



Geotechnical and Geoenvironmental Report Toronto Avenue, Margam

Prepared For: CJ Construction Ltd

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Proposed Residential Development, Toronto
Avenue, Margam**

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	Name	Signature
Prepared	Mathew Lake MEng FGS Tech IOSH	
Checked	David Emanuel BSc (Hons), MSc, FGS, Dip.Chem, M Phil, CGeol	
Approved	Gwyn Lake BSc (Hons). PhD, CGeol, FGS	

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Executive Summary

Site Location and Proposed Development	The site is located off Toronto Avenue, in the Margam area of Port Talbot, and is centred on a National Grid Reference of 278150 187960. The site covers an area of 0.48 hectares. The development is to consist of residential properties.																										
Site History	The desk study has shown the site to have been unoccupied throughout the years researched, however, BGS boreholes at the site suggest a significant quantity of Made Ground has been placed at the site with a suggestion from one borehole log that there may be some oil in the soil at more than 2.25m depth. There is also some evidence of disturbance of the soil at the north of the site.																										
Geology	The site is underlain by the South Wales Middle Coal Measures. Tidal flat deposits are shown to overly the solid geology.																										
Radon	No radon protection is required for new development on the investigation site.																										
Coal Mining Risk Assessment	There is no risk to the scheme from shallow mining.																										
Ground Conditions	MADE GROUND: Vegetation over dark brown organic-rich clayey gravelly SAND. Gravel is angular sandstone and brick to 0.1/0.5m / Medium dense to very dense] brown gravelly silty SAND/SAND & GRAVEL. Gravel, cobbles and boulders are angular sandstone, brick and concrete. Occasional metal and timber to 1.6/1.8m. Soft to firm grey CLAY to 2.9m.																										
Contamination of Concern	<table border="1"> <thead> <tr> <th>Location</th><th>Depth</th><th>Contaminant</th><th>Source</th></tr> </thead> <tbody> <tr> <td>TP02</td><td>0.3</td><td>Lead, Benzo[a]anthracene, Benzo[b]fluoranthene, Benzo[a]pyrene Dibenzo(a,h)Anthracene</td><td>S1 – made ground</td></tr> <tr> <td>TP02</td><td>1.0</td><td>Arsenic, Lead, Benzo[b]fluoranthene, Dibenzo(a,h)Anthracene</td><td>S1– made ground</td></tr> <tr> <td>TP04</td><td>0.2</td><td>Benzo[a]anthracene, Chrysene, Benzo[b]fluoranthene, Benzo[a]pyrene Dibenzo(a,h)Anthracene</td><td>S1– made ground</td></tr> <tr> <td>TP04</td><td>1.2</td><td>Arsenic, Benzo[b]fluoranthene, Benzo[a]pyrene Dibenzo(a,h)Anthracene</td><td>S1– made ground</td></tr> <tr> <td>TP05</td><td>0.5</td><td>Lead, Dibenzo(a,h)Anthracene</td><td>S1 – made ground</td></tr> </tbody> </table>	Location	Depth	Contaminant	Source	TP02	0.3	Lead, Benzo[a]anthracene, Benzo[b]fluoranthene, Benzo[a]pyrene Dibenzo(a,h)Anthracene	S1 – made ground	TP02	1.0	Arsenic, Lead, Benzo[b]fluoranthene, Dibenzo(a,h)Anthracene	S1– made ground	TP04	0.2	Benzo[a]anthracene, Chrysene, Benzo[b]fluoranthene, Benzo[a]pyrene Dibenzo(a,h)Anthracene	S1– made ground	TP04	1.2	Arsenic, Benzo[b]fluoranthene, Benzo[a]pyrene Dibenzo(a,h)Anthracene	S1– made ground	TP05	0.5	Lead, Dibenzo(a,h)Anthracene	S1 – made ground		
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Ground Gas Risk Assessment	No significant sources of ground gas have been identified during the investigation. Mine gas has been discounted as a potential source of gas given the significant depth to the shallowest coal seam/mine workings beneath the site. However, given the findings of the Gore bridge incident it is recommend that CS2 measures are adopted for the scheme as a precautionary measure in line with the recommendations made in the enquiry into the incident.																										
Foundation Solution	The soft and variable consistency of the made ground soils beneath the site precludes the use of traditional shallow foundations. As such, three foundation solutions are presented for the site: • Ground Improvement – Turn and compact made ground AND use a reinforced strip foundation in the Engineered material • Ground Improvement – Vibro Stone Column's • Piling																										
Recommended Further Works	There is currently some uncertainty with the data presented in the available BGS boreholes located on site. The Engineering descriptions and in-situ strength testing presented in the logs contradict each other. It is recommended that additional boreholes are sunk across the site to provide confidence in the available data. The following sections are based upon the best case scenario when using the SPT/CPT strengths presented on the logs. A remediation strategy will also be required given the presence of contamination across the site																										

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ANNEX B Risk Assessment Definitions
ANNEX C Trial Pit Logs
ANNEX D Laboratory Soil Chemical Test Results
ANNEX E Laboratory Soil Geotechnical Test Results

Drawings

Drawing 01 Proposed Site Layout

SECTION 1 Introduction and Proposed Development

1.1 Introduction

C J Construction Limited (the Client) is proposing the development of land located off Toronto Avenue at Margam.

Terra Firma (Wales) Limited have been commissioned by the Client to undertake a geoenvironmental assessment and geotechnical investigation of the site.

The main objectives of the geoenvironmental assessment programme are:

- Investigate the potential human health and environmental liabilities at the site associated with any contamination
- Provide a summary of the human health and environmental conditions at the site, together with any necessary further intrusive works and / or remediation works to render the site fit for its intended use

The main objectives of the geotechnical site investigation are:

- Investigated the type, strength and bearing characteristics of the shallow superficial and underlying solid geology
- Investigate the risk, if any, from historical shallow underground mining features
- Provide engineering foundation and floor slab recommendations for the proposed development
- Provide infiltration rates and stormwater drainage viability.
- Provide recommendations regarding any other geotechnical aspects pertaining to the development

In order to achieve the above objectives, Terra Firma (Wales) Limited carried out an assessment programme including a site walkover, a review of existing data, followed by a field investigation to collect geotechnical and geoenvironmental data from selected locations.

1.2 Limitations and Exceptions of Investigation

The Client has requested that a Geoenvironmental Site Assessment (GSA) and Geotechnical Investigation (GI) be performed to enable the outlined main objectives.

The GSA and GI were conducted, and this report has been prepared for the sole internal reliance of the Client and their design and construction team. This report shall not be relied upon or transferred to any other parties without the express written authorisation of Terra Firma (Wales) Limited. If an unauthorised third party comes into possession of this report, they rely on it at their peril and the authors owe them no duty of care and skill. The report represents the findings and opinions of experienced geoenvironmental and geotechnical consultants. Terra Firma (Wales) Limited does not provide legal advice and the advice of lawyers may be required.

The subsurface geological profiles, any contamination and other plots are generalised by necessity and have been based on the information found at the locations of the exploratory holes and depths sampled and tested.

The investigation was limited by the presence of underground services.

1.3 Quality Assurance

The quality and environmental aspects of the assessment and investigation comply with UKAS Accredited ISO 9001:2015 and ISO 14001:2015 standards.

SECTION 2 Review of Existing Data

2.1 Physical Setting and Current Site Use

The site is located off Toronto Avenue, in the Margam area of Port Talbot, and is centred on a National Grid Reference of 278150 187960. The site covers an area of 0.48 hectares. The location of the site is shown below in **Figure 2.1**

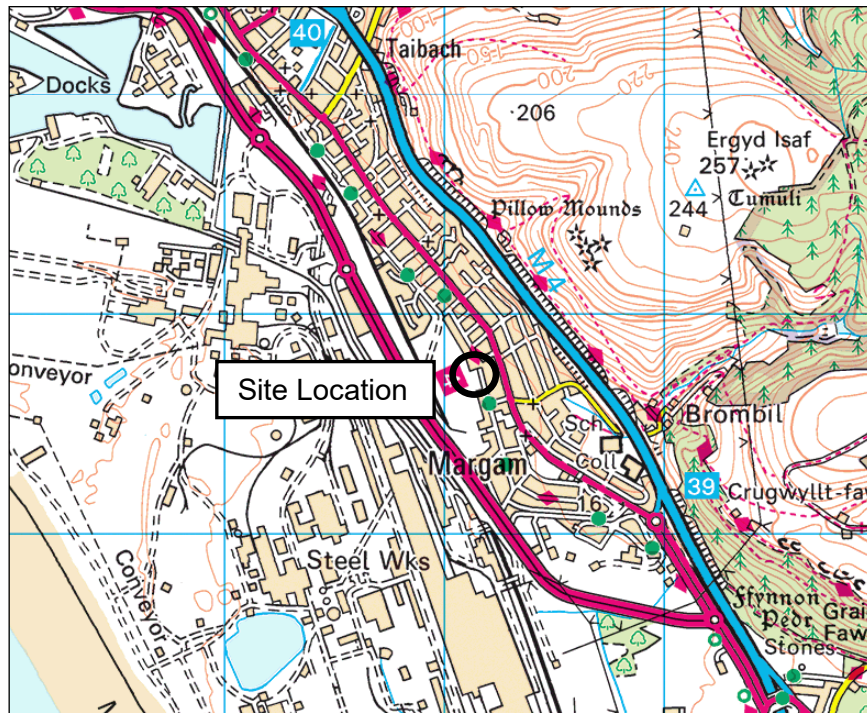


Figure 2.1 Site Location

The site lies to the immediate north of houses fronting onto Toronto Avenue, and to the immediate west of Pant Celydd. Houses lie on the opposite side of Pant Celydd. To the immediate west of the site and separated by a wall is Groeswen Playing Fields. To the north of the site is a footpath, beyond which are houses.

The site is covered by trees, brambles, bushes and long grass. A path passes through the site from the north northwest to south southeast, however due to the overgrown nature of the site, this is no longer evident or usable. The site is generally flat throughout and lies at approximately 8m above Ordnance Datum.

2.2 Site History

Historical maps of the site have been obtained in an Envirocheck Report, provided by Landmark Information Group. The history plans are supplied in **Annex A** of this report, and the most relevant editions are summarised in **Table 2.1**. Distances are approximate, and any changes in-between map editions may not be recorded.

Table 2.1 Historical Development from Map Information

Map Edition & Scale	Key Features on Site	Key Features off Site
1876-77 1:2,500	The site is unoccupied and lies upon field land in the south and a marsh in the north. A possible hedgerow or wall and drainage channel courses through the middle of the site from northeast to southwest.	A north northwest to south southeast orientated railway line is located 175m west. A small settlement known as Stall Court is located approximately 20m to the east, which is accessed by a north to south orientated road. The surrounding area mostly comprises marsh to the west and field land to the east.
1899 1:2,500	No significant changes.	No significant changes.
1917-18 1:2,500	No significant changes apart from a drainage channel, which crosses the far northwest corner of the site.	No significant changes.
1939-40 1:10,560	The drainage channel, which crosses the far northwest corner of the site is no longer evident. The west of the site is covered by rough pasture and the east by field land. A field boundary running from north northwest to south southeast passes through the site.	A large housing estate has been built in the Margam area and abuts the southeast corner of the site.
1949 1:10,000	No significant changes.	A large steel works is located approximately 410m west of the site.
1967 1:2,500	A shallow excavation appears to extend from the northeast onto the northeast corner of the site. A track runs from north to south through the site.	A builder's yard is located approximately 20m north of the site, and allotment gardens lie along the site's east boundary. More houses have been built in the surrounding area.
1982 1:10,000	No significant changes.	Playing fields are located to the immediate west and houses lie to the immediate south of the site.
1991 1:1,250	No significant changes.	The builders yard has been replaced by a depot and has been extended to within 5m north of the site. No tanks are identified on the site. An electricity substation is located 50m northeast of the site.
1994-95 1:1,250	No significant changes. The path is no longer shown passing through the site.	Houses have been built to the immediate east of the site.
2006 1:10,000	No significant changes.	No significant changes. The electricity substation is no longer shown.
2009 1:10,000	No significant changes.	Houses have been built to the immediate north upon the former depot.
2020 1:10,000	No significant changes.	No significant changes.

2.3 Geological Setting

2.3.1 Geology

The 1:50,000 scale British Geological Map of the area was consulted for geology underlying the site. The site is shown to be underlain by the South Wales Middle Coal Measures Formation. Detailed stratigraphical information is provided in **Table 2.2**.

Table 2.2 Detailed Stratigraphical Information

Period	Group	Formation
Carboniferous	South Wales Coal Measures.	South Wales Middle Coal Measures Formation.

The site sits upon the boundary between Tidal Flat Deposits (clay, silt and sand) at the west and Glaciofluvial Ice Contact Deposits (sand & gravel) at the east.

Made Ground is expected to overlie the superficial deposits.

2.3.2 BGS Borehole Information

Several BGS boreholes are available across the site area. All logs show low strength made ground ranging from 1-2m in thickness. Softy clays are found below the ground which gradual become firmer with depth. Some contamination is noted in the boreholes at the base of the made ground.

2.3.3 Radon

The Envirocheck Report (**Annex A**) details that NO radon protective measures are required for new developments on the investigation site.

2.3.4 Mining

A coal mining report was procured for the site from the Coal Authority. The report is presented in **Annex B**. The report concludes that the site could be affected by underground mining in 1 seam of coal at 620m depth, and last worked in 1908. Any movement from the ground due to coal mining activity should have stopped.

There are no known coal mine entries within, or within 20 metres of the boundary of the property.

Based upon the above and the anticipated geology it is considered that there is no risk to the development from past shallow coal/mineral mining.

Relevant BGS mineral sites as recorded in the Envirocheck Report datasheets (**Annex A**) are summaries in **Table 2.3**.

Table 2.3 BGS Recorded Mineral Sites

Site Name	Distance/ Direction from site	Type	Commodity
Craig Groeswen	534m north east	Underground	Coal deep

2.3.5 Natural Hazards

The underlying geology is not prone to dissolution due to the significant mudstone component of the geological units and the risk of natural cavities in the bedrock is considered negligible.

The risk of landslides and running sands is considered negligible.

2.4 Environmental Setting

The following sections have been compiled using the Landmark Information Group Envirocheck datasheet and maps which can be found in **Annex A**.

2.4.1 Hydrogeology

Superficial deposits beneath the site have an aquifer designation of secondary aquifer – A and Undifferentiated strata.

The bedrock deposits beneath the site have an aquifer designation of secondary aquifer – A strata.

Deeper groundwater flow within the underlying bedrock will be controlled by the strata dip and any fractures or bedding planes within the rock units.

The hydraulic gradient will be at its steepest during periods of heavy rainfall and aquifer recharge.

The site does not locate within a groundwater source protection zone.

The nearest groundwater abstraction point is located 299m West of the site, operated by Costain Limited for dust suppression.

2.4.2 Hydrology

The nearest surface water feature is a small stream known as Arnallt Brook located 97m southeast of the site. Arnallt Brook flows from northeast to the southwest and joins a drainage channel, which flows along the nearby railway line until it drains into the River Afan, approximately 1.45km to the north.

2.4.3 Flooding

The site is not at risk from extreme flooding from rivers or sea.

2.4.4 Waste

The Envirocheck report shows no records of historic or active landfills within influencing distance of the site.

There are no licensed waste management facilities within influencing distance of the site.

There are no licensed waste management facilities or waste transfer sites within 250m of the site.

2.4.5 Pollution

No pollution incidents are recorded to have occurred within 250m radius of the site.

2.4.6 Sensitive Land Use

The site is not located within a sensitive land use area.

2.4.7 Measured Urban Soil Chemistry

The BGS hold no urban soil chemistry data for the site.

2.4.8 Industrial Land Use

Relevant contemporary trade directory entries recorded within proximity of the site are summarised in **Table 2.4**.

Table 2.4 Relevant Contemporary Trade Summary

Company	Distance/Direction from site	Classification	Status
M W Air Conditioning & Refrigeration	15m east	Conditioning & Refrigeration Contractors	Inactive

2.5 Ecology

During the site walk over, no evidence of Japanese Knotweed was encountered on site.

Please note that Terra Firma (Wales) Ltd are not specialists in this field and the advice of an expert should be sought.

2.6 Historical Site Investigation Data

Terra Firma undertook a site investigation on the site in November 2017. The investigation identified three small exceedances of dibenzo(ah)anthracene in the shallow made ground soils.

SECTION 3 Preliminary Human Health and Environmental Risk Assessment

3.1 General

The preliminary human health and environmental risk assessment is a qualitative evaluation of unacceptable risks to human health or the environment from potential 'contaminated land', based on reviewed information in preceding sections of this report.

For 'contaminated land' to exist as defined in Part 2A of the Environmental Protection Act (EPA) 1990, a Pollutant Linkage needs to be identified. Pollutant linkages are defined by having a valid 'source – pathway – receptor' as established in the preliminary conceptual site model.

For our definitions of pollution linkage and how we define risk please refer to **Annex B** which includes our classifications of consequence and probability, and risk assessment matrix.

3.2 Potential Sources of Contamination

Potential or known sources of contamination associated the sites current and historical land use are summarised in **Table 3.1**.

Table 3.1 Contamination Sources

ID	Source	Contaminant
S1	Known Made Ground	Metals, metalloids, PAH, TPH, asbestos
S2	Builders Yard and Depot	Metals, metalloids, PAH, TPH, asbestos
S3	Coal Measures	CH ₄ , CO ₂

The electrical substation has been discounted as a source of contamination given that the substation was constructed in the 1990's.

3.3 Potential Pollution Pathways

Potential contaminant pathways associated with a residential with home grown produce land use are as follows.

- P1 – Direct soil and dust ingestion
- P2 – Consumption of home grown produce
- P3 – Dermal contact
- P4 – Inhalation of dust and vapours
- P5 – Vertical migration of leachates (unsaturated zone)
- P6 – Horizontal and vertical migration of contaminants (saturated zone)
- P7 – Artificial contaminant pathway (borehole, pile, excavation etc)
- P8 – Surface run-off
- P9 – Plant uptake
- P10 – Horizontal and vertical migration of ground gasses and vapours
- P11 – Direct contact with construction materials
- P12 – Inhalation of asbestos fibres

3.4 Potential Receptors

There are human and hydrological receptors to any contamination that may be present on site. Potential receptors include.

- R1 – Construction and maintenance workers
- R2 – Future site users (residents)
- R3 – Passers-by or neighbouring site users
- R4 – Groundwater (aquifer)
- R5 – Surface waters (river/lake)
- R6 – Area of public open space
- R7 – Construction materials (concrete/potable water pipes)

3.5 Preliminary Conceptual Site Model

The preliminary conceptual site model establishes potential pollutant linkages between contaminants (source), pathways and receptors, realised during the preparation of the desk study report. Where a potential pollutant linkage is identified an assessment of risk is subsequently undertaken. The preliminary conceptual site model is tabulated in **Table 3.2**.

Outcomes of the preliminary conceptual site model are used as a basis for the design and implementation of the site investigation, whereby areas of potential contamination can be targeted as well as investigating the wider site.

Findings of the site investigation can in turn be used to develop and refine the conceptual site model.

Table 3.2 Preliminary Conceptual Site Model

Source	Pathway	Receptor	Preliminary Risk Assessment		
			Consequence	Probability	Risk
Human Health					
Contaminated Soils S1 + S2	Direct soil and dust ingestion P1 Dermal contact P3 Inhalation of dust and vapours P4	Construction and maintenance workers R1	Medium	Likely	Medium Risk - COSHH assessment and good level of PPE/ hygiene by site workers/ staff; dust suppression measures if required. Suitably designed site investigation recommended
		Passers-by or neighbouring site users R3	Medium	Low Likelihood	Low Risk - Dust suppression measures if required.
		Future site users (residents) R2	Medium	Likely	Medium Risk - Suitably designed site investigation recommended
Coal Measures S3	Horizontal and vertical migration of mine gasses P10	Future site users (residents) R2	Severe	Unlikely	Low Risk – Shallowest workings are located at 620m depth, therefore no viable pathway between Coal seam/workings and the site
Contaminated Soils S1 + S2	Plant uptake P9 Consumption of home grown produce P2	Future site users (residents) R2	Medium	Likely	Medium Risk
Contaminated Soils S1 + S2	Direct Contact P11	Construction materials (water pipes) R7	Medium	Likely	Medium Risk
		Construction materials (concrete) R7			
Aquatic Environment					
Contaminated Soils S1	Vertical migration of leachates (unsaturated zone) P5	Groundwater (aquifer) R4 Surface waters (river/lake) R5	Mild	Low Likelihood	Low Risk – Clay based sols will prevent leaching of contaminants
	Surface run-off P8	Surface waters (river/lake) R5			
	Horizontal and vertical migration of contaminants (saturated zone) P6				

SECTION 4 Field Investigation

4.1 Site Works

A geotechnical and geoenvironmental site investigation comprising seven trial pits and two soakaway tests was undertaken on the 10th November 2020.

The fieldwork was supervised by Terra Firma (Wales) Limited, who logged the exploratory holes to the requirements of BS 5930:2015+A1:2020. The proposed locations of the exploratory holes were determined by Terra Firma (Wales) Ltd in general accordance with BS 10175:2011+A2:2017 in order to assess the findings of the preliminary conceptual site model.

Trial pits referenced TP01 to TP07, were formed using a 13 tonne tracked excavator with a 2.00m wide bucket.

Representative disturbed samples were taken and retained in airtight containers for environmental and geotechnical testing.

Soakaway tests were carried out in trial pits TP01 and TP02 in general accordance with BRE DG 365:2016. The excavation sides were squared using the excavator bucket and dimensions recorded within the test section. The trial pit was partially filled with clean water using a dedicated bowser with a 75mm diameter outlet and the fall in level recorded against time.

On completion all trial pits were backfilled with materials arisings compacted in layers using the excavator bucket. The ground surface was reinstated.

The trial pit logs are presented in **Annex C**.

Exploratory hole locations are shown on **Drawing 01**.

4.2 Ground Conditions

The ground conditions encountered by the exploratory holes can in general be summarised as shown in **Table 4.1**. Trial pit logs are presented in **Annex D**.

Table 4.1 Summary of Typical Ground Conditions

Depth (m)			Thickness (m)	Stratum
0.00	-	1.7/2.4	1.7/2.4	MADE GROUND: Vegetation over dark brown organic-rich clayey gravelly SAND . Gravel is angular sandstone and brick / Medium dense to very dense] brown gravelly silty SAND/SAND & GRAVEL . Gravel, cobbles and boulders are angular sandstone, brick and concrete. Occasional metal and timber.
1.7/2.4	-	1.8/2.5	0.1	PEAT/BURIED TOPSOIL
1.8/2.5	-	>3.0	Unproven during investigation though BGS data suggests this strata extends down to 7.5m	Soft to firm blueish grey mottled brown slightly sandy CLAY

4.3 Groundwater

Groundwater information recorded during the site investigation is summarised in **Table 4.2**.

Table 4.2 Groundwater Summary

Location	Depth (m)	Details
TP1	2.2	Slow groundwater inflow
TP2	1.7	Slow groundwater inflow
TP3	1.5	Slow groundwater inflow
TP4	1.7	Slow groundwater inflow
TP6	1.7	Slow groundwater inflow

4.4 Stability and Obstructions

Trial pits remained stable and vertical during excavation.

A concrete obstruction was encountered in TP7 at 0.3m depth.

4.5 Laboratory Chemical Testing

4.5.1 Sampling Strategy

Soil sampling locations were selected on a non-targeted basis to characterise the contamination status of the site.

Sample locations, depths and suspected/known contamination source targets are summarised in **Table 4.33**:

Table 4.3 Sample Locations, Depths and Targets

Location	Depth (m)	Contamination Targets
TP1	0.5	S1 + S2
TP2	0.3	S1 + S2
TP2	1.0	S1 + S2
TP3	0.5	S1 + S2
TP3	1.6	S1 + S2
TP4	0.2	S1 + S2
TP4	1.2	S1 + S2
TP5	0.5	S1 + S2
TP6	0.2	S1 + S2
TP7	0.8	S1 + S2

4.5.2 Soil Laboratory Analysis

During the site investigation works soil samples were taken and despatched to the accredited laboratories of Eurofins Chemtest for laboratory chemical testing. Soil samples were tested for the determinants listed in **Table 4.4**.

Table 4.4 Soil Laboratory Analysis

Metals & Metalloids	In-Organics	Organics	Others
Arsenic	Cyanide	Phenols	pH (acidity)
Cadmium	Sulphate	PAH	Asbestos
Chromium III		Petroleum Hydrocarbons CWG	
Chromium VI			
Copper			
Lead			
Mercury			
Nickel			
Selenium			
Zinc			

The results are discussed in detail in **SECTION 6** and the laboratory test results certificates may be found in **Annex D**.

4.6 Soil Property Testing

4.6.1 In-situ Permeability Testing

During the site investigation one* trial pit soakaway test was undertaken in TP* and carried out in general accordance with BRE DG 365:2016.

Soakaway test results are summarised in **Table 4.55**.

Table 4.5 Summary of Soakaway Results

Trial Pit	Depth Range of Test (m)	Infiltration Rate (ms ⁻¹)
TP1	2.5-3.0	No infiltration recorded – Test terminated due to negligible infiltration and groundwater inflows
TP2	2.5-2.9	No infiltration recorded – Test terminated due to negligible infiltration and groundwater inflows

4.6.2 Laboratory Geotechnical Testing

A schedule of laboratory tests was prepared by Terra Firma Wales Ltd and samples were despatched to the accredited laboratories of Apex Testing Solutions. A summary of the testing carried out is presented in **Table 4.6.6**.

Table 4.6 Summary of Geotechnical Testing

Geotechnical Test	Standard (BS1377:1990)	No. Tested
4 Point Liquid and Plastic Limit	Part 2, Clause 4.3 & 5.3	2

The test results are presented in **Annex E** and discussed in **SECTION 6** of this report.

SECTION 5 Evaluation of Geoenvironmental Analytical Results

5.1 Assessment Methodology

Comparison of the analytical results has been made with the 2015 Suitable 4 Use Levels (S4UL) provided by Land Quality Management (LQM) Limited and the Chartered Institute of Environmental Health (CIEH) or provisional Category 4 Screening Levels (pC4SL).

Soil leachate and groundwater analytical results have been compared with available published guidelines in the Water Framework Directive (Standards and Classification) Directives (England and Wales) 2015 and Drinking Water Directive (98/83/EC).

Sulphate results have been compared to guidelines presented in British Research Establishment (BRE SD1:2015). Sulphate levels need only be considered for buried concrete risk assessment and are not human health related.

Soils subjected to a UK Water Industry Research (UKWIR) suite of testing have been compared with guidelines set out in UKWIR Guidance for the Selection of Water Supply Pipes to be Used in Brownfield Sites (Ref 10/WM/03/21).

5.2 Soil Test Results

A summary of the chemical test results which include the regulatory soil guideline values used in a residential setting with plant uptake are given in the following tables. The complete results can be found in **Annex D**.

5.2.1 Inorganics & Miscellaneous

Ten samples were tested for a standard suite of inorganics, pH and organic matter. The summarised results are in **Table 5.1**.

Table 5.1 Summary of Soil Chemical Test Results – Inorganics & Miscellaneous

Substance	Threshold Value (mg/kg)	Source	Measured Concentrations (mg/kg)		Number of Exceedances
			Minimum	Maximum	
Arsenic	37	LQM/CIEH	8.5	100	2 of 10
Cadmium	11	LQM/CIEH	<0.1	1.3	0 of 10
Chromium III	910	LQM/CIEH	9.9	63	0 of 10
Chromium VI	6	LQM/CIEH	<0.5	<0.5	0 of 10
Copper	2400	LQM/CIEH	22	1300	0 of 10
Lead	200	pC4SL	26	610	3 of 10
Mercury (inorganic)	40	LQM/CIEH	<0.05	1.4	0 of 10
Nickel	180	LQM/CIEH	11	35	0 of 10
Selenium	250	LQM/CIEH	<0.2	1.6	0 of 10
Zinc	3700	LQM/CIEH	70	1700	0 of 10
Cyanide	-	-	<0.5	<0.5	-
Boron	290	LQM/CIEH	<0.4	2.1	0 of 10
Sulphate (%)	0.24	BRE	<0.01	0.13	0 of 10
Organic Matter (%)	-	-	0.9	6.2	-
pH	-	-	6.8	10	-
Notes:					
- No available guideline					

5.2.2 Organics

Ten samples were tested for speciated polycyclic aromatic hydrocarbons. The summarised results are in **Table 5.2**.

Table 5.2 Summary of Soil Chemical Test Results – Speciated Polycyclic Aromatic Hydrocarbons

Substance	Threshold Value (mg/kg)	Source	Measured Concentrations (mg/kg)		Number of Exceedances
			Minimum	Maximum	
Naphthalene	2.3	LQM/CIEH	<0.01	1.4	0 of 10
Acenaphthylene	170	LQM/CIEH	<0.01	1.0	0 of 10
Acenaphthene	210	LQM/CIEH	<0.01	4.9	0 of 10
Fluorene	170	LQM/CIEH	<0.01	4.8	0 of 10
Phenanthrene	95	LQM/CIEH	<0.01	23	0 of 10
Anthracene	2400	LQM/CIEH	<0.01	5.3	0 of 10
Fluoranthene	280	LQM/CIEH	<0.01	33	0 of 10
Pyrene	620	LQM/CIEH	<0.01	27	0 of 10
Benzo(a)anthracene	7.2	LQM/CIEH	<0.01	19	2 of 10
Chrysene	15	LQM/CIEH	<0.01	17	1 of 10
Benzo(b)fluoranthene	2.6	LQM/CIEH	<0.01	25	4 of 10
Benzo(k)fluoranthene	77	LQM/CIEH	<0.01	8.8	0 of 10
Benzo(a)pyrene	2.2	LQM/CIEH	<0.01	15	3 of 10
Indeno(123cd)pyrene	27	LQM/CIEH	<0.01	10	0 of 10
Dibenzo(ah)anthracene	0.24	LQM/CIEH	<0.01	4	5 of 10
Benzo(ghi)perylene	320	LQM/CIEH	<0.01	9	0 of 10
Total PAH	-	-	<2.0	210	-
Notes:					
Thresholds based on 1.0% soil organic matter					
- No available guidelines					

Ten samples were tested for petroleum hydrocarbon. The summarised results are shown in **Table 5.3**.

Table 5.3 Summary of Soil Chemical Test Results – Petroleum Hydrocarbons

Substance	Threshold Value (mg/kg)	Source	Measured Concentrations (mg/kg)		Number of Exceedances
			Minimum	Maximum	
Aliphatic					
PH C5 – C6 Ali	42	LQM/CIEH	<1.0	<1.0	0 of 10
PH C6 – C8 Ali	100	LQM/CIEH	<1.0	<1.0	0 of 10
PH C8 – C10 Ali	27	LQM/CIEH	<1.0	<1.0	0 of 10
PH C10 – C12 Ali	130	LQM/CIEH	<1.0	<1.0	0 of 10
PH C12 – C16 Ali	1100	LQM/CIEH	<1.0	9.1	0 of 10
PH C16 – C21 Ali	65000*	LQM/CIEH	<1.0	14	0 of 10
PH C21 – C35 Ali	65000*	LQM/CIEH	<1.0	68	0 of 10
PH C35 – C44 Ali	65000	LQM/CIEH	<1.0	13	0 of 10
Aromatic					
PH C5 – C7 Arom	70	LQM/CIEH	<1.0	<1.0	0 of 10
PH C7 – C8 Arom	130	LQM/CIEH	<1.0	<1.0	0 of 10
PH C8 – C10 Arom	34	LQM/CIEH	<1.0	<1.0	0 of 10
PH C10 – C12 Arom	74	LQM/CIEH	<1.0	<1.0	0 of 10
PH C12 – C16 Arom	140	LQM/CIEH	<1.0	16	0 of 10
PH C16 – C21 Arom	260	LQM/CIEH	<1.0	81	0 of 10
PH C21 – C35 Arom	1100	LQM/CIEH	<1.0	450	0 of 10
PH C35 – C44 Arom	1100	LQM/CIEH	<1.0	50	0 of 10
Notes: PH – Petroleum Hydrocarbon Ali – Aliphatic Arom – Aromatic Thresholds based on 1.0% soil organic matter * – Ali C16-21 and C21-C35 based on criteria for Ali EC >16-35					

5.2.3 Asbestos Testing

All made ground soil samples were scheduled for asbestos screening. Asbestos was not detected.

SECTION 6 Quantitative Risk Assessment

Geotechnical testing results are summarised in the following sections and presented in their entirety in **Annex E**.

6.1 Contaminants of Concern

During the investigation two samples of the shallow clay material was taken and submitted for plasticity testing. The test results are summarised in **Table 7.1**,

Table 6.1 Plasticity & Moisture Content Test Results

Location	Depth (m)	Laboratory Principal Soil Type	Moisture Content (%)	Plasticity Index (%)	Passing 425µm Sieve (%)	Modified Plasticity Index (%)	Volume Change Potential
TP01	1.80	CLAY	33	17	0	17	Medium
TP03	1.60	CLAY	68	41	0	41	High

In line with the NHBC (Chapter 4.2), the modified plasticity index for each sample was calculated. For design purposes the soils on site should be assumed to have a high volume change potential.

SECTION 7 Quantitative Risk Assessment

7.1 Contaminants of Concern

Contaminants identified as part of the investigation are summarised in **Table 7.1**, along with an interpretation of the likely contamination source. Where applicable, the contaminant, source relationship is based on the inferences made in the preliminary conceptual site model.

Table 7.1 Contaminants of Concern

Location	Depth	Contaminant	Source
TP02	0.3	Lead, Benzo[a]anthracene, Benzo[b]fluoranthene, Benzo[a]pyrene, Dibenz(a,h)Anthracene	S1 – made ground
TP02	1.0	Arsenic, Lead, Benzo[b]fluoranthene, Dibenz(a,h)Anthracene	S1– made ground
TP04	0.2	Benzo[a]anthracene, Chrysene, Benzo[b]fluoranthene, Benzo[a]pyrene, Dibenz(a,h)Anthracene	S1– made ground
TP04	1.2	Arsenic, Benzo[b]fluoranthene, Benzo[a]pyrene, Dibenz(a,h)Anthracene	S1– made ground
TP05	0.5	Lead, Dibenz(a,h)Anthracene	S1 – made ground

7.2 Pollutant Linkages

Based on the findings of the intrusive site investigation and identified contaminants, the preliminary conceptual site model has been revised. Significant pollutant linkages are tabulated in the refined conceptual site model **Table 7.2**. Identified pollutant linkages will require detailed risk assessment, appropriate mitigation or remedial measures.

Table 7.2 Refined Conceptual Site Model

Source	Pathway	Receptor
Made ground – S1	P1 – Direct soil and dust ingestion P2 – Consumption of home grown produce P3 – Dermal contact P4 – Inhalation of dust and vapours P7 – Artificial contaminant pathway (pile, excavation) P8 – Surface run-off P9 – Plant uptake P11 – Direct contact with construction materials	R1 – Construction and maintenance workers R2 – Future site users (residents) R3 – Passers-by or neighbouring site users

7.3 Mitigation and Remedial Measures

The following sections summarise the likely mitigation and remedial measures suitable for the identified contamination and proposed development. Detailed methodology to achieve the measures should be prescribed in a Remediation Strategy Report and the results presented in a Validation Report upon completion of the development.

7.3.1 Human Health

7.3.1.1 Contaminated Soils

To protect future site users from the identified contamination the site will require remedial measures to break the identified pollutant linkages. It is therefore recommended that a capping system is installed across the site. The capping should consist of the proposed buildings and hard standings. In garden and soft landscaped areas the capping should consist of 600mm of suitable inert topsoil, and subsoil if desired.

As good practice, construction workers should adhere to good site management, COSHH, good standards of hygiene and appropriate health & safety on site, with personal protection equipment (PPE) and dust suppression where appropriate.

All imported soils should be validated as clean and suitable for use in accordance with 'Requirements for the Chemical Testing of Imported Soils for Various End Uses and Validation Cover Systems'.

For proposed new supply water pipes, the UK Water Industry Research publication 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites (Report 10/WM/03/21)' should be consulted.

In accordance with EC Regulation 1272/2008 and Environment Agency Guidance WM3 soils destined for off-site disposal should be classified on the basis of their hazard phrases prior to disposal. Soils are classified as a mirror entry waste and should be classified on the basis of their specific chemical properties.

7.3.1.2 Ground Gas

No sources of ground gas have been identified during the investigation. Mine gas has been discounted as a potential source of gas given the significant depth to the shallowest coal seam/mine workings beneath the site. However, given the findings of the Gorebridge incident it is recommended that CS₂ measures are adopted for the scheme as a precautionary measure in line with the recommendations made in the enquiry into the incident.

The ground gas protection system should be designed, verified, installed and validated in accordance with the British Standard 8485:2015+A1:2019 and CIRIA guidance C735:2014.

It is recommended that a specialist consultant is retained to prepare a risk assessed ground gas protection system Verification Plan for the proposed development. The Verification Plan will detail the required protection measures based on the perceived risk associated with the complexity of design, experience of the installer, size of the site and gas characteristic situation. The Verification Plan also details the step by step process and requirements to allow for the completion of a Validation Report. Terra Firma (Wales) Ltd offer Verification and Validation services.

Validation of installed ground gas protection systems by an independent third party will be required upon completion of the development. Validation may only be achieved if processes prescribed in the Verification Plan are undertaken.

7.3.2 Aquatic Environment

The low permeability of the tidal flat deposits located beneath the site will prevent leaching of contaminants into the underlying aquifers.

Site specific mitigation and remedial measures are not required with respect to the aquatic environment.

During the construction period, there is a risk to the environment/adjacent sites from de-watering, digging foundations, moving contaminated soil, drainage misconnections, discharges to local surface waters or the ground, runoff from construction materials and/or exposed ground, wheel washings and oil or chemical spills.

The risk is considered to be negligible as any adverse effects will be easily preventable by due diligence to good construction practise and housekeeping in preventing surface runoff and the spillage of materials.

The basic measures that should be taken are as follows:

- Prepare a drainage plan and mark the manholes to prevent pollutants accidentally reaching the surface water sewers;
- Carry out any activities that could cause pollution in a designated, bunded area, away from rivers or boreholes. Where possible it should drain to the foul sewer;
- Use settlement ponds to remove silty water;
- Store all oils and chemicals in a fully bunded area to prevent leaks or spills;

SECTION 8 Engineering Recommendations

8.1 Preparation of Site

Areas of vegetation including all roots should be stripped and removed from beneath the proposed development site.

Allowances should be made for any temporary/permanent support works to any existing adjacent structure necessary as a result of the proposed works.

Contingencies should be made for the protection/diversion of any underground/overhead services present beneath/above the site brought about as a result of the proposed works.

Any reduced levels should be brought up to the required levels with suitable inert mainly granular materials. Department of Transport (DTP) type 2 sub-base or similar should be used and compacted in layers to the requirements of the Specification for Highway Works.

Allowances should also be made for the excavation of any soft spots/areas and their replacement with well compacted imported granular materials.

In accordance with EC Regulation 1272/2008 and Environment Agency Guidance WM3 soils and other materials destined for off-site disposal should be classified on the basis of their hazard phrases prior to disposal. Soils are classified as a mirror entry waste and should be classified on the basis of their specific chemical properties. Terra Firma (Wales) Ltd offer this service if required.

8.2 Foundation and Floor Slab Solution

The soft and variable consistency of the made ground soils beneath the site precludes the use of traditional shallow foundations. As such, three foundation solutions are presented for the site. There is also some uncertainty with the data presented in the available BGS boreholes located on site. The Engineering descriptions and in-situ strength testing presented in the logs contradict each other. It is recommended that additional boreholes are sunk across the site to provide confidence in the available data. The following sections are based upon the best case scenario when using the SPT/CPT strengths presented on the logs.

8.2.1 Ground Improvement – Turn and Compact

In order to provide a suitable founding stratum, it is recommended that the made ground is excavated and following removal of all deleterious materials recompacted in layers to the Specification for Highway Works. It should be noted that to prevent settlement of the recompacted materials that they should be compacted to at least 95% of the materials Maximum dry density. For this to be achieved, the natural moisture content of the fill materials should be with 10 to 15% of their optimum moisture content. Before recompacting made ground soils, the layer of peat/buried topsoil should be excavated and removed from the excavation formation. It should be noted that given the presence of shallow perched water, compaction may prove difficult, especially during periods of prolonged rainfall.

Following successful re-compaction, a reinforced strip foundation may be used founded within the compacted material. For a strip foundation founded within the recompacted materials, an allowable bearing capacity of 75 kPa will likely be achievable where total settlements are limited to 25mm and differential settlements are limited to 1:750. Foundations should be taken down to a minimum depth of 0.9m to protect against the effects of frost heave.

The strip reinforcement should be designed to span a soft spot of 3m.

All foundation formations should be inspected by a suitably qualified Engineer before being concreted.

8.2.2 Ground Improvement – Vibro Stone Column's

Ground improvement works in the form of vibro stone column's may be a feasible solution for the proposed development. The ground improvement scheme should be designed to provide an allowable bearing capacity of 100 kPa for a maximum total settlement of 30mm.

A specialist contractor should be consulted to confirm if this approach is viable.

If viable then the Specialist Contractor is likely to require Cable Percussive boreholes should be drilled on site to confirm the ground conditions presented in the available BGS logs and also the depth of stone columns.

8.2.3 Piling

If the above solutions prove difficult/prohibitive, then a piled foundation solution may be adopted for the site. Given the proximity to adjacent buildings, a bored pile will likely be required for the development to limit vibrations during piling.

The type, depth and working load of the piles should be confirmed by cable percussive boreholes.

8.3 Excavations and Formations

The shallow excavations will be possible with normal soil excavating machinery.

Shallow perched water and groundwater flows were encountered during the investigation. Any water inflows together with rainwater infiltration should be dealt with by conventional pumping techniques. However, it should be noted that during times of heavy rainfall a higher water table will be encountered.

The sides of any excavations deeper than 1.20m, or shallower if unstable, should be supported by planking and strutting or other proprietary means.

The sub-formations/formations are likely to be susceptible to loosening, softening and deterioration by exposure to weather (rain, frost and drying conditions), the action of water (flood water or removal of groundwater) and site traffic.

Formations should never be left unprotected and continuously exposed to rain causing degradation, or left exposed/uncovered overnight, unless permitted by a qualified engineer.

Construction plant and other vehicular traffic should not be operated on unprotected formations.

As a minimum the formation/excavation surfaces must be protected by blinding concrete immediately after exposure.

Allowances should be made for the removal of soft spots/areas and their replacement with well compacted granular materials.

Allowances should also be made for special precautions to prevent formation deterioration in addition to the above.

8.4 Protection of Buried Concrete

When the results are compared with Table C1/C2 of BRE Digest 1:2005, it indicates that buried concrete should generally conform to Class AC-1.

8.5 Storm Water Drainage

During the site investigation two soakaway tests were undertaken in general accordance with BRE DG 365:2016. The soakaway tests was carried out in trial pit TP1 and TP2 within natural materials.

The soakaway test recorded insufficient infiltration and was subsequently terminated early.

Based upon the negligible infiltration of the underlying tidal flat deposits along with shallow perched water, It is considered that soakaway storm water draining is unsuitable at the site.

ANNEX A
Envirocheck Report

Historical Mapping Legends

Ordnance Survey County Series 1:10,560

	Gravel Pit		Sand Pit		Other Pits
	Quarry		Shingle		Orchard
	Osiers		Reeds		Marsh
	Mixed Wood		Deciduous		Brushwood
	Fir		Furze		Rough Pasture
	Arrow denotes flow of water		Trigonometrical Station		
	Site of Antiquities		Bench Mark		
	Pump, Guide Post, Signal Post		Well, Spring, Boundary Post		
	Surface Level				
	Sketched Contour		Instrumental Contour		
	Main Roads		Minor Roads		
	Sunken Road		Raised Road		
	Road over Railway		Railway over River		
	Railway over Road		Level Crossing		
	Road over River or Canal		Road over Stream		
	Road over Stream				
	County Boundary (Geographical)				
	County & Civil Parish Boundary				
	Administrative County & Civil Parish Boundary				
	County Borough Boundary (England)				
	County Burgh Boundary (Scotland)				
	Rural District Boundary				
	Civil Parish Boundary				

Ordnance Survey Plan 1:10,000

	Chalk Pit, Clay Pit or Quarry		Gravel Pit
	Sand Pit		Disused Pit or Quarry
	Refuse or Slag Heap		Lake, Loch or Pond
	Dunes		Boulders
	Coniferous Trees		Non-Coniferous Trees
	Orchard		Scrub
	Bracken		Heath
	Marsh		Reeds
	Building		Glasshouse
	Sloping Masonry		Pylon
	Cutting		Embankment
	Road Under		Road Over
	Level Crossing		Foot Bridge
	Standard Gauge Multiple Track		Standard Gauge Single Track
	Siding, Tramway or Mineral Line		Narrow Gauge
	Geographical County		Administrative County, County Borough or County of City
	Municipal Borough, Urban or Rural District, Burgh or District Council		Borough, Burgh or County Constituency
	Civil Parish		
	Boundary Post or Stone		Police Station
	Church		Post Office
	Club House		Public Convenience
	Fire Engine Station		Public House
	Foot Bridge		Signal Box
	Fountain		Spring
	Guide Post		Telephone Call Box
	Mile Post		Telephone Call Post
	Mile Stone		Well

1:10,000 Raster Mapping

	Gravel Pit		Refuse tip or slag heap
	Rock		Rock (scattered)
	Boulders		Boulders (scattered)
	Shingle		Mud
	Sand		Sand Pit
	Slopes		Top of cliff
	General detail		Underground detail
	Overhead detail		Narrow gauge railway
	Multi-track railway		Single track railway
	County boundary (England only)		Civil, parish or community boundary
	District, Unitary, Metropolitan, London Borough boundary		Constituency boundary
	Area of wooded vegetation		Non-coniferous trees
	Non-coniferous trees (scattered)		Coniferous trees
	Coniferous trees (scattered)		Positioned tree
	Orchard		Coppice or Osiers
	Rough Grassland		Heath
	Scrub		Marsh, Salt Marsh or Reeds
	Water feature		Flow arrows
	Mean high water (springs)		Mean low water (springs)
	Telephone line (where shown)		Electricity transmission line (with poles)
	Bench mark (where shown)		Triangulation station
	Point feature (e.g. Guide Post or Mile Stone)		Pylon, flare stack or lighting tower
	Site of (antiquity)		Glasshouse
	General Building		Important Building

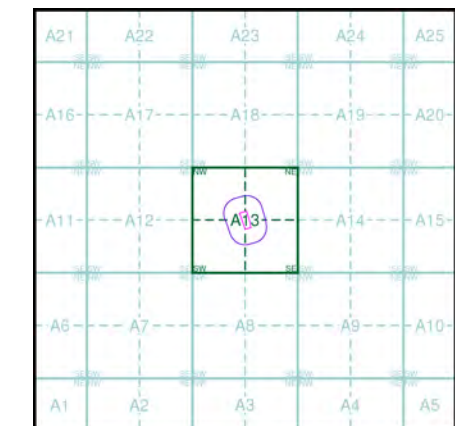


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Historical Mapping & Photography included:

Mapping Type	Scale	Date	Pg
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Glamorganshire	1:10,560	1900	3
Glamorganshire	1:10,560	1921	4
Glamorganshire	1:10,560	1938 - 1952	5
Historical Aerial Photography	1:10,560	1949	6
Glamorganshire	1:10,560	1951	7
Ordnance Survey Plan	1:10,000	1965	8
Ordnance Survey Plan	1:10,000	1982	9
Ordnance Survey Plan	1:10,000	1993	10
10K Raster Mapping	1:10,000	1999	11
10K Raster Mapping	1:10,000	2006	12
VectorMap Local	1:10,000	2020	13

Historical Map - Slice A



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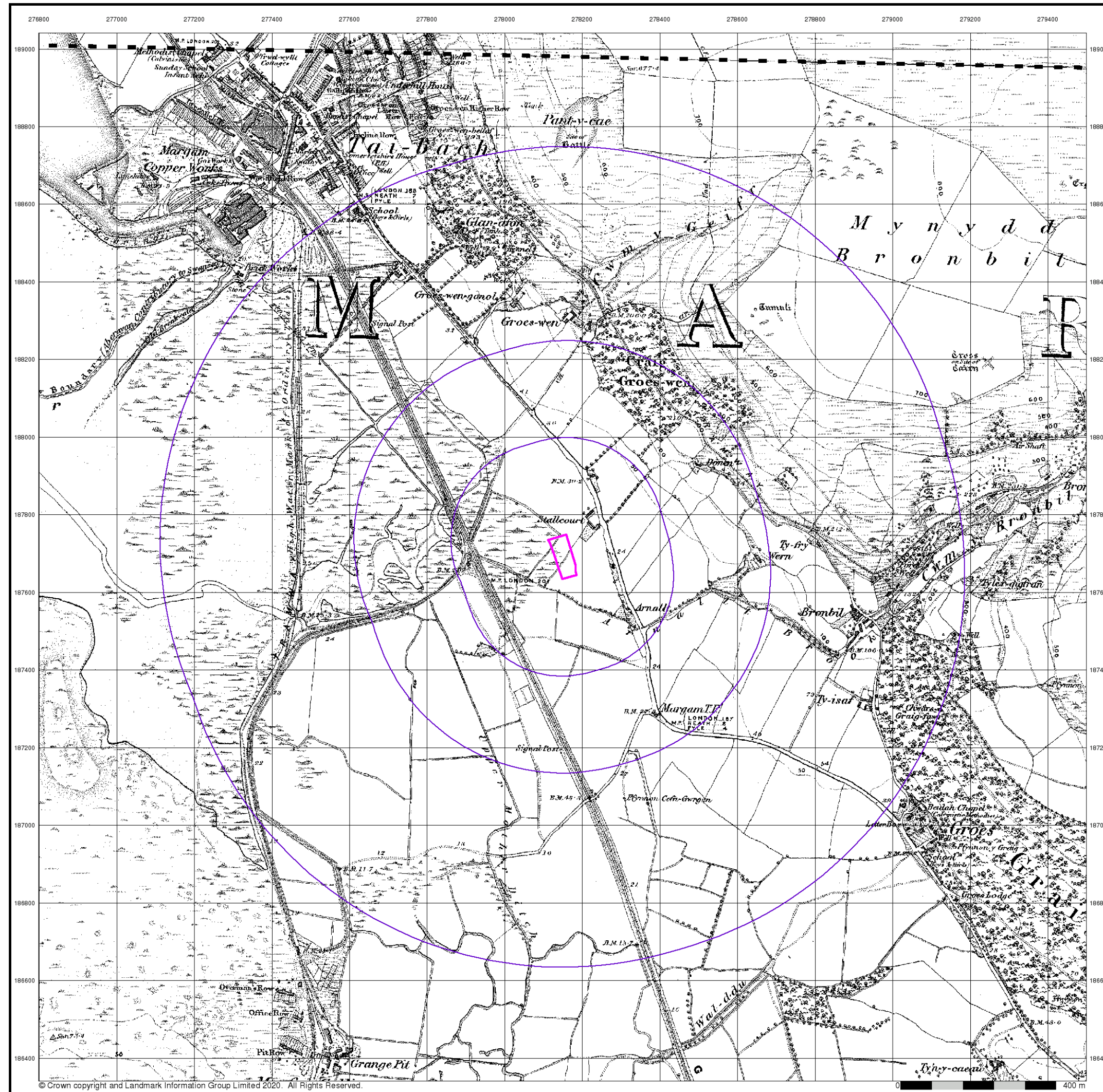
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National Grid Reference: 278150, 187690
Slice: A
Site Area (Ha): 0.48
Search Buffer (m): 1000

Site Details

Pant Celydd, Margam, Port Talbot, SA13 2DJ



Tel: 0844 844 9952
Fax: 0844 844 9951
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Glamorganshire

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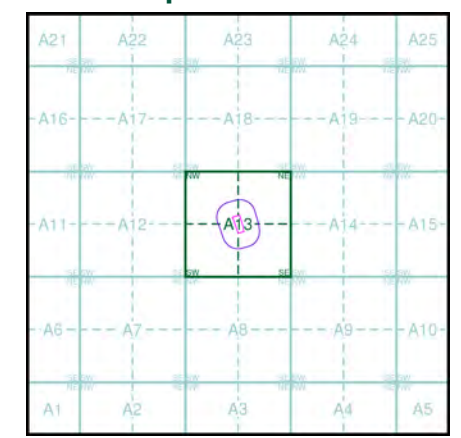
Source map scale - 1:10,560

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840's. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940's, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)

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1:10,560
03300
1885
1:10,560

Historical Map - Slice A



Order Details

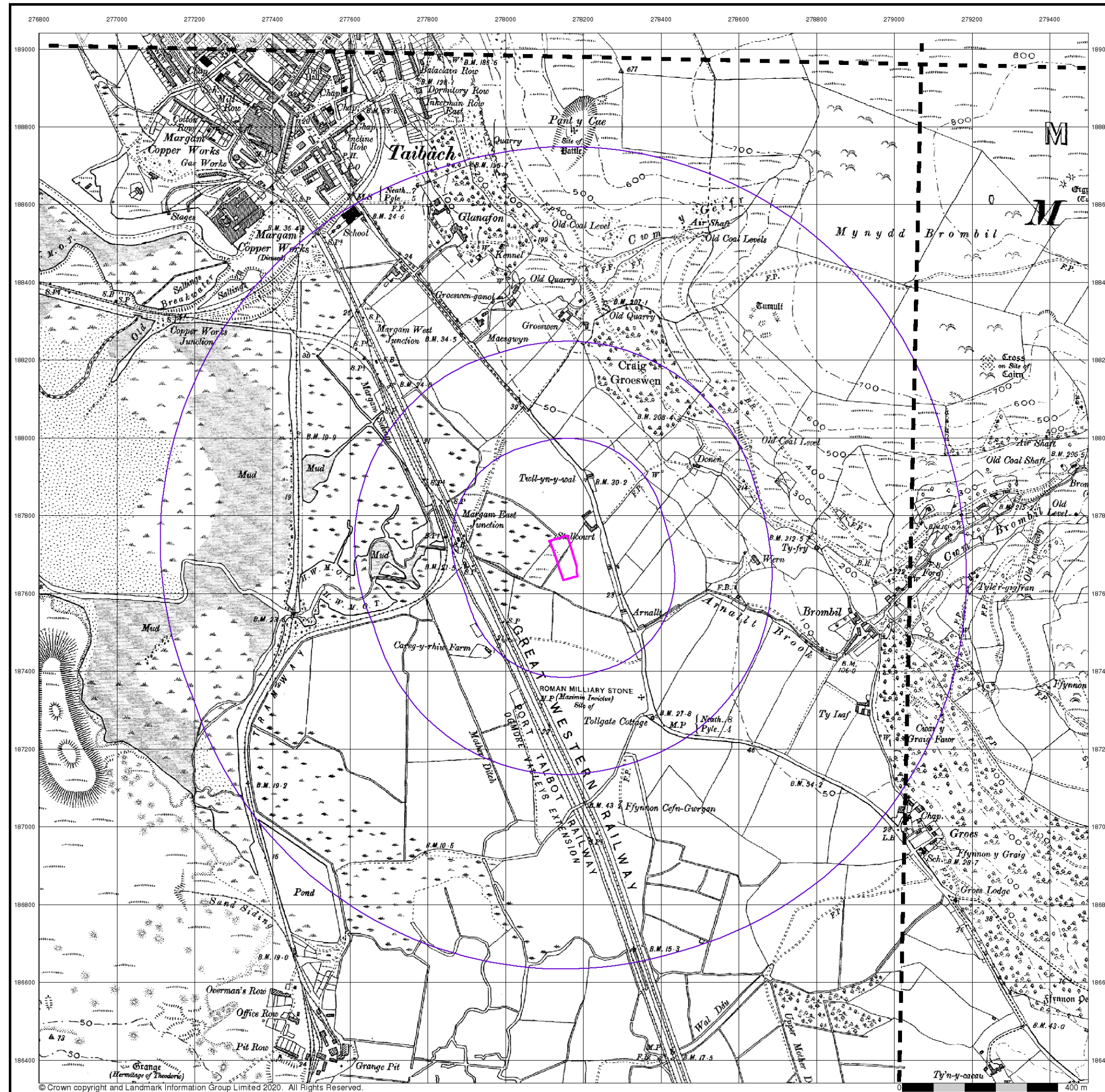
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Slice:	A
Site Area (Ha):	0.48
Search Buffer (m):	1000

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Fax: 0844 844 9951
Web: www.envirocheck.co.uk



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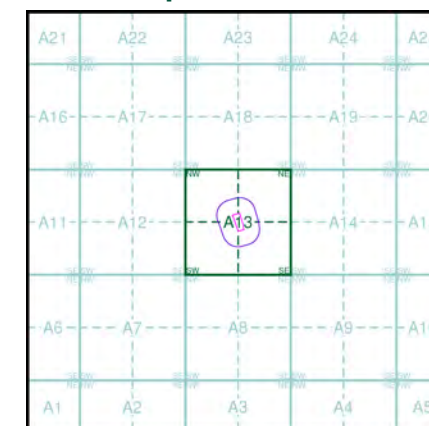
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Map Name(s) and Date(s)

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Historical Map - Slice A



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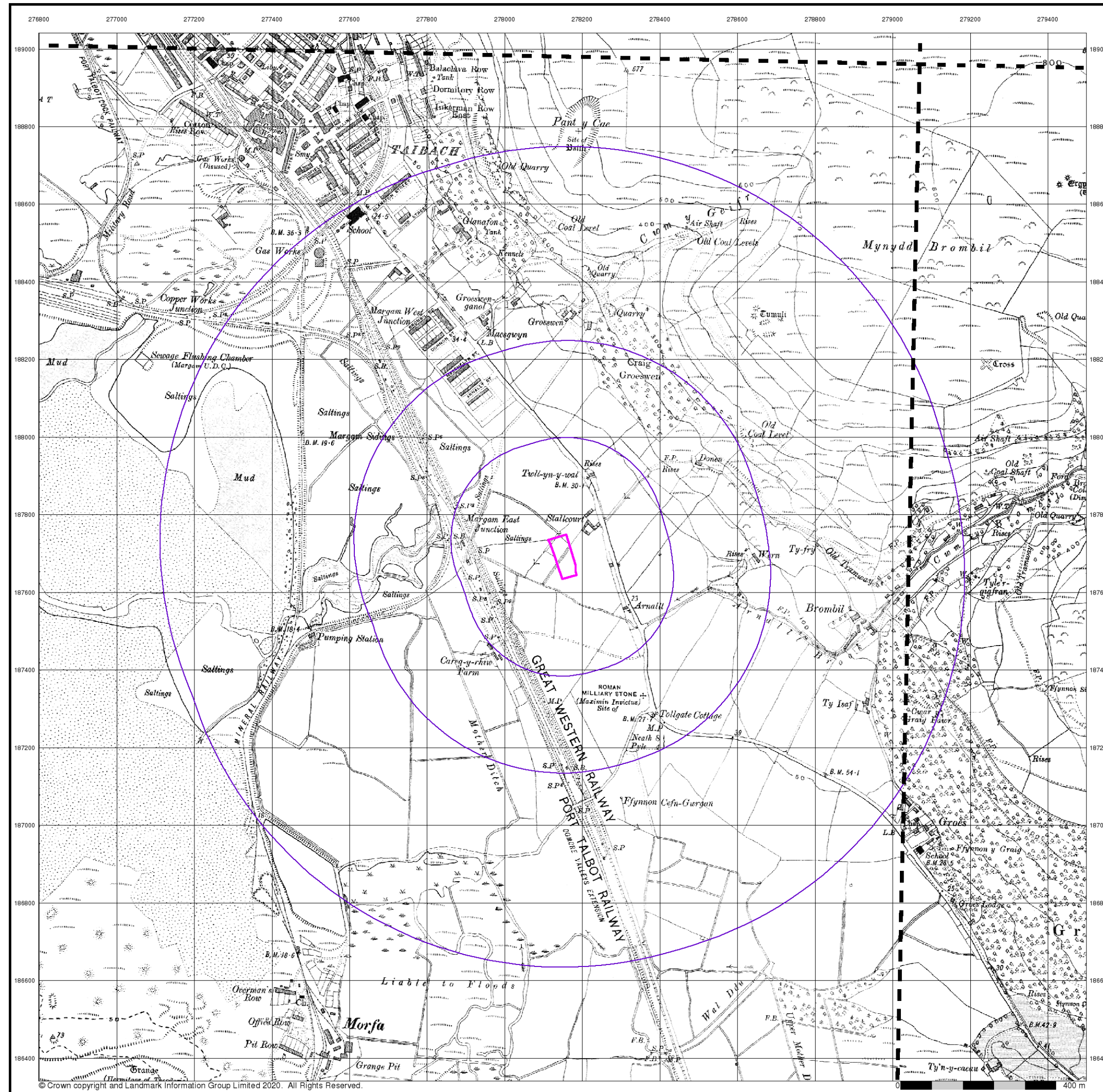
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Slice: A
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Published 1921

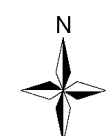
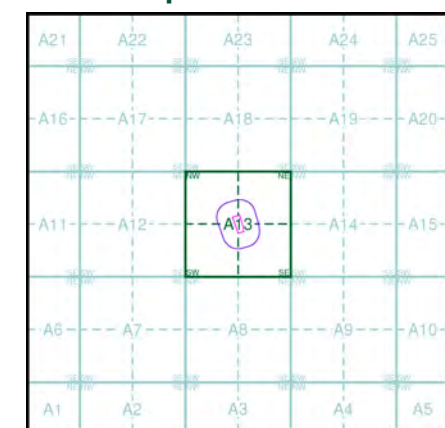
Source map scale - 1:10,560

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840's. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940's, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)

025SW 1921 1:10,560	025SE 1921 1:10,560
033NW 1921 1:10,560	033NE 1921 1:10,560

Historical Map - Slice A



Order Details

Order Number: 266059570_1_1
Customer Ref: Toronto Avenue, Margam, Port Talbot
National Grid Reference: 278150, 187690
Slice: A
Site Area (Ha): 0.48
Search Buffer (m): 1000

Site Details

Pant Celydd, Margam, Port Talbot, SA13 2DJ



Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk