Garnswllt WwTW:

Dewatering Design Note

Contract Name:	Garnswllt WwTW
Client Name:	Mott MacDonald Bentley
Groundwater & Dewatering Specialist:	Stuart Wells Ltd (SWL)
Report No:	23-112-01-DN-01
Location:	Garnswllt, Ammanford

Revision	Date	Description	Prepared By (SWL)	Checked By (SWL)
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Stuart Wells Limited

Contents

1. Introduction

Stuart Wells Limited (SWL), as instructed by Mott MacDonald Bentley Limited (MMB), has developed a conceptual groundwater control scheme for the proposed works at Garnswllt WwTW (Wastewater Treatment Works), Garnswllt, Ammanford, Wales, SA18 2RH.

The purpose of this Dewatering Design Note is to outline the dewatering strategy proposed to be adopted onsite to control and lower the groundwater level in the target aquifer. The strategy is based on documents and information provided by MMB, which are listed in Appendix A. No site visit was carried out as part of this study.

Following the introduction, this design note is structured as follows:

- Section 2: A brief summary of the project; Garnswllt WwTW.
- Section 3: Geotechnical Conceptual Model.
- Section 4: Dewatering Design.
- Section 5: Development of conceptual Groundwater Control Scheme.
- Section 6: Environmental Considerations.
- Section 7: Recommendations.
- Section 8: References.

2. Project Details

The project involves a number of construction works; the first area that requires dewatering is around two existing structures, Final Settlement Tank 1 (FST 1) and Final Settlement Tank 2 (FST2), Area 1a and Area 1b, respectively. The second area that requires dewatering is understood to consist of the draining of an existing pond prior to the construction of a Feed Pumping Station (FPS) and Primary Settlement Tank (PST) (Area 2). It is assumed that the excavation works are enclosed by a sheet piled cofferdam. The approximate location of the site is shown in an aerial photograph, Figure 1, and schematic layout, Figure 2.

A summary of the details of each structure and the corresponding dewatering area is presented Table 1.

Table 1: Summary of Structures and Dewatering Areas

Structure	Ground Level	Excavation Depth		Details	Dewatering Area	
	(mAOD)	(mBGL)	(mAOD)		Designation	Plan Dimensions
FST 1	16.6	5.3	11.3	~ 16.5 dia.	1a	20 x 20 m
FST 2	16.6	5.3	11.3	~ 16.5 m dia.	1b	20 x 20 m
PST	16.6	7.0	9.6	~ 24.4 m dia.	2	40 x 30 m
FPS	16.6	8.0	8.6	~ 8.5 m dia.		

Figure 1: The location of the Garnswllt WwTW site (red outline).

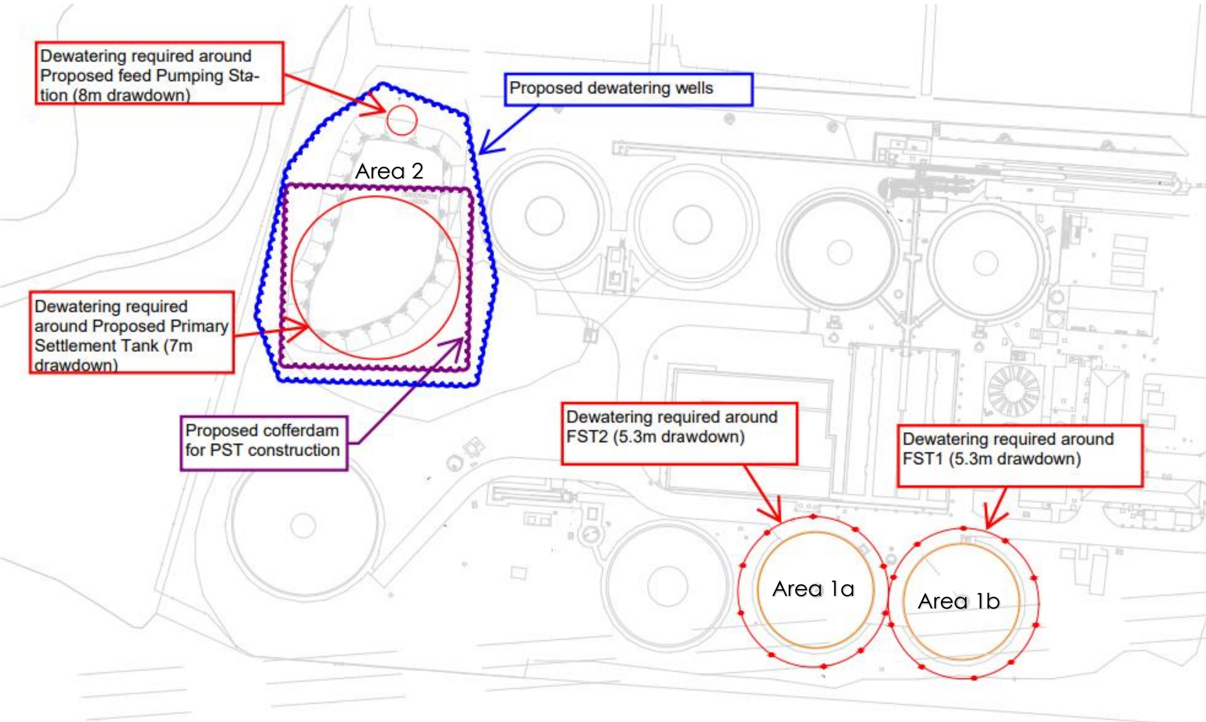

Figure 2: The location of the dewatering works at Garnswllt WwTW (taken from MMB drawing (MMB, 2023a)).

3. Geotechnical Conceptual Model

3.1. Geotechnical Conceptual Model

A Ground Investigation Factual Report (QGL, 2023), has been provided. The reported geology underlying the site is believed to consist of Made Ground overlying Superficial Deposits of Alluvium, Glacial Sand and Gravel, and Glacial Till, underlain by bedrock of the South Wales Upper Coal Measures.

Several cable percussive and rotary boreholes were drilled across the site. The following table (Table 2) summarises the ground conditions reported, and therefore anticipated to be encountered during works and associated dewatering.

Table 2: Summary of Ground Conditions

Geotechnical Unit	Depth to base		Description
	(mBGL)	(mAOD)	
Made Ground	0.35 to 6.00	10.57 to 16.66	Generally consisting of slightly clayey sandy gravel with subordinate clay strata.*1 *2
Alluvium/ Glacial Sand and Gravel/ Glacial Till	>25 m*3	> -8.39*3	Generally granular strata consisting of clayey gravelly SAND, slightly silty slightly sandy GRAVEL or slightly silty or clayey sandy GRAVEL with a low to medium cobble content. Subordinate sandy slightly gravelly CLAY and sandy SILT strata noted.

Notes:

(1) BH02: Sandstone boulder encountered at 1.0 m bgl (15.6 mAOD).
(2) BH-SD-02: Possible hydrocarbon contamination at 5.6 to 6.0 m bgl (10.6 to 11.0 mAOD).
(3) Base not proven, encountered to 25.0 m bgl (-8.39 mAOD) at BH-SD-01.

Peak groundwater levels monitored in the boreholes (BH-SD-01 through to BH-SD-04) range between 1.54 to 4.03 m bgl (14.86 to 15.07 mAOD).

The Ground Investigation (QGL, 2023) undertook a number of Variable Head Tests (VHTs) within the aforementioned boreholes with limited success. In addition, Particle Size Distribution (PSD) Tests were completed at varying depths across the site. Empirical methods are available to give an approximate estimate of the soils' permeability based on the PSD curve (CIRIA, C750). We have utilised the Hazen's formula, which relates permeability (k) in m/s to the D_{10} particle size in mm.

$$k = C(D_{10})^2$$

where C is a calibration factor, 0.01.

A summary of the permeability values is included in Table 3. In addition, the inferred permeability values derived from PSD tests have been plotted against elevation, and are presented in Chart 1.

Table 3: Summary of permeability values for Target Aquifer (Superficial Deposits).

Type of Test	Number of tests completed	Inferred Permeability Value (m/s)
Variable Head Tests	3	7.27E-05 to 9.20E-05
Particle Size Distribution	13	2.25E+00 to 3.60E-07

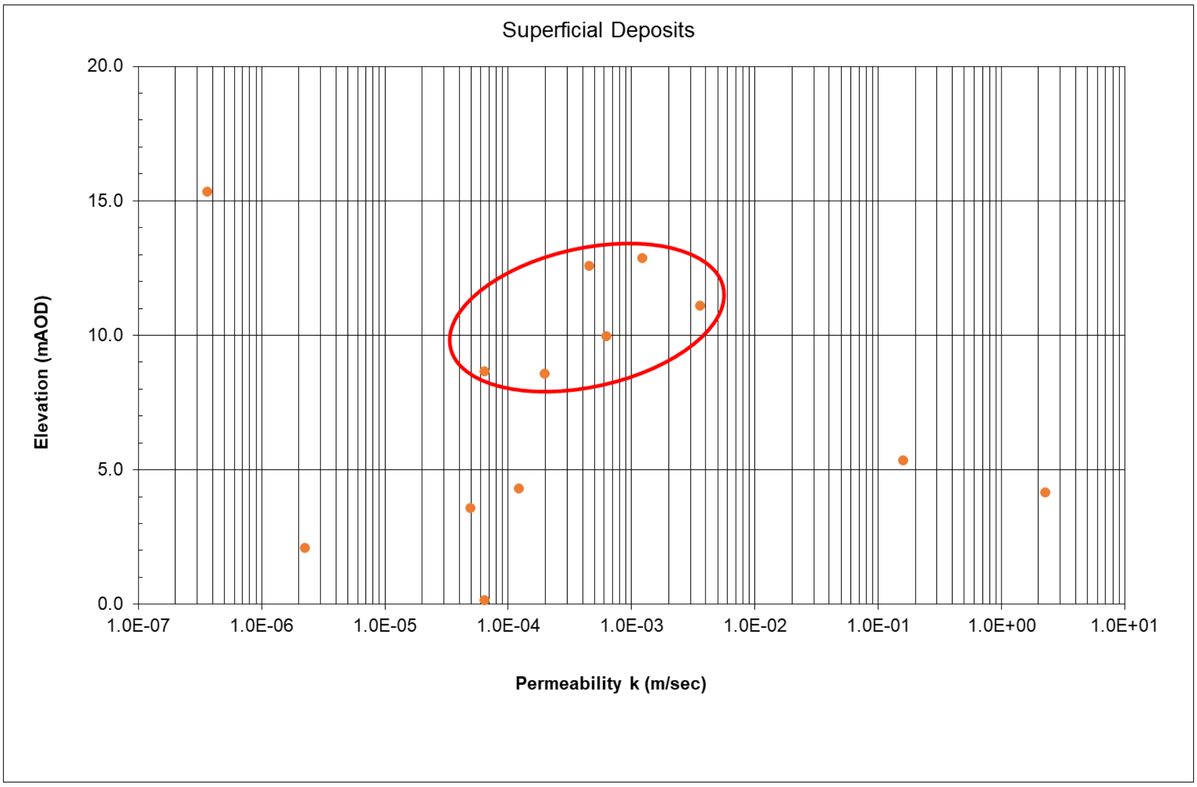

Chart 1: Inferred permeability values derived from PSD test results. The red circle encapsulates those results that are deemed suitable for the use of dewatering design. In that, they are located at suitable depths and are within the granular soils where groundwater would be abstracted by the dewatering wells.

4. Dewatering Design

During the works, there is a requirement to control and lower groundwater within the target aquifer, granular Superficial Deposits. A cofferdam is proposed to surround the Feed Pumping Station and Primary Settlement Tank. Although, the details of the sheet piled walls are to be finalised, we have assumed that, whilst they would restrict horizontal groundwater flow, they would not provide a cut-off to vertical groundwater flow, and as a result would not act as a groundwater cut-off.

The structure details, geotechnical conceptual model, and aquifer properties are inputted into our engineering calculations for dewatering design. The engineering calculations estimate the likely abstraction flows required by each dewatering system to achieve satisfactory drawdown (groundwater lowering) during construction works. Our engineering calculations are derived from accepted industry best-practices for groundwater control (CIRIA Report C750 (2016)).

A summary of our dewatering engineering calculations is presented in Table 4.

5. Groundwater Control Strategy

The conceptual groundwater control scheme developed in this report utilises the information presented in Section 3 and dewatering design basis, Section 4, accepted industry best-practices for groundwater control (CIRIA Report C750 (2016), and Cashman and Preene (2021)), as well as extensive experience of similar projects.

The proposed groundwater control strategy comprises the following elements:

I. Surface water control measures.
II. Shallow seepage control from Made Ground and cohesive Superficial Deposits.
III. Main works dewatering. An array of dewatering wells around the perimeter of the excavation works, dewatering Areas; Area 1a, Area 1b and Area 2, to lower and control groundwater within the Target Aquifer (Superficial Deposits).

5.1. Surface Water Control

A system may be required to control and remove surface water. Precipitation falling directly onto the site may inadvertently soak into the ground, especially for such a large site. It is considered that conventional sump pumping techniques would be appropriate, most likely with the aid of collection ditches and/or French drains that would direct surface water to sumps, from where water can be pumped away.

It is likely that surface water discharged from sump pumps would be laden with suspended solids. It is good practice to pass the discharge water through a settlement tank(s) to allow the situation to be monitored and remove those solids that settle in the tank.

Table 4: Summary of Engineering Dewatering Design Calculations

Item	Units	Final Settlement Tanks Area 1a and Area 1b*1	Feed Pumping Station and Primary Settlement Tank Area 2	Notes
Plan length, a	m	20.0	40.0	
Plan width, b	m	20.0	30.0	
Perimeter	m	80.0	140.0	
Working Platform level	mOD	16.60	16.60	
Groundwater level	mOD	15.07	15.07	Peak GWL at BH-SD-01
Formation level	mOD	11.30	8.60 to 9.60	
Target drawdown level	mOD	10.80	8.10	0.5 m below formation level.
Base of aquifer	mOD	-8.39	-8.39	As proven to at BH-SD-01
Aquifer				
Permeability, k	m/s	1.0E-03 to 5.0E-05	1.0E-03 to 5.0E-05	As inferred from relevant onsite and laboratory testing.
Equation parameters				
r = (a + b) / pi	m	12.73	22.28	
Depth of aquifer, H	m	23.46	23.46	
Residual depth, h	m	19.19	16.49	
Drawdown, H - h	m	4.27	6.97	
Distance of influence				
R_0 = 3,000 (H -h) rt k	m	90.58 to 905.80	147.86 to 1,478.56	
R_0 = re 3,000 (H -h) rt k	m	103.31 to 918.54	170.14 to 1,500.84	
Chosen R_0 value	m	103.31 to 918.54	170.14 to 1,500.84	
Estimated Calculated Flow	l/s	5.19 to 62.28	10.33 to 122.65	Using Radial Unconfined calculation: Q = pi k ($H^2 – h^2$)/ ln R/r, and Partial Penetration factor applied.
	m^3/hour	18.69 to 224.20	37.18 to 441.55	
	m^3/day	448.61 to 5,380.92	892.32 to 10,597.08	

Notes:

(1) Engineering calculations presented are for one dewatering area only.

5.2. Shallow Seepage Control

Similar, to surface water control, as the excavation proceeds through shallow Made Ground and cohesive Superficial Deposits, local perched water and pockets of groundwater may be encountered, and seep into excavations. It is envisaged that conventional sump pumping techniques would be appropriate, most likely with the aid of collection ditches, and/or French drains that would direct surface water to sumps, from where water can be pumped away.

Similar to sump pumping of surface water, the water discharged from sump pumps would be laden with suspended solids. It is good practice to pass the discharge water through a settlement tank to allow the situation to be monitored and remove those solids that settle in the tank.

5.3. Main Works Dewatering

The primary groundwater control requirement at the site is to lower groundwater levels in the Superficial Deposits (granular soils) during construction works associated with two FSTs, one PST and one FPS at Garnswllt WwTW. The anticipated abstraction flows required for each structure are presented in Table 4. From which we have developed indicative dewatering systems to be installed and operated in each dewatering area, and are summarised in Table 5.

Table 5: Summary of dewatering systems.

Area	Drawdown required (m)	System flow required (l/s)	Individual Well Yield (l/)	No. of pumped wells	System flow capacity (l/s)
Area 1a	4.27	5.19 to 62.28	1.0 to 10.0	10 no.	10.0 to 100.0
Area 1b	4.27	5.19 to 62.28	1.0 to 10.0	10 no.	10.0 to 100.0
Area 2	6.97	10.33 to 122.65	1.1 to 11.0	14 no.	15.4 to 154.0

Each dewatering system would comprise an array of deepwells installed around the perimeter of each structure. A schematic layout of the proposed dewatering systems is shown in Figure 3, and a schematic cross section provided in Figure 4.

The design for the deep well and pumping systems is as follows:

i. Wells to be drilled with rotary drilling methods (water-flush) at 300 mm diameter bore. Assuming installation of deep wells from the existing ground level,16.6 mAOD, they would extend to a toe depth up to 12 m (Areas 1a and 1b) and 15 m (Area 2) below ground level, 4.6 and 1.6 mAOD, respectively.
ii. Installation of 200 mm well screen and casing, with graded filter pack.
iii. Each well to be developed via conventional air-lifting techniques. The purpose of well development is to remove finer soil particles/drilling debris from the well liner and filter pack, and as a result increase well yield. An airlift shoe will be attached to an airline and flexible discharge riser pipe and in turn placed to the base of the well. The airline will be coupled to a compressor. The well will then be pumped by airlift for a minimum period of 1 hour or until the discharge water is free of drilling mud and/or fines. Initial development will only cease when fines removal is negligible.

iv. Each well will be equipped with an electric submersible pump, installed on riser pipe, with a control valve and headworks. A dip tube will also be installed to facilitate manual monitoring of water levels in the well using a dip meter.

v. Each electric submersible pump would be rated to pump up to 11 l/s. The borehole pumps would be provided with a suitable electrical supply and distribution system. Power is a critical component to ensure that each dewatering system operates on a continuous basis. To ensure a continuous power supply to each dewatering system, we propose to utilise 1 no. 150 KVA duty generator with back-up of power supply to be provided using a diesel driven standby generator, with an automatic mains failure (AMF) system, which will automatically restart pumps should there be an interruption of the main power supply. It would be fitted with a bunded fuel tank (3,000 l), which would ensure that the dewatering system can run for a period of up to five days in the event of a mains power failure.

vi. Each borehole pump would be connected to a common header main via flexible connection pipes. The common headermains will transfer abstracted groundwater to the discharge location, yet to be confirmed, via multiple discharge pipelines, each between 150 to 200 mm diameter.

vii. At the interface level between granular deposits and cohesive deposits, overbleed may be encountered. Residual 'overbleed' water will be required to be controlled with conventional sump pumps.

6. Environmental Considerations

As is shown in Tables 4 and 5, the dewatering systems will involve the pumping of potentially large amounts of groundwater. All dewatering activities must be undertaken within any local environmental constraints, and in accordance with Abstraction Licence and Discharge Consent, as issued by Natural Resources Wales (NRW).

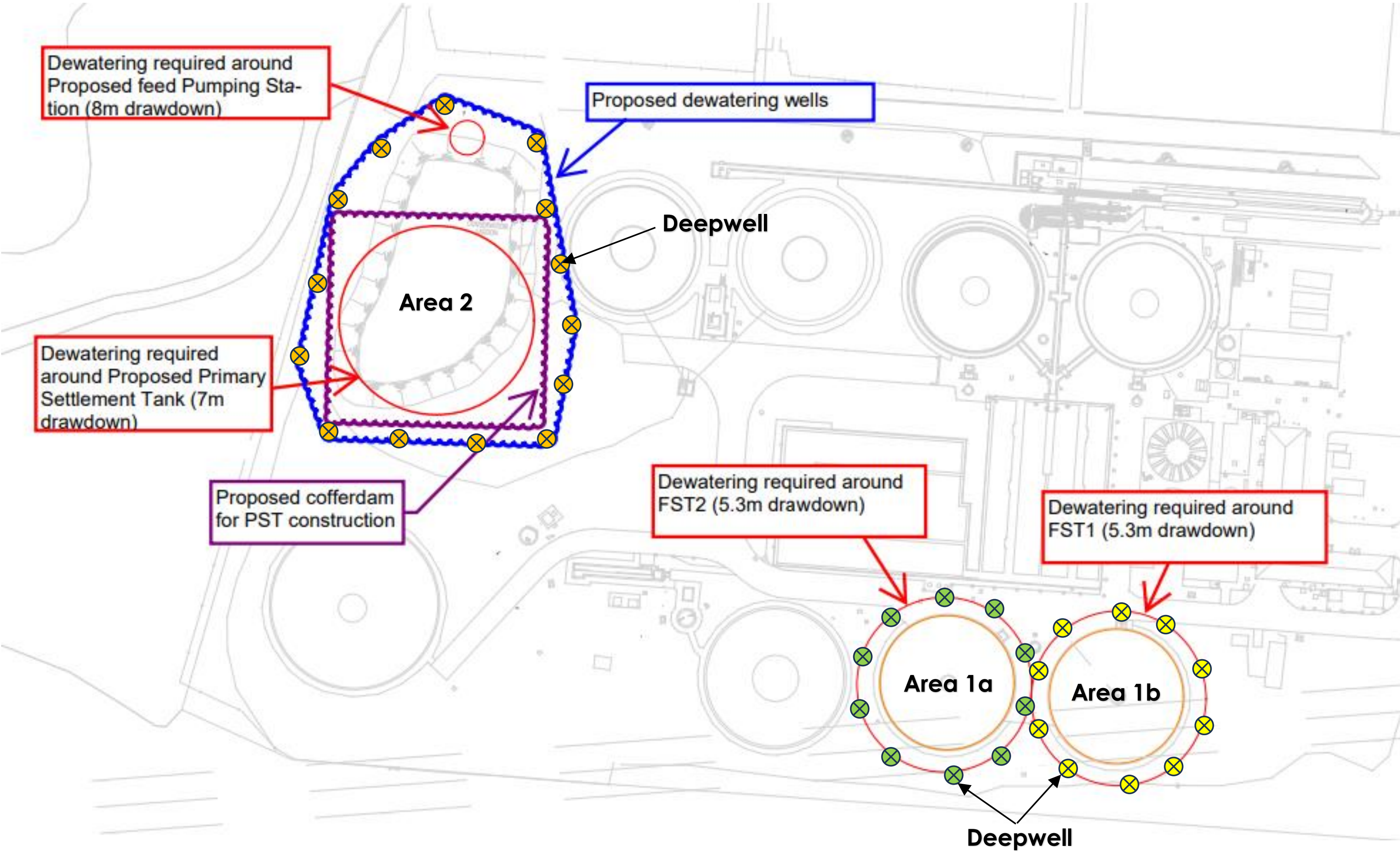

Figure 3: Indicative Deepwell Dewatering Systems Layout at Garnswllt WwTW (base map taken from MMB drawing (MMB, 2023a)).

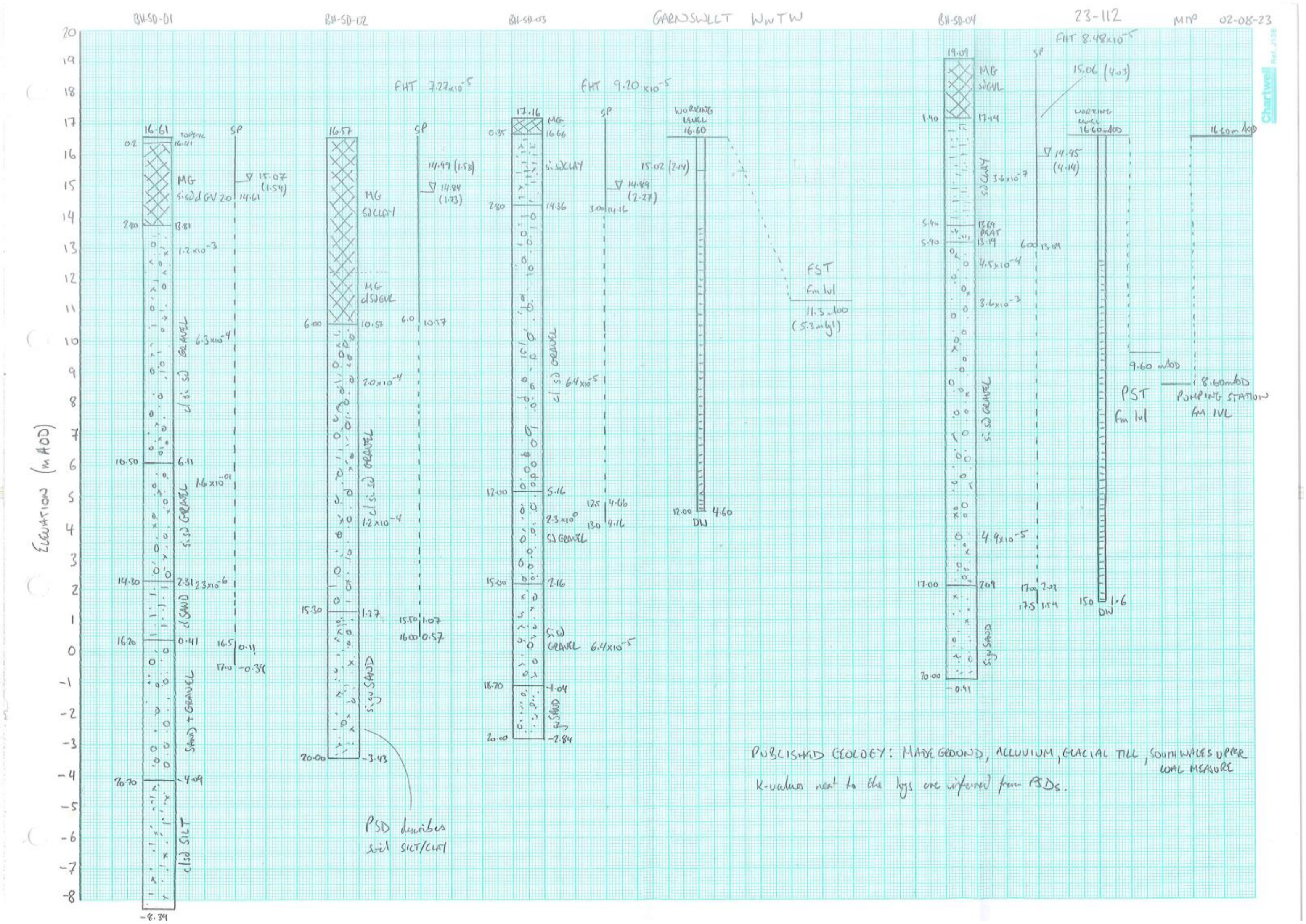

Figure 4: Dewatering Cross Section

7. Summary and Recommendations

In consideration of the information reviewed during the preparation of this Dewatering Design Note, we make the following summations and recommendations:

1. Three dewatering systems are proposed to be installed in areas; Area 1a, Area 1b and Area 2. They are required to control and lower groundwater levels in the Target Aquifer (Superficial Deposits) during excavation works associated with two Final Settlement Tanks (FSTs), one Primary Settlement Tank (PST) and one Feed Pumping Station.
   The dewatering systems comprise between 10 no. to 14 no. deep wells installed to depths between 12 to 15 m, at between 8 to 10 m centers around the perimeter of each area. Estimated system capacities are between 10 to 154 l/s (864 to 13,305.6 m^3/day).
   Abstracted groundwater would be transported via pipework to the allocated discharge location(s), to be confirmed.
   It is assumed that only one dewatering system would be operated at any one time, and therefore it would be possible to relocate the pumps, pipework and plant between dewatering areas. This would reduce the amount of equipment and plant on site and reduce the amount of groundwater abstracted at any one time.
2. Please note there is a relative lack of site-specific data on aquifer conditions, which lead to uncertainty in dewatering flow rates and well yields. As a result, we highly recommend undertaking a pumping test. The pumping test would further inform the dewatering design, allow more accurate estimation of the abstraction flow rates and distance of influence.
   Furthermore, the pumping test would afford the opportunity to obtain samples of groundwater for analysis at a UKAS accredited laboratory.
   It is highly likely that pumping test data and results of groundwater analysis would be required when applying for environmental permits.
   It is possible to offset the initial additional costs of undertaking a pumping test through location of the investigation wells in positions where they may be incorporated into the main works dewatering system.
3. The potential influence of the River Loughnor (Afon Llwchwr) is currently unknown. Should it be in hydraulic connection with the Superficial Deposits, the actual abstraction flows may be higher than those estimated. As a result, the proposed dewatering systems would need to be suitably upsized.
   A pumping test could be planned to provide the required further data and/or a monitoring well should be installed within close proximity of the river to provide further groundwater level monitoring data. A corresponding stilling well should also be installed in the river close to the monitoring well. A comparison may then be made of the two water levels.

8. References

Preene, M., Roberts, T.O.L., and Powrie, W. 2016. *Groundwater control: design and practice, second edition*. Construction Industry Research and Information Association, CIRIA Report C750.

Cashman, P.M. and Preene, M. 2021. *Groundwater Lowering in Construction: A Practical Guide to Dewatering, third edition.* CRC Press.

Appendix A: Information Reviewed

Construction and Design Information (listed in date order):

Mott MacDonald Bentley (MMB, 2023a) drawing no. B10670-123532-ZZ-XX-SK-CA-MM0503, entitled '*Proposed Site General Arrangement - Dewatering*' rev. P01 dated April 2023.

Mott MacDonald Bentley (MMB, 2023b) drawing no. B10670-123532-XX-XX-SK-CA-CI0501, entitled '*Proposed PST Cross Section*' undated.

Mott MacDonald Bentley (MMB, 2023c) drawing no. B10670-123532-XX-XX-SK-CA-CI0502, entitled '*Proposed PST feed PS Cross Section*' undated.

Ground Investigation and Geotechnical Reports (listed in date order):

Quantum Geotech Limited (QGL, 2023). *Garnswllt WwTW Ground Investigation Factual Report*. Report no. Q1031/FR.01 dated June 2023.