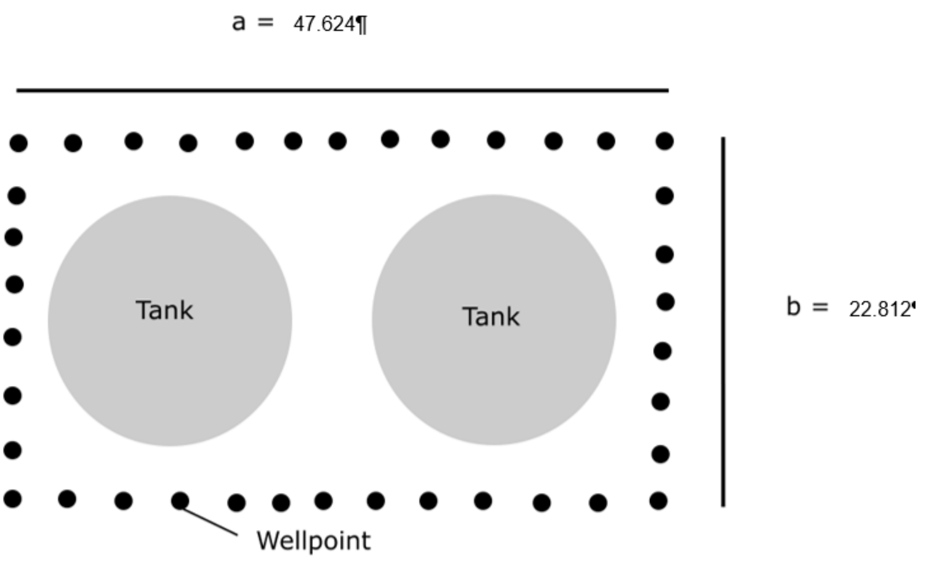

Figure 4. Plan view of excavation showing approximate well arrangement

1.5m spacing's between Wellpoints.

Alternative well point arrangements may be used; however the estimated discharge will not change as that is dependent on the target areas for dewatering and permeability of the ground.

Quantities expected to be abstracted for dewatering purposes are as follows:

Abstraction period (state 'all year' or give months)	T = 2 months
Peak abstraction rate (litres per second)	r_{pk} = 8.5 l/s
Number of hours of abstraction per day tank works	hr_{abs} = 24 hr per day during dry

Maximum hourly abstraction volume (cubic metres) $Vol_{hr} = r_{pk} =$ **30.6** m^3/hr

Maximum daily abstraction volume (cubic metres) $Vol_d = Vol_{hr} \times 24hr/1day =$ **734** m^3/day

Maximum abstraction volume for abstraction period (cubic metres)
$Vol = Vol_d \times (365day/12) \times T =$ **44676** m^3

The above calculated volumes are based on both settlement tanks being emptied simultaneously with drawdown required for the entire area surrounding both tanks. The period of abstraction estimated includes the period to achieve the initial drawdown for tanks to be emptied and the works completed. The volume is based on the assessed maximum permeability from the soil grading and a pump test will be completed prior to commencing works to confirm this assessment and the layout of the dewatering wells.

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4 The Hydrological Impact Assessment

Step 1: Regional water resource status

Garnswllt WWTW lies in the Loughor & Gower CAMS catchments AP6 Area (Table 3a - Water availability for the assessment points of the Loughor & Gower CAMS catchments) from The Carmarthen Bay Abstraction Licensing Strategy May 2014.

AP	Name	Water Resource Availability Colour at Q95	HOF Restriction (Ml/d) and percentile flow (Q)	Number of days per year abstraction may be available	Approximate volume available with restriction (Ml/d)	Is there a gauging station at this AP?	Additional restrictions
6	Amman downstream Pontamman level station	Water available for licensing	MRF 14.5Ml/d	365	1.6	No	See licensing strategy below.

Figure 5. AP6, extract from Table 3a

The dewatering site is located in the AP6, Amman downstream of Pontamman level station area of the Loughor River system. Water resource availability means there is more water than required to meet the needs of the environment. New licences can be considered depending on local and downstream impacts.

There is water available for licensing within these assessment points. This means that:

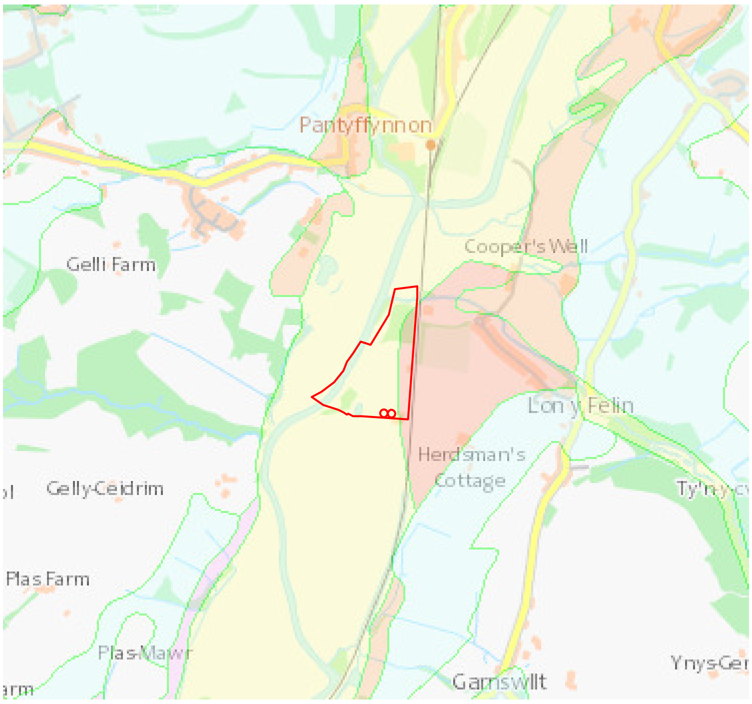
- New licences will be issued, with HOF conditions where appropriate.
- There are SACs within the CAMS area which are water dependent. Therefore, it will need to take into account requirements of the Habitat Regulations, where appropriate, which may mean more stringent restrictions than set out in the CAMS.

Step 2: Conceptual model

The geology of the strata targeted for dewatering comprises made ground of sandy clay and soft to firm silt and clay overlying silty medium dense sand, or silty sandy gravel and cobbles. The Alluvium and River Terrace Deposits are classified as a Secondary A aquifer of permeable layers 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. These are generally aquifers formerly classified as minor aquifers (Natural Resources Wales Interactive Map Viewer). The alluvium comprises cohesive deposits overlying river terrace gravels that may or may not be connected hydraulically with the River Loughor. It is assumed the water level could be near the ground surface with recharge from the River Terrace Deposits and hillside to the East and hydraulic connection from the river to the West.

The superficial glacial till deposits on the lower slopes of the eastern hillside are classified as Secondary Undifferentiated - has been assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.

The bedrock across the local area of the valley floor is overlain by surficial alluvium and river terrace deposits (Figure 6). The local underlying bedrock geology dipping to the southwest comprises the middle and upper coal measures and Llynfi Member sandstones, siltstones and mudstones (Figure 7. The bedrock geology coal measures are classified as Secondary B aquifers of predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers (Natural Resources Wales Interactive Map Viewer) can contain large quantities of ground water and forma multi-layered aquifer system with separate water bodies in each Sandstone horizon. Where disturbed by mining these sandstones can be in hydraulic continuity or dewatered, however the local area is not known for historical coal workings.



Superficial deposits 1:50,000 scale

- GLACIOFLUVIAL DEPOSITS, DEVENSIAN - SAND AND GRAVEL
- TILL, DEVENSIAN - DIAMICTON
- ALLUVIUM - CLAY, SILT, SAND AND GRAVEL
- RIVER TERRACE DEPOSITS (UNDIFFERENTIATED) - SAND AND GRAVEL
- ALLUVIAL FAN DEPOSITS - SAND AND GRAVEL
- PEAT - PEAT

Figure 6. Superficial Geology. Online Geology of Britain Viewer. Open Government Licence, Contains British Geological Survey materials © UKRI [2021]

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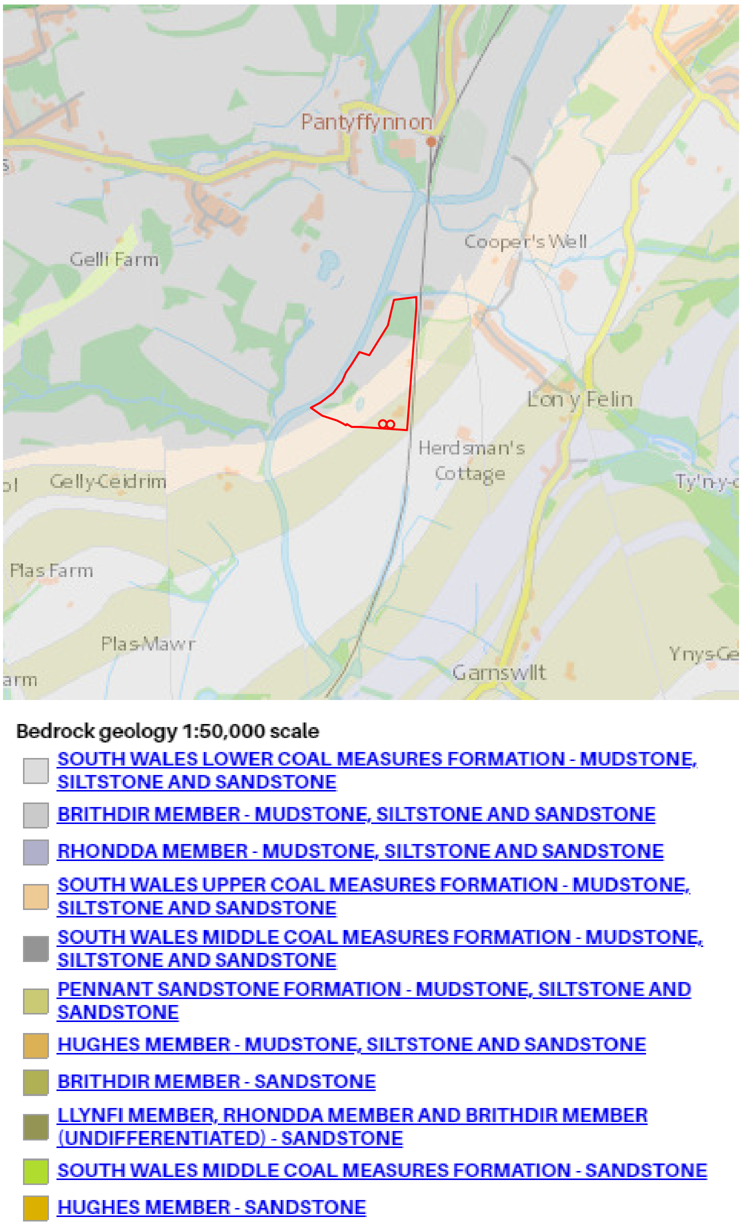

Figure 7, Basement Geology. Online Geology of Britain Viewer. Open Government Licence, Contains British Geological Survey materials © UKRI [2021]

The principle surface drainage in the vicinity is the River Loughor to the west of the site and River Cathan to the north of the site. At its closest point the River Loughor is 177m away from the proposed dewatering.

The conceptual model is based on near west to east section (Figure 8) though the centre of the dewatering zone to best represent the local water features, topography, geology and conceptual water flow (Figure 9).

Figure 8. Location of cross section for conceptual model. (Google earth V 7.3.3.7786 (64-bit). (June 24, 2021). 51° 46' 11.76"N, 3° 59' 56.50"W, Eye alt 1.389km)

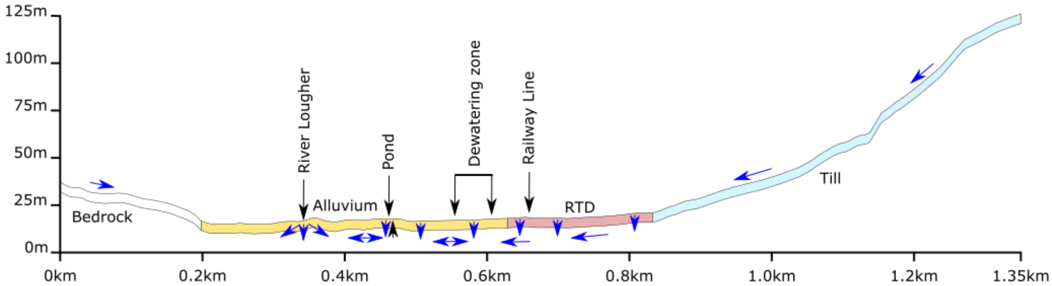

Figure 9. Conceptual Model

Water is to be removed by pumping from a number of well points (the exact number and diameter of wells are to be confirmed depending on site conditions encountered while drilling the wells). Dewatering is expected to be continuous to safely empty the settlement tanks for the duration of remedial works.

The dewatering zone along the section of the conceptual model is about 65m across with a target level of 3.5m below ground level. Ground levels are not recorded by the Ground Investigation, however preliminary assessment of Google Earth levels indicate the ground level at the settlement tanks is about 17m AOD. The lowest ground level of the river terrace deposits and alluvium along the conceptual section is about 15m AOD. Measurements taken during the site visit on 16/06/2021 indicates at the time of the site visit the River Lougher water level was about 4m below the ground level at the settlement tanks. This preliminary assessment indicates the target water level for dewatering is below the current water level in River Loughor.

Discharge from dewatering is to be fully discharged to the sewage treatment works and not discharged back to the local environment.

Step 3: Water features susceptible to flow impacts

From the conceptual model, it is considered that the only water features identified on drawing 300392-DEL-XXX-DR-00001 P01 (Appendix A) that are susceptible to for impacts from dewatering activities at Garnswllt WWTW are

- Pond P12: is ponded on natural/made ground and may be susceptible to dewatering induced ground water drawdown.
- Ponds P22, P23, P24: may also be susceptible depending on the condition of the containment structures but are for considered to be sealed off from hydraulic connection with the ground water for this assessment.
- River Loughor MW01: dewatering will lower the water table in the gravels which may result in a hydraulic gradient between the dewatered gravels and the river. The relative levels and hydraulic connectivity between the gravels targeted by dewatering and the river is not known.
- Potentially River Cathan MW07, located about 360m to the north of the dewatering may be impacted. It is not known how hydraulically connected this river is to the river terrace deposits and alluvium and how extensive hydraulic transmissivity is across the river terrace deposits towards the dewatering site. Inspection of the Natural Resource Wales Flood Risk Viewer indicates water is free flowing across the River Terrace deposits during the 1:100 year floods from River Cathan towards the site, suggesting there is possibly of a subsurface groundwater connection.
- Catchment drainage of runoff from the glacial till on the hillside to the east that drains onto the river terrace deposits and into water course W10 and W11 water courses.
- Ephemeral Pond P25 located downstream will not be impacted as ponding only occurs during periods of high surface water runoff.
- The downstream W12 ephemeral watercourses are also interpreted to not be impacted as these are also generally surface water runoff features, although the relict river channel W12.1 was identified to be filled with water during the site visit on 16/06/2021 and is thought to be sufficiently far enough from the dewatering site and likely hydraulically connected with the River Loughor,

The local area of dewatering is classified as Medium risk for the simplified groundwater vulnerability (Natural Resources Wales Interactive Map Viewer).

All the above water features have a high flood risk except for P12 that has a low flood risk and P22, P23, P24 and W10 that have no flood risk (Figure 10).

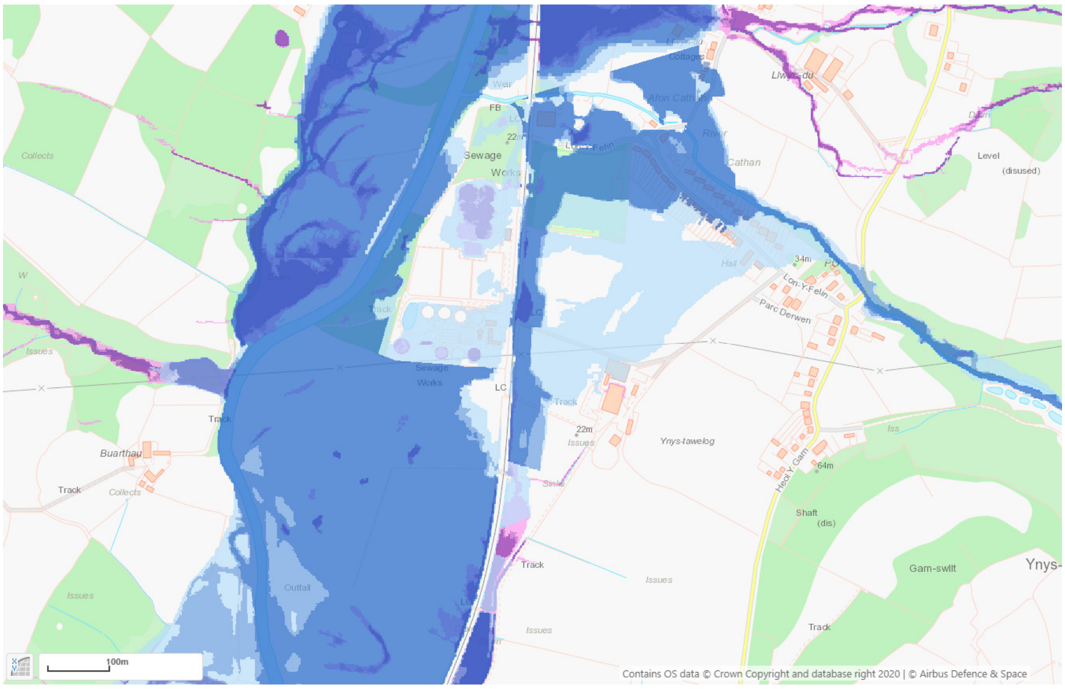

Figure 10. Natural Resources Wales Flood Risk Map, Contains OS data © Crown Copyright and database right 2020 | © Airbus Defence & Space.

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Step 4: Apportion the flow impacts

Based on the conceptual model and application of Principle 1, that the impact of ground water abstraction spreads until it has stopped an equal amount of water leaving the aquifer, the apportioned impact on the water features is estimated in the Table 2.

Table 2. Apportioning of impact to nearest water features

Water feature	Apportioned impact (%)
Pond P12:	5
Ponds P22, P23, P24:	0 as ponds are sealed holding ponds and not hydraulically connected to the ground water.
River Loughor:	45
River Cathan:	25
Hillside catchment and springs:	25
P25	0 as considered dry except when surface water runoff fills this depression
W12.2, W12.2, W12.3, W12.4, 12.5	0 as considered dry except when flooded by River Loughor or temporarily filled by surface water runoff
W12.1	0 as considered recharged by hydraulic connection with River Loughor

Step 5: Mitigation of flow impacts

The water abstracted from well points is proposed be directly discharged into the Garnswllt WWTW system. Therefore, the dewatering will be entirely consumptive and the potential impacts from the abstraction (from the secondary aquifer) will therefore will not be mitigated.

The abstracted water will join the discharge from Garnswllt WWTW that is discharged into Loughor river at approximately NGR Easting 261756 , Northing 209770, refer to the Garnswllt WWTW site drawings in Appendix A.

Step 6: Significance of net flow

Discharge from the dewatering is intended to be directly into the Garnswllt WWTW works with no discharge back to the environment. The water will eventually be returned to the environment via the treated water discharged from the Garnswllt WWTW to River Loughor. Consequently, the dewatering of the ground water will be locally 100% consumptive, but downstream the net flow will be balanced with the return of the ground water flow to River Loughor.

The impact of this dewatering is that if the River terrace deposits are hydraulically connected, then the drawdown from the dewatering will continue to expand for the duration of dewatering unit outflows are balanced by inflows. This may result in some of the base flows for River Loughor and River Cathan being intercepted. The net gain/loss for the river flow may mean contribution to river flow from the local base flow may be reduced, however this will be balanced by discharge from the WWTW back into the river further downstream.

According to the Catchment Abstraction Management Strategy (CAMS) assessment for the Carmarthen Bay, the site falls within the Ground Water Management Unit (GWMU) resource availability classified as Green: where Water is available for licensing (Figure 11). The implication for licensing is “There is more water than required to meet the needs of the environment. New licences can be considered depending on local and downstream impacts“, and “Groundwater unit balance shows groundwater available for licensing. New licences can be considered depending on impacts on other abstractors and on surface water”.

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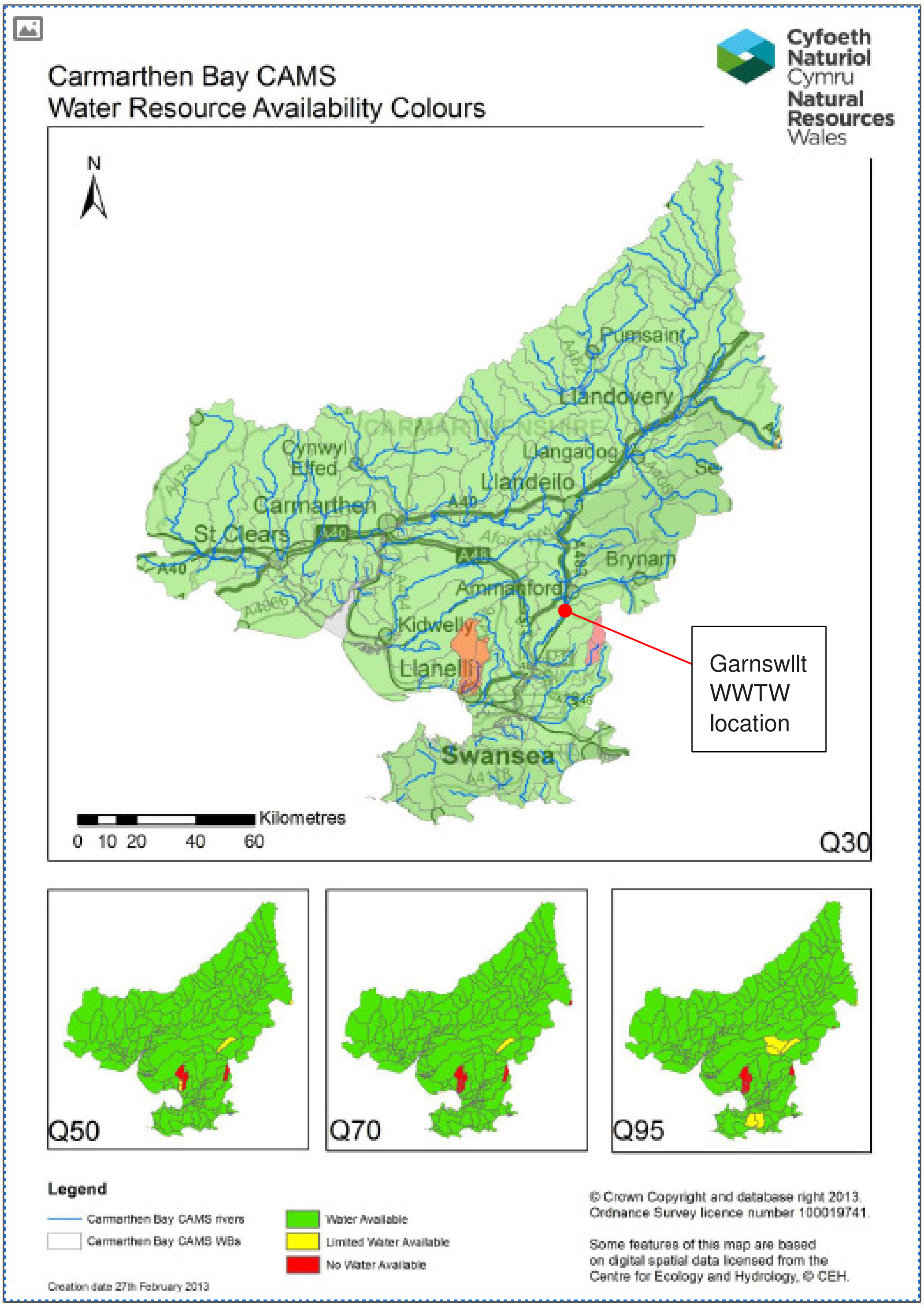


Figure 11. Ground Water Management Unit (GWMU) resource availability

Assessment Point AP6 Amman downstream Pontamman level station water resource availability colour for Q95 (lowest flows) is assessed as Green: Water is available for licensing. This means there is more water than required to meet the needs of the environment. New licences can be considered depending on local and downstream impacts. Consumptive abstraction is available at least 95% of the time.

The licencing strategy for AP6 is as follows.

There is water available for licensing within these assessment points. This means that:

- New licences will be issued, with HOF conditions where appropriate.
- There are SACs within the CAMS area which are water dependent. Therefore, it will need to take into account requirements of the Habitats Regulations, where appropriate, which may mean more stringent restrictions than set out in the CAMS.

The status of both the GWMU and APs is Green: 'Water available', the presumption by the Environment Agency will be to grant the licence subject to local considerations (on which the HIA should therefore concentrate).

For the period of dewatering of up to two months, and due to the nature of the works required, abstraction will be continuous while the settlement tanks are empty. While the abstraction is for a defined period, it can be assumed any rivers hydraulically connected to the strata abstracted will change the river flow at a constant rate. It is assumed that all the abstracted water apportioned to River Loughor in Step 4 will eventually be derived from the river and dewatering drawdown has achieved steady state flow.

Step 7: Search area for drawdown impacts

Various methods are in common use for estimating Ro, such as Sichardt's empirical formula, however the HIA methodology takes a different approach. For this assessment the key HIA principles that need to be considered to define the radius of influence (usually denoted as Ro) of the dewatering are Principle 1, Principle 2 and Principle 4 outlined in Section 2.4 of the guidance notes

- Principle 1: The impact of a ground water abstraction spreads until it has stopped an equal amount of water leaving the aquifer for both confined and unconfined aquifers. The cone of ground water depression spreads, eventually reducing the gradient of the water table until it intersects a waterbody and ground water flow into that waterbody will be reduced. All ground water abstractions eventually have an impact, it is a question of where the impact will appear and how long it will take.
- Principle 2: Impacts can be changes in flow as well as water level where subsurface water flows can be intercepted.
- Principle 4: Impacts are the same upstream and downstream

Based on these key principles the radius of the search area for drawdown impacts is defined by the furthest water feature likely to be deprived of water by the dewatering. From the conceptual model, this is River Cathan that lies about 420m to the north of the abstraction area. River Cathan likely to be in hydraulic connection with the surrounding River Terrace Deposits to form a major ‘recharge boundary’ such that it is considered unlikely that there will be any drawdown impacts beyond the river.

River Loughor lies in the centre of the alluvial deposits in the centre of the valley floor and lies to the west of the area of abstraction. The River Loughor will be the western-most feature that could be impacted. For the purposes of this case study The River Loughor is assumed to be a barrier to groundwater flow within the superficial deposits by forming a major ‘recharge boundary’.

Applying the second and fourth key principles ground water flows in the River Terrace Deposits to the east are likely to be intercepted and the zone of influence is expected to extend the same distance downstream as the upstream influence.

The search area is therefore limited to the area between River Loughor to the west, River Cathan to the north and would follow the course of sand and gravel deposits in the Alluvial and River Terrace Deposits to the east. The southern boundaries are interpreted to extend 420m from the dewatering zone, although the catchment zone is expected to be much less.

Based on this reasoning the radius of influence (denoted as Ro) of the dewatering based on HIA key principles is estimated to be 420m with the area reduced to major recharge boundaries where appropriate.

Step 8: Water features susceptible to drawdown impacts

The natural water features that may be susceptible to drawdown impacts are defined to be limited to the area of the alluvial deposits and River Terrace Deposits as bounded by the River Loughor, River Cathan and the foot of the hillside to the east where River Terrace Deposits are bounded by Glacial Till deposits on the slopes.

The water features survey (300392-DEL-XXX-RP-00001 P01) and site visit has identified the closest groundwater abstraction is located approximately 340m to east the within the search area. This abstraction is also the only known private water supply abstraction that is located near the edge of the zone of influence and comprises a spring on lower slope of Garnswllt Hill. This spring is used by the neighbouring farm at Herdsman’s Cottage, the exact location is unknown, however the spring line is located above the level of the River Terrace Deposits.

Step 9: Predict maximum drawdown impacts

The EA guidance recommends the Tier 1 Thiem and Theim-Dupuit analytical equations be used for assessing lumped long-term average water balances. However, pump test data is not available and will not be undertaken until the well points are installed for dewatering.

In absence of pump test data the so-called Sichardt's formula can be used. This is an empirical formula, $Ro = Cs\sqrt{K}$, where s is the target drawdown in the excavation, R_o and K are as defined above, and C is an empirical calibration factor. If s and K are in m and m/s respectively, to obtain R_o in m, C is usually taken as 3,000 for radial flow (Preene et al 2000). It is recognised that there are limitations and uncertainties in the use of this empirical formula, partly because of the uncertainty surrounding C, but mainly because it is not consistent with the principle of the impact of an abstraction spreading until it has 'captured' sufficient water. The Sichardt’s formula does not distinguish proximity to recharge points or boundaries and would give exactly the same answer whether an abstraction was immediately adjacent to a hydraulically connected river or was remote from any such features. Therefore, to be consistent with HIA methodology, the results from the Sichardt's method will be considered to provide a minimum radius of influence.

The maximum drawdown impacts are the locations identified in Step 7.

The assessment will consider both the use of Sichardt's formula, and the maximum radius of influence according to HIA methodology. The maximum assessed drawdown of water features will be assessed on the basis of the maximum radius of influence according to HIA methodology.

STEADY STATE FLOW AND RADIOUS OF INFLUENCE (SICHARDT FORMULA)

Based on the assumptions and levels outlined for the proposed dewatering works in Section 3.2 Sichardt's formula can be used to estimate R_o

In absence of in-situ permeability tests, permeabilities can be estimated based on soil sample particle size distributions where permeability, $k(C/10^4)$ x $(D_{10})^2$ m/s, In this case the D_{10} and D_{60} values are estimated based on soil particle descriptions.

Ground Material 1

Estimated size of material passing at 10%, D_{10} $D_{10.1} = 0.095$

Estimated size of material passing at 60%, D_{60} $D_{60.1} = 3.5$

Uniformity Coefficient, C $C_1 = D_{60.1}/D_{10.1} =$ **36.842**

Permeability, k $k_1 = (C_1/10^4) \times D_{10.1}^2 \times 1m/s =$ **$3.33*10^{-5}$** m/s

Ground Material 2

Estimated size of material passing at 10%, D_{10} $D_{10.2} = 0.028$

Estimated size of material passing at 60%, D_{60} $D_{60.2} = 2$

Uniformity Coefficient, C $C_2 = D_{60.2}/D_{10.2} =$ **71.429**

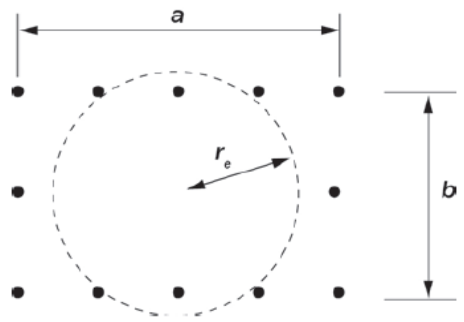
Permeability, k $k_1 = (C_2/10^4) \times D_{10.2}^2 \times 1m/s =$ **$5.60*10^{-6}$** m/s

As permeabilities can vary by an order of magnitude, a permeability of 10^{-5} to 10^{-4} will be used.

Section 6.2 of CIRIA C750 gives equations to calculate the flow rate of the ground (Q).

Unconfined conditions: $$Q = \frac{\pi k\left(H^2 - h_w^2\right)}{\ln\left[R_o/r_e\right]}$$

Inputs for the equation can be found in Figure 12, Figure 13 and Figure 14



b) Rectangular system modelled as equivalent well of radius, r_e

Figure 12. Rectangular system modelled as equivalent well of radius, r_e

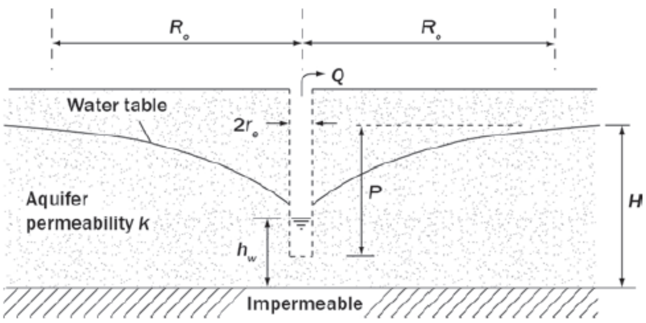


Figure 13. Idealised radial flow to wells

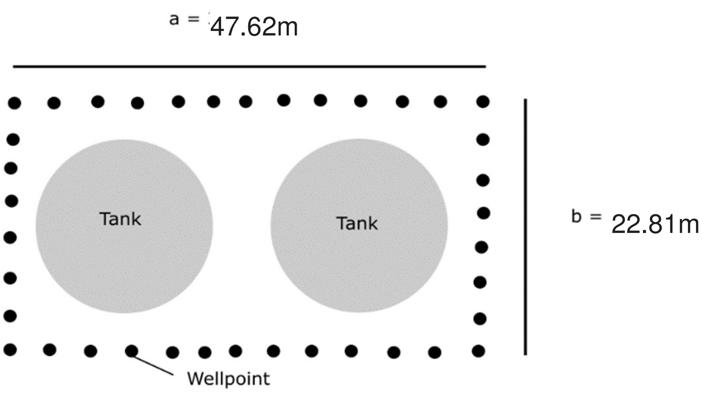


Figure 14. Plan view of excavation showing approximate well arrangement

ID of tank	ID = 19.812m
Space between tanks 5m	d_1 = 5m
Minimum distance of wellpoints from the tanks	d_2 = 1.5m
Dewatering zone length	a = (ID × 2) + d_1 + (d_2 × 2) = **47.62** m
Dewatering zone width	b = ID + (d_2 × 2) = **22.81** m
Wellpoint spacing	d_s = 3m

No. of well points	$N = ((a \times 2) + (b \times 2)) / d_s =$ **47** well points

Derivation for both r_e and R_o taken from CIRIA C750 section 6.2.1 can be found below:-

Equivalent well of radius based on dewatering for both tanks simultaneously.

$\mathbf{r_e} = (a + b) / \pi =$ **22.42** m

Radius of influence where $\mathbf{R_o} = C (H - h_w) \sqrt{(k)}$ (Sechardt formula)

Constant C (CIRIA 750)	$C = 3000 \times (1s/m)^{0.5}$
Base of aquifer (taken as base of the borehole)	$d_w = 7.75$ m
GWL (ground water level mBGL)	GWL = 0m
Depth of aquifer	$H = d_w - GWL =$ **7.75**m
Required drawdown to the top of the base slab for the tank bgl	$d_{bs} = 3.505$m bgl
Required reduced GWL below the base slab	dr = 1.5m
Required reduced GWL	$h_{dr} = d_{bs} + dr =$ **5.005** m bgl
Reduced depth of aquifer	$h_w = H - h_{dr} =$ **2.75** m
Target drawdown	$s = H - h_w =$ **5.01** m

$k_1 = 10^{-5}$ m/s	$k_2 = 10^{-4}$ m/s
$\mathbf{R_{o1}} = C \times s \times \sqrt{(k_1)} =$ **47** m	$\mathbf{R_{o2}} = C \times s \times \sqrt{(k_2)} =$ **150** m

To be consistent with the principle of the impact of an abstraction spreading until it has 'captured' sufficient water, these values will be considered as the minimum values for estimates of R_o.

As groundwater level has been modelled at the surface the conditions have been assessed as unconfined.

Therefore:

Flow Rate

$$\text{Unconfined conditions: } Q = \frac{\pi k \left(H^2 - h_w^2\right)}{\ln\left[R_o / r_e\right]}$$

Q1 $= (\pi \times k_1 \times (H^2 - h_w^2)) / \ln((\mathbf{R_{o1}} / \mathbf{r_e})) =$ **2.199** l/s

Q2 $= (\pi \times k_2 \times (H^2 - h_w^2)) / \ln((\mathbf{R_{o2}} / \mathbf{r_e})) =$ **8.678** l/s

MORGAN SINDALL ENGINEERING SOLUTIONS

HIA MAXIMUM DRAWDOWN ASSESSMENT FOR WATER FEATURES (THEIEM-KUPUIT EQUATION)

According to HIA principle of the impact of an abstraction spreading until it has 'captured' sufficient water, R_o is specified from the conceptual model to represent the maximum distance a water feature may be impacted. Knowing the target drawdown at the edge of the excavation (at r_e) we can calculate Q, then use Q to estimate the drawdowns at other Radii. The Conceptual model required by Natural Resource Wales defines the distance to the River Cathan as the maximum radius of influence.

Conceptual model R_o	R_o = 420m
Equivalent well of radius	r_e = 22.42 m
Depth of aquifer	H = 7.75m
Reduced depth of aquifer	h_w = 2.75 m
$k_1 = 10^{-5}$ m/s	$k_2 = 10^{-4}$ m/s

Q1 = $(\pi \times k_1 \times (H^2 - h_w^2)) / \ln((\mathbf{R_o} / \mathbf{r_e}))$ = **0.563** l/s

Q2 = $(\pi \times k_2 \times (H^2 - h_w^2)) / \ln((\mathbf{R_o} / \mathbf{r_e}))$ = **5.629** l/s

Water feature maximum drawdown based on the Theim-Dupuit equation rearranged to solve for s_i

Water Feature	Distance from centre	Maximum Drawdown
Pond P12	r_i = 83 m	$S_i = H - \sqrt{(H^2 - (2.30 \times Q1 \times \log(R_o/r_i))/(\pi \times k_1))}$ = **2.178** m
Ponds P22, P23, P24	r_i = 82 m	$S_i = H - \sqrt{(H^2 - (2.30 \times Q1 \times \log(R_o/r_i))/(\pi \times k_1))}$ = **2.198** m
River Loughor MW01	r_i = 177 m	$S_i = H - \sqrt{(H^2 - (2.30 \times Q1 \times \log(R_o/r_i))/(\pi \times k_1))}$ = **1.072** m
River Cathan MW07	r_i = 418 m	$S_i = H - \sqrt{(H^2 - (2.30 \times Q1 \times \log(R_o/r_i))/(\pi \times k_1))}$ = **0.006** m
Small drain that terminates in a soakaway W10	r_i = 235 m	$S_i = H - \sqrt{(H^2 - (2.30 \times Q1 \times \log(R_o/r_i))/(\pi \times k_1))}$ = **0.702** m
Drainage ditch W11.4	r_i = 191 m	$S_i = H - \sqrt{(H^2 - (2.30 \times Q1 \times \log(R_o/r_i))/(\pi \times k_1))}$ = **0.971** m
Ephemeral Pond P25	r_i = 82 m	$S_i = H - \sqrt{(H^2 - (2.30 \times Q1 \times \log(R_o/r_i))/(\pi \times k_1))}$ = **2.198** m

Water Feature	Distance from centre	Maximum Drawdown
Ephemeral watercourse W12.2	r_i = 315 m	$S_i = H - \sqrt{(H^2 - (2.30 \times Q1 \times \log(R_o/r_i))/(\pi \times k_1))}$ = **0.340** m
Ephemeral watercourse W12.3	r_i = 275 m	$S_i = H - \sqrt{(H^2 - (2.30 \times Q1 \times \log(R_o/r_i))/(\pi \times k_1))}$ = **0.505** m
Ephemeral watercourse W12.4	r_i = 385 m	$S_i = H - \sqrt{(H^2 - (2.30 \times Q1 \times \log(R_o/r_i))/(\pi \times k_1))}$ = **0.101** m
Ephemeral watercourse W12.5	r_i = 218 m	$S_i = H - \sqrt{(H^2 - (2.30 \times Q1 \times \log(R_o/r_i))/(\pi \times k_1))}$ = **0.798** m
Herdsman's Cottage Spring	r_i = 340 m	$S_i = H - \sqrt{(H^2 - (2.30 \times Q1 \times \log(R_o/r_i))/(\pi \times k_1))}$ = **0.248** m

The Thiem-Dupuit equation is for steady-state conditions only and as such represents the worst case scenario, because it give the drawdown if abstraction continues until steady state conditions are reached.

Additionally the Thiem-Dupuit formula does not account for a delayed watertable effect and ignores the existance of a seapage face at the well and initially steep hydrological gradients near the well. An approximate steady state flow condition in an unconfined aquirfer will ony be reached after long pumping times. At a point where the flow in the aquifer is essentially horizontal again.

It is unlikely worst case steady state conditions will be reached due to the limited duration of dewatering proposed.

Step 10: Mitigation of drawdown impacts

It is proposed that there will be no mitigation of the groundwater drawdown impacts as the CAMS indicate there is sufficient groundwater to recover from any short-term effects from the dewatering.

All extracted water will be discharged through the Garnswllt WWTW with an upper limit on the flow rate before discharge to River Loughor. All ground water flows extracted are expected to be returned to the downstream flow of River Loughor, offsetting the impact of the ground water drawdown.

Step 11: Significance of drawdown impacts

4.1 Derogation of existing abstractors, (affecting other water users)

Other water users are expected to not be affected. The only water user in the vicinity of the Garnswllt WWTW is the local farmer. The farmer has informed the site visit that their water supply comes from a spring source above the river terrace deposits, and therefore will most likely not be impacted by the dewatering works. The drawdown impact prediction indicates even if drawdown did occur the effect would be inconsequential.

4.2 Environmental impacts on water bodies and wetlands

It is expected the drawdown on the water table for the short periods of dewatering proposed will have little impact on the surrounding water features. The Trees surrounding the site are mature and expected to be able to tolerate a short period of water table reduction.

The pond water level is much higher than expected and likely to be contained within the near surface fine grained alluvium and may not be significantly hydrologically connected to the underlying river terrace deposits.

4.3 Subsidence/desiccation

There may be some risk of limited subsidence due to the 2m to 3m of soft cohesive made ground and Soft clay/silt Alluvial Deposits overlying river gravels and sands across the Garnswllt WWTW Site. The period of ground water lowering is also expected to be only for a short period that will mean the cohesive deposits will have little time to consolidate before ground water levels recover. While the settlement risk from the underlying river gravels is considered low, there may be a risk of fines washing out from localised sand deposits that could result in localised settlement.

There are no third-party assets that are likely to be affected if settlement does take place.

The short period expected for ground water lowering will also minimise potential for any desiccation of the superficial cohesive alluvial deposits.

Step 12: Water quality impacts

Water quality impacts are largely mitigated by discharge of all extracted water through the Garnswllt WWTW. Extraction of any poor-quality water or sediment-laden water will not be discharged directly into surface watercourses.

Potential threats to water quality that have been identified at nearby sites (Table 3) that may include point sources for accidental spills of fuels, oils, solvents etc:

- PS01: The final potential source of pollution is a commercial property located to the north where a cement works is present and there is potential for ground contamination at this site.

- PS02: The closest source of pollution is the Railway line ballast that is likely to be contaminated. It is likely there exists a pollution pathway from the railway line ballast into the Garnswllt Site area.
- PS03: The next closest potential source of pollution is the Farm Buildings to the east, with possible oil and fuel spills. Any pollution that may be present is unknown. If present, there would likely be an existing plum pathway towards the dewatering site due to natural ground water gradients.

Table 3. Potential pollution plume sources

Water Feature Ref	Name / Description	Category	NGR Easting	NGR Northing	Distance from source
PS01	Potential ground contamination from an aggregate cement works.	Constructed Feature	262282	210240	406
PS02	Potential ground contamination from railway.	Constructed Feature	262215	209838	49
PS03	Potential ground contamination from headsman's Cottage buildings area.	Constructed Feature	262395	209784	231

Step 13: Redesign mitigation measures

There is no identifiable risk/impact to the local ground water environment and there are no protected areas nearby downstream. There will be no discharge of potentially poor water quality to the environment, the distances between the dewatering source and water features is generally large with potential for significant recharge through the base flows of River Cathan and River Loughor.

Step 14: Monitoring and reporting plan

A schedule of monitoring for groundwater and surface water, along with trigger and action levels for any mitigation, will have to be agreed with the Environment Agency and Natural Resource Wales. As this is not an urban built up site it should be possible to make sure in advance that infrastructure is in place to enable water balances to be calculated. In particular, the following quantities should be measured as accurately as practicable: abstraction from the dewatering sumps consumptive discharges into the Garnswllt WWTW water level in the onsite pond.

After Tier 1

The case study has assumed the cumulative effects for dewatering requirements of both settlement tanks emptied simultaneously. Simultaneous dewatering will require the maximum envisaged dewatering to achieve the required drawdown. In reality, the Garnswllt WWTW only has enough spare capacity for one tank at a time at a time to be emptied. Therefore only 50% of the areas of dewatering will be engaged at any one time.

The River Cathan and River Loughor are sufficiently large enough to ensure there is no ground water connection to water feature to the west and north of these rivers and confine the search area

There are no wells or abstractions within the search area, therefore not mitigations are required to minimise the consumptive impact of the dewatering.

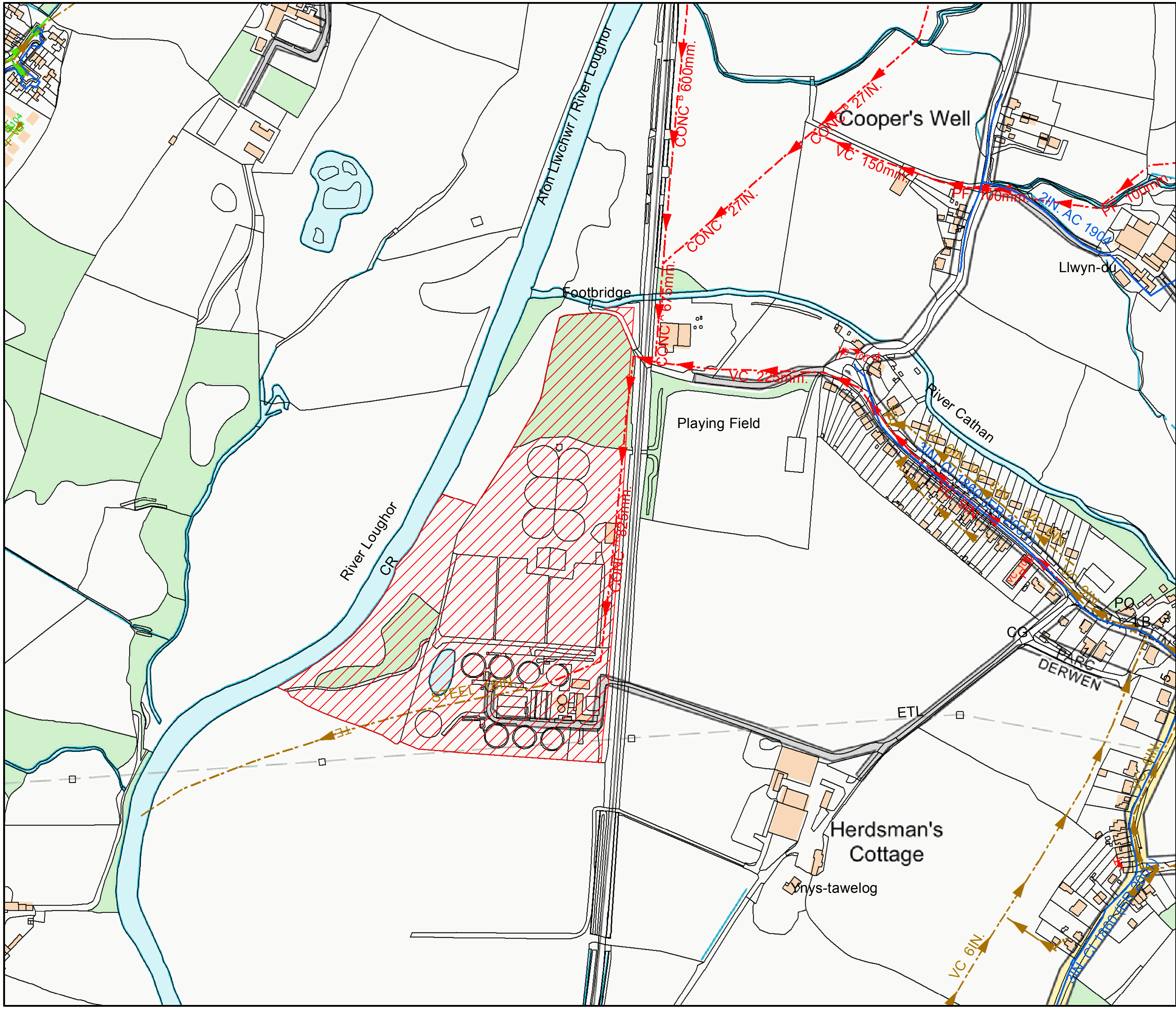
There are no nearby SSSIs or SACs that required mitigation measures

The hydroecology of the River Loughor, or River Cathan are not expected to be impacted.

Reducing the uncertainty

MSES believes there is sufficient confidence in the conceptual model developed to account for the potential impact on the surrounding water features, particularly in light of the low number of water features that may be impacted and there not being SSSIs and SACs nearby to be affected.

Appendix A Drawings



Dŵr Cymru
Welsh Water

Garnswllt WWTW

N
W E
S

LEGEND

- Sluice Valve
- Air Valve SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- Bulk Meter
- Fire Hydrant
- Cap
- Non Dwr Cymru
- Existing Distribution Main
- Gravity Sewer
- Rising Main
- Outfall
- Pumping Station
- Lamphole
- Combined Sewer Overflow
- Special Purpose Chamber
- Treatment Works
- Private Sewer Transfer
- Lateral Drain
- Inspection Chamber

NB:
Sewer symbol colour indicates the sewer type.

RED - Combined
GREEN - Surface Water
BROWN - Foul

Notes:

--- Type notes here ---
--- Remembering to manually add line breaks ---

Whilst every reasonable effort has been taken to correctly record the pipe material of DCWW assets, there is a possibility that in some cases pipe material (other than Asbestos Cement or Pitch Fibre) may be found to be asbestos cement (AC) or Pitch Fibre (PF) . It is therefore advisable that the possible presence of AC or PF pipes be anticipated and considered as part of any risk assessment prior to excavation

Dŵr Cymru Cyfyngedig ('the Company') gives this information as to the position of its underground apparatus by way of general guidance only and on the strict understanding that it is based on the best information available and no warranty as to its correctness is relied upon in the event of excavations or other works made in the vicinity of the company's apparatus. The onus of locating apparatus before carrying out any excavations rests entirely on you. The information which is supplied by the Company, is done so in accordance with statutory requirements of sections 198 and 199 of the Water Industry Act 1991 which is based upon the best Information available and, in particular, but without prejudice to the generality of the foregoing, it should be noted that the records that are available to the Company may not disclose the existence of a water main, service pipe, sewer, lateral drain or disposal main and any associated apparatus laid before 1 September 1989, or, if they do, the particulars thereof including their position underground may not be accurate. It must be understood that the furnishing of this information is entirely without prejudice to the provision of the New Roads and Street Works Act 1991 and the Company's right to be compensated for any damage to its apparatus.

Service pipes are not generally shown but their presence should be anticipated.

EXACT LOCATIONS OF ALL APPARATUS TO BE DETERMINED ON SITE.

Map Ref:	262,192, 210,068
Map scale:	1:5,000
Printed by:	sgrey
Printed on:	18/03/2021

Dŵr Cymru
Welsh Water

Garnswllt WWTW

N
W E
S

LEGEND

- Sluice Valve
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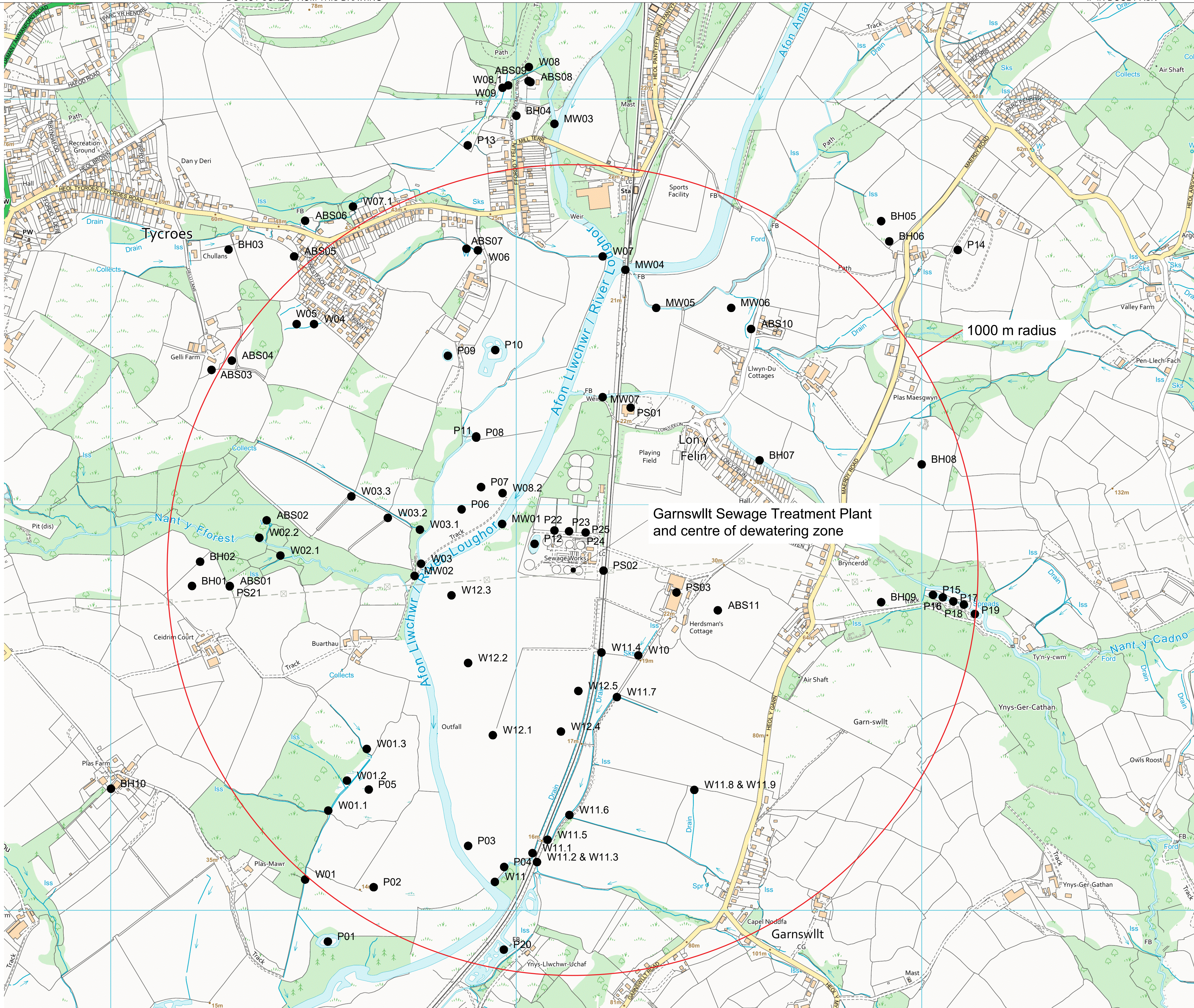
DO NOT SCALE FROM THIS DRAWING

IF IN DOUBT ASK



Notes

1. Drawing has been prepared as supplementary information for the Water Features Survey required for the Garnswllt Dewatering Application
2. Map scale is 1:10,000
3. Search area for the water features survey is 1000 m radius from the dewatering zone
4. Drawing to be read in conjunction with Report No. 300392-DEL-XXX-RP-00001
5. Centre of dewatering zone;
   - Grid Reference: SB62139 09839
   - Grid Reference (6 figure): SN621098
   - X (Easting): 262139
   - Y (Northing): 209839

Revision	Description	Designed	Drawn	Checked	Approved	Date
P01	First Issue	NH	SMM	CH	PT	02/07/2021

Client

Originator

MORGAN SINDALL ENGINEERING SOLUTIONS

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Drawing Title: Water Features Survey

Project: Garnswllt

Drawing Number: 300392-DEL-XXX-DR-00001

Revision: P01

Scale: N.T.S

Original Size: A3

Drawing Status: Preliminary