

Landare Investments

Trefechan

Addendum to
Geotechnical Desk Study

Landare Investments

Trefechan

Addendum to
Geotechnical Desk Study

November 2007

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1 INTRODUCTION

Landare Investments Ltd propose to develop an area of land at Trefechan (North of Merthyr Tydfil) for residential use.

Arup were commissioned by Landare Investments Ltd to undertake an initial desk top survey of the site in order to assess the current ground conditions, including the potential for sink holes and solution features associated with the underlying geology, and identify any further issues with regard to the proposed end use of the site.

The geotechnical desk study was issued to Landare Investments Ltd in September 2007 (and is enclosed as Appendix A). The report identified that strong bedrock was likely to exist at shallow depth across a large part of the site and there was some evidence to indicate a possibility of solutional features that may relate to voiding in the underlying limestone.

The report recommended that a two stage investigation be undertaken at the Trefechan site to confirm the ground conditions. The first stage of the investigation would be a preliminary geophysical survey of the whole site in conjunction with trial pitting and Phase 2 would be a follow up investigation of any specific features identified in Phase 1, using geophysical techniques, should this be necessary.

This addendum presents the results of the first phase (Phase 1) of the recommended further investigation at the site. From these findings it was concluded that the further Phase 2 investigation was not required.

This report therefore presents geotechnical recommendations for the proposed residential end use, based on the desk study and investigations carried out in Phase 1.

2 GEOPHYSICAL SURVEY

The geophysical survey was undertaken between the 18th and 19th of September 2007 by Terradat and was observed by Arup. The Terradat Geophysical Report for the site is enclosed as Appendix B.

2.1 Survey Objectives

The objectives of the survey were to;

1. Locate anomalous features that may be associated with Karstic processes, generally and specifically investigate features identified in the desk study and site walkover as possibly solutionally related.
2. Provide information on the character of the shallow ground conditions.

2.2 Survey Design

The survey was undertaken using ground conductivity mapping (GEM-2) to map variations in the near surface material across the site. The conductivity data were acquired using a multi-frequency GEOPHEX GEM-2 instrument and data were acquired at a nominal 0.5m interval over all accessible areas of the site, at a line spacing of 5m. The data obtained using the GEM 2 instrument was downloaded and configured, and presented in planar format overlying the site area.

2.3 Survey Results

The results of the ground conductivity survey are shown on Figure 1. The results of the survey, which are described in detail in Terradat's report, can be summarised as follows (for each area of the site).

2.3.1 North Eastern Field

In the north east of the site, two fields displayed a generally anomalous character. The northern field indicated an increase in conductivity which may be attributed to a thickening of clay or overburden material, or an increase in moisture content of the shallow deposits.

A point anomaly was apparent in the east of the northern field, which was interpreted by Terradat to be related to a discarded motorcycle.

2.3.2 South Eastern Field

The most south eastern field exhibited a broad scattering of anomalies, much of which was attributed by Terradat to small metal debris across the field's surface. A subtle anomaly was identified close to the centre of the field, which was identified to potentially relate to geological processes, and hence may warrant further investigation.

2.3.3 Central Field (area of farm and bungalow)

No significant features were identified by Terradat in the central field of the site that could relate to Karstic features.

2.3.4 North Western Field

The boundary fence and demolition debris present on the field perimeter were identified by Terradat as the sources of the anomalies portrayed on Figure 1. No indication of possible features associated with Karstic processes was indicated from the survey.

2.3.5 South Western Field

Linear conductivity features were apparent along the road on the eastern boundary and the fence on the southern field boundary. These are related to anthropogenic features.

A slight increase in conductivity was apparent in the north eastern area of the site, possibly indicative of a gradual change in lithology or subtle thickening of the overburden.

2.4 Survey Conclusions

The ground conductivity plot from the geophysical survey delineated a number of features that appear to relate to both geological and artificial processes.

In terms of solution features, some isolated anomalies were indicated which may be related to Karstic processes. However, the form of the anomalies predominantly indicate widespread areas of conductivity changes rather than point locations, which is likely to be directly related to the geology underlying the site (in terms of superficial deposits) rather than solution features in particular. Where point anomalies were identified during the survey (indicated on Figure 1), attributable sources; such as metal debris, were observed and accounted for by Terradat.

It was apparent that the anomalies depicted by the geophysical survey did not coincide with the possible features identified during the original Arup geotechnical desk study; no previously identified feature was located in the areas where increases in conductivity were recorded during the geophysical survey; as shown on Figure 1, and summarised in Table 1 below.

Table 1 Correlation of Desk Study and Geophysical Survey Features

I.D	Notes	Geophysical Results
1	Large mound of artificially placed loose rocks partly vegetated with fern and bracken. Possible infill of depression.	No anomalies recorded in locality
2	Artificially placed loose angular rocks covered by bracken and fern shrubbery. Possible infill of shallow depression.	No anomalies recorded in locality
3	Deliberate mound of artificially placed loose rocks close to distinct break in slope (scarp dip) covered by bracken and fern shrubbery. Possible infill of shallow depression.	No anomalies recorded in locality
4	10m diameter circular pile of artificially placed angular cobbles and boulders of quartzite, indicating infilling of shallow depression.	No anomalies recorded in locality
5	Un-vegetated area amongst rough vegetation. Possible infill of depression	No anomalies recorded in locality
6	Possible identified sink hole (1967-2007) in approximate location of circular 4m diameter bonfire mark.	General vicinity of variations in conductivity no point anomaly identified
7	Evidence of formerly identified possible two sink holes (1989)	No anomalies recorded in locality
8	Slightly smaller mound of artificially placed loose rock with slight vegetative cover.	No anomalies recorded in locality
11	No evidence of formerly identified possible depression (1972)	In location of metal debris on site, causing increase in conductivity
E2	Line of stone wall from farm house falling towards south leading into a slight depression with a large pile of loose rocks.	No anomalies recorded in locality

As a result of the limited correlation between areas of high conductivity and features previously observed during the desk study, trial pits were excavated across the site in locations of both high conductivity and potential features identified from the desk study. The locations of excavations are summarised in Table 1 in Section 3.

3 TRIAL PITTING INVESTIGATION

The trial pitting investigation was undertaken by Arup on the 4th October 2007, following receipt and interpretation of the geophysical survey results.

3.1 Investigation Objectives

The main objectives of the trial pitting exercise were to;

1. Calibrate the geophysical works,
2. Investigate both specific features revealed during the geophysical survey and the potential features observed during the original Arup geotechnical desk study,
3. Investigate depth to bedrock
4. Identify subsurface conditions and any potential contaminative issues

3.2 Investigation Design

Eleven trial pits in total were excavated during the investigation. Trial pits were located to investigate the results of both the geophysical survey and the initial features identified during the site walkover and historic data review (Arup geotechnical desk study report Appendix A). For accuracy, and where necessary, a GPS was used to position the trial holes with reference to the co-ordinates of potential features listed in the Desk Study Report and those taken from the geophysical survey plan.

For reference, trial pits were labelled TH1-TH11 to correspond to the numbers given to potential features or landforms identified in the Arup geotechnical desk study report and G1-G5 to correspond to features identified during the geophysical survey.

A summary of the trial pits excavated is given in Table 2 below. Their locations are shown on Figure 2.

Table 2 Trial Pit Details

TH ID	NGR	Details/Reason for Excavation
TH1	SO 03365, 09116	Large mound of artificially placed loose rocks partly vegetated with fern and bracken. Possible infill of depression.
TH4	SO 03339, 08954	10m diameter circular pile of artificially placed angular cobbles and boulders of quartzite, indicating possible infilling of shallow depression. Depression follows line of scarp.
TH6	SO 03398, 08998	Possible identified sink hole (1967-2007) in approximate location of circular 4m diameter bonfire mark.
TH7	SO 03477, 09116	possible two sink holes from aerial photographs (1989)
TH8	SO 03346, 09137	Slightly smaller mound of artificially placed loose rock with slight vegetative cover.
TH11	SO 03456, 09148	formerly identified possible depression from aerial photographs (1972) and area of increased conductivity (although attributed to metal debris)
G1	SO 03356, 09016	Localised area of increase in conductivity possibly associated with thickening of over-burden over solution feature.
G2	SO 03382, 08966	Located in area identified to have a slight rise in conductivity; may be indicative of increase in clay overburden.
G3	SO 03419, 09133	Located in broad area of increased conductivity values indicative of a broad thickening of clay rich overburden.

TH ID	NGR	Details/Reason for Excavation
G4	SO 03442, 09094	Located in broad area of increased conductivity values indicative of a broad thickening of clay rich overburden.
G5	SO 03490, 09080	Localised area of increase in conductivity possibly associated with thickening of over-burden over solution feature

3.3 Ground Conditions Encountered

The logs of the trial pits excavated are included in Appendix C, and some photographs of the excavations illustrating the material encountered are enclosed in Appendix D.

3.3.1 Fill

Loose piles of cobbles existing at surface level were observed during the site walkover and interpreted as possible fill on site. Three locations were excavated where rock piles existed. The only noticeable variation was observed in TH4, which was excavated within the large historic rock pile in the south west of the site. Loose quartzite cobbles were encountered up to 0.8m in thickness (expected due to stockpile size) beneath which a very dark layer of decaying vegetation and roots was observed. Beneath the vegetation a layer (0.7m in thickness) of grey soft sandy clay existed which on initial observation appeared almost ashy. Underlying the light clayey material, slightly clayey gravelly sand was encountered, consistent with the glacial deposits encountered elsewhere across the site, (and beneath the other two rock piles excavated). The glacial deposits are described below.

3.3.2 Superficial Deposits

Superficial deposits were encountered across the whole site at a greater thickness than anticipated from the desk study and site walkover.

The superficial deposits encountered comprised glacial deposits consisting of mixtures of clayey silts, sands and gravels with cobbles of limestone and quartzite throughout and boulders increasing in frequency with depth. The material was generally granular, loose to medium dense in consistency and averaging 2.6m in thickness. In areas where the clay and silt content was slightly higher, the material was damp, and appeared soft to firm.

Excavation of the pits generally became more difficult with depth as a result of the increasing boulder and cobble content, which on a number of occasions was the reason for trial pit termination. In northern and eastern areas of the site, large fossiliferous bearing limestone slabs were encountered, generally at about 2m below ground level, and hence a slight decrease in thickness of granular glacial deposits was observed to occur from the south west to the north east of the site.

Apart from the obvious piles of quartzite cobbles and boulders at the surface in a number of trial pit locations, no evidence of any materials indicative of filling were encountered in the trial pits. One piece of wood was found in TPG5, which appeared to be from an old fence post and probably fell into the pit during excavation. The superficial deposits are therefore interpreted as natural glacial deposits.

Bedrock is exposed at surface level immediately to the north west of the site on the scarp slope which runs along the boundary of the site (see Figure 3). The superficial deposits are therefore interpreted as deposited along the glacier margins. Their comparatively loose condition is typical of this depositional environment.

With the exception of minor variations in silt, clay, gravel and sand content, the glacial deposits encountered across the site were relatively uniform; generally becoming more granular with an increasing cobble and boulder content with depth.

3.3.3 Bedrock

Bedrock was not proved during the trial pitting investigation. However it is reasonable to assume that in instances where a high frequency of limestone slabs, boulders and cobbles were encountered the trial pits were relatively close to the top of bedrock strata.

Ground conditions at the site have been summarised in Table 3 below;

Table 3 Ground Conditions

Strata	Thickness (m)	Description
Silty Topsoil/vegetation, loose rocks	0.1-0.8	Loose, occasionally clayey SILT with many rootlets. Often damp.
Silt and Decaying organic matter	0.1	Encountered beneath stockpiles of loose rock (TH8, TH1, and TH4)
Sandy Clay	0.7	Encountered in TH4 only. Grey soft, damp sandy clay with quartzite fragments/pebbles
Mixtures of clayey silts, sands, and gravels	1.6-2.85m	Granular mixtures of silts, sands, gravels, and clay, with frequent limestone and quartzite fragments, cobbles, and occasional boulders. Limestone slabs encountered generally from 2m below ground level in northern and eastern excavations. One piece of wood encountered (G5)
Silty sands and gravel matrix between limestone boulders, slabs and cobbles	0.2-0.7 (thickness unproved)	Difficult to excavate granular matrix of silty sands and gravels between frequent boulders, slabs, and cobbles of occasional quartzite and primarily limestone.

3.4 Investigation of Possible Solution Features

3.4.1 Features Observed During Geotechnical Desk Study

The trial pitting investigation encountered no evidence of possible solution features in the localities identified in the Geotechnical Desk Study (historic data review and walkover). All superficial deposits encountered in the excavations in these localities were observed to be of relatively the same nature as elsewhere on the site; comprising natural glacial deposits. No evidence of any sinks or depressions were apparent during excavation of the trial pits. There was no evidence to suggest that piles of cobbles and boulders had been used to infill depressions, and where the rock piles existing at surface level were investigated (TH1, TH4, TH8) they did not extend to significant depths, and were not indicative of being used as backfill for a depression. The loose rocks were instead underlain by a layer of decaying vegetative matter, indicating that they had been placed directly upon the grassy surface of the site.

3.4.2 Geophysical Features (G1, G2, G3, G4, & G5)

Trial pits were excavated where the results of the geophysical survey indicated localised increases in conductivity potentially related to thickness of overburden, and hence possible solution features.

Trial pits excavated in these localities did not encounter any evidence of deliberately placed fill; rather the superficial deposits were consistent with those generally encountered across the site. If the depths at which frequent boulders and limestone slabs were encountered in all trial pits are compared (interpreted as being close to bedrock), little difference is seen between thicknesses of superficial deposits in trial holes excavated in conjunction with the

geophysical survey results (where thickening of overburden was identified during the geophysical survey) and other areas of the site.

3.5 Contamination

3.5.1 Sampling and Analysis

Soil sampling and subsequent laboratory analysis was undertaken during the trial pitting investigation in order to ascertain the contaminative nature of the site, and identify any resulting issues with regard to its proposed residential end use.

Historically the Trefechan site has remained relatively undeveloped and consequently the risk of subsurface contamination is considered low. For this reason only four soil samples (thought to be representative of subsurface conditions across the site) were sent for laboratory chemical analysis. The samples were obtained from trial pits G3, G5, TH1 and TH6 as to provide good spatial coverage of soils across the site area.

Samples were analysed for a number of chemical determinands including heavy metals, sulphate, pH, total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAH). The results of the chemical analysis undertaken on the soil samples are enclosed as Appendix E, and the results are summarised below.

3.5.2 Analysis Results

The soil analysis results have been compared to CLEA residential and CLEA residential with plant uptake guideline values. In the absence of CLEA values, LQM Generic Assessment Criteria guidelines for residential and residential with plant uptake land use scenarios were used for comparison.

Inorganics

All concentrations of inorganic contaminants were recorded well within both CLEA residential guidelines and the Land Quality Management Generic Assessment Criteria guideline values.

Concentrations of cyanide, for which no guideline values exists, were recorded at levels less than the laboratory test detection limit of 0.6mg/kg, and therefore cyanide is not regarded a cause for concern with regard to future site development.

Organics

Concentrations of polycyclic aromatic hydrocarbons (PAH) were recorded as predominantly less than the laboratory test detection limit of 0.1mg/kg and are therefore not considered significant or a cause for concern.

Total petroleum hydrocarbons (TPH) were recorded at relatively low concentrations within the soil samples; ranging from 11.5mg/kg to 33mg/kg. Such concentrations are not considered elevated nor thought to present any significant risk to developers, or future end users of the site.

3.6 Trial Pitting Conclusions

Glacial deposits were encountered across the whole site area, at thicknesses up to 4m. Deposits were granular in nature, loose to medium dense, with varying silt, clay, sand and gravel content, becoming more cohesive and soft to firm in places. A slight decrease in thickness of the granular deposits was observed to occur from the south west to the north east of the site. No groundwater was encountered in any excavation.

Intact bedrock was not proved in any excavation; although where a high frequency of boulders and limestone slabs was encountered (making excavation difficult) it is likely that the pits were close to rock head.

No evidence of any solution features was encountered during the trial pitting investigation. The superficial deposits encountered across the site were generally of the same nature; no

indication of any made ground or backfill was observed to exist at point locations. In addition, depressions were not evident from any significant changes in thickness of overburdening glacial deposits or from the appearance of the hard rocks encountered at depth within the pits.

The geophysical survey also detected no anomalies which would be attributable to voided ground associated with the features identified in the geotechnical desk study and walkover survey.

Chemical analysis undertaken on soil samples obtained from the site indicated there to be little risk of subsurface contamination which would affect any future development on the site.

3.7 Ground Survey Results

A survey of the site was undertaken in September 2007 to determine current ground levels across the site. The survey plan is enclosed as Figure 4.

From the survey, it can be seen that ground levels generally slope from the north west of the site towards the south east and south west.

The north western site boundary lies at 318mAOD while the southern site boundary generally lies at 288mAOD. From the survey results it can be seen that the central north western and western regions of the site are the steepest areas of the site, indicative of the underlying geology and in particular the scarp slope of the adjacent quartzite of the Millstone Grit outcrop.

4 GEOTECHNICAL RECOMMENDATIONS

4.1 Summary of Ground Conditions

The intrusive investigation undertaken at the Trefechan site encountered glacial deposits across the whole site area, at thicknesses up to 4m. Deposits were granular in nature, loose to medium dense, with varying silt, clay, sand and gravel content.

The glacial deposits encountered during the investigation have indicated bedrock to exist at a greater depth than originally anticipated. However, the scarp slope of the Millstone Grit exists immediately west of the site close to the site boundary, and therefore along western site margins, bedrock may remain at shallow depth.

No groundwater was encountered in any excavation, and no evidence of fill was observed on the site, other than the piles of quartzite cobbles existing at surface level in the south west and northern site areas. Such rock piles did not extend to any depth beneath the surface of the site, and were therefore not indicative of backfill used to infill depressions.

No evidence of any solution features was encountered during both the trial pitting investigation and the geophysical survey.

4.2 Proposed Development

It is anticipated that the site will be developed for residential use. However at present no layout for any proposed development or proposed site levels for house platforms, roads or the inverts of drains and manholes have been received by Arup. When such development plans and specific details are received, the following recommendations will need to be reviewed and possibly amended in light of the detailed proposals.

4.3 Site Preparation and Earthworks

Prior to construction of the development, vegetation, topsoil and isolated areas of fill (principally the piles of cobbles and boulders identified) will need to be stripped. The topsoil is suitable for reuse in domestic gardens and landscaping, and may be reserved for final reinstatement of the site. Any surplus should be removed and disposed of in accordance with current legislation, or alternatively recycled for use on other sites.

Other than the above, little additional site preparation is considered necessary, except for keeping a watching brief for unexpected materials or ground contamination not revealed by the investigation, see Section 4.6.

It is anticipated that earthworks will be kept to the minimum necessary to prepare level platforms for development of individual house units and that generally, the finished site levels will follow existing levels. On this assumption, excavations will be within the glacial deposits and should be easily carried out using conventional mechanical excavators. However, it should be realised that excavations for foundations and service runs may locally encounter difficult conditions in boulders or weathered rock. The areas most at risk are the uphill sides of excavated platforms for houses and the extreme west/north perimeter of the site.

No earthworks control tests have been carried out on the in-situ glacial deposits. In their existing condition it is considered that they are likely to be wet of optimum and not acceptable for re-use as engineered fill beneath structures. However, with some drying out, they would become acceptable. See also discussion of foundation options below.

4.4 Service Runs

As mentioned above, service runs for the proposed development may locally encounter difficult excavation conditions due to boulders and weathered rock.

During the site investigation, boulders/weathered rock were encountered across the whole site area at relatively consistent depths. No particular area of the site was identified to indicate a higher or lesser frequency of boulders/weathered bedrock and therefore the deposits are not considered as localised or area sensitive.

Occasional boulders were encountered during excavations at an average depth of 1m below ground level, with the frequency of boulder occurrence increasing below this depth. A higher density of boulders was encountered in excavations typically at around 2m (below ground level), while trial pits became increasingly difficult to dig due to boulder and rock content at around 2.5m below ground level.

It is likely that some boulders will be encountered within service runs and earthworks on site at approximately 1m below ground level, with excavations becoming progressively more difficult beyond this depth; particularly so at around 2m. Such assumptions are however solely based on the results of the trial pits excavated at the site, and there may be some variations across the site.

4.5 Foundations and Floor Slabs

Two foundation options are considered feasible for conventional two storey housing on the site, lightly reinforced strips or lightweight flexible rafts.

Conventional strip foundations taken a minimum of 0.5m into the undisturbed glacial soils and penetrating at least 1.0m below finished ground level is a viable option. A bearing pressure of 100 kN/m² is recommended to proportion the foundations. Because of the loose nature of the ground and the residual, albeit low potential for disturbance due to solution features, it is recommended that the strips are lightly reinforced to be capable of spanning up to 2m. If this option is preferred, suspended floor slabs are recommended.

Alternatively, reinforced, flexible raft foundations could be used for the proposed development, founded on cut-fill platforms with the fill depth not exceeding 1m. The rafts should incorporate downstand edge beams penetrating a minimum of 0.6m below finished ground level, using a maximum bearing pressure of 50 kN/m². If this option is preferred, it will be necessary to create level cut-fill platforms on which the rafts would be founded. If the in-situ glacial soils are to be reused as fill it would be necessary to carry out earthworks control testing to determine optimum moisture content and also to monitor the moisture content of the fill throughout construction, as defined in an appropriate specification for engineered fill. It is also probable that some conditioning of the glacial soils would be needed to reduce their moisture content to an acceptable level. An alternative would be to use imported granular fill to create the platform.

4.6 Description of Roads and Hardstanding

It is anticipated that formations for roads and hardstandings will be within the glacial soils. A California Bearing Ratio of 3% is recommended for the design of roads and hardstandings in this material. The formation should be proof rolled and any particularly soft or loose areas excavated to an additional depth of 200mm and replaced with well compacted granular material.

4.7 Ground Contamination

Chemical analysis undertaken on soil samples obtained during the trial pitting investigation indicated no contaminants of concern to exist within the subsurface of the site. On the basis of the chemical analysis results, and given the site has remained historically relatively undeveloped, it is unlikely that future site development will encounter any contamination within the subsurface, and risks to end users of the site from any potential contamination is considered to be low. Nevertheless, a careful watch should be maintained, and should any visual or olfactory evidence of contamination be encountered during earthworks on site, the potentially contaminated material should be stockpiled on an impermeable membrane and

covered to protect it from rain. It should then be tested and dealt with accordingly. Despite there being little risk of contamination within the subsurface, it is recommended that appropriate PPE (as in all site developments) is worn by all construction workers involved in future site works and that good hygiene practice is adopted.

4.8 Ground Gases

Landfill gases are not anticipated to exist within the subsurface of the site, and therefore are not expected to present a risk to future site development.

However, due to the nature of the strata underlying the site, a Radon Protective Measures Site Report was previously obtained (from the British Geological Survey) and is enclosed as Appendix F. The report indicates that full radon protection measures are required in the construction of new dwellings on site. For further information on the protective measures required, a detailed or follow up radon protective measures site report may be requested from the BGS.

FIGURES

Figure 1 Geophysical Survey Results

Figure 2 Trial Pit Location Plan

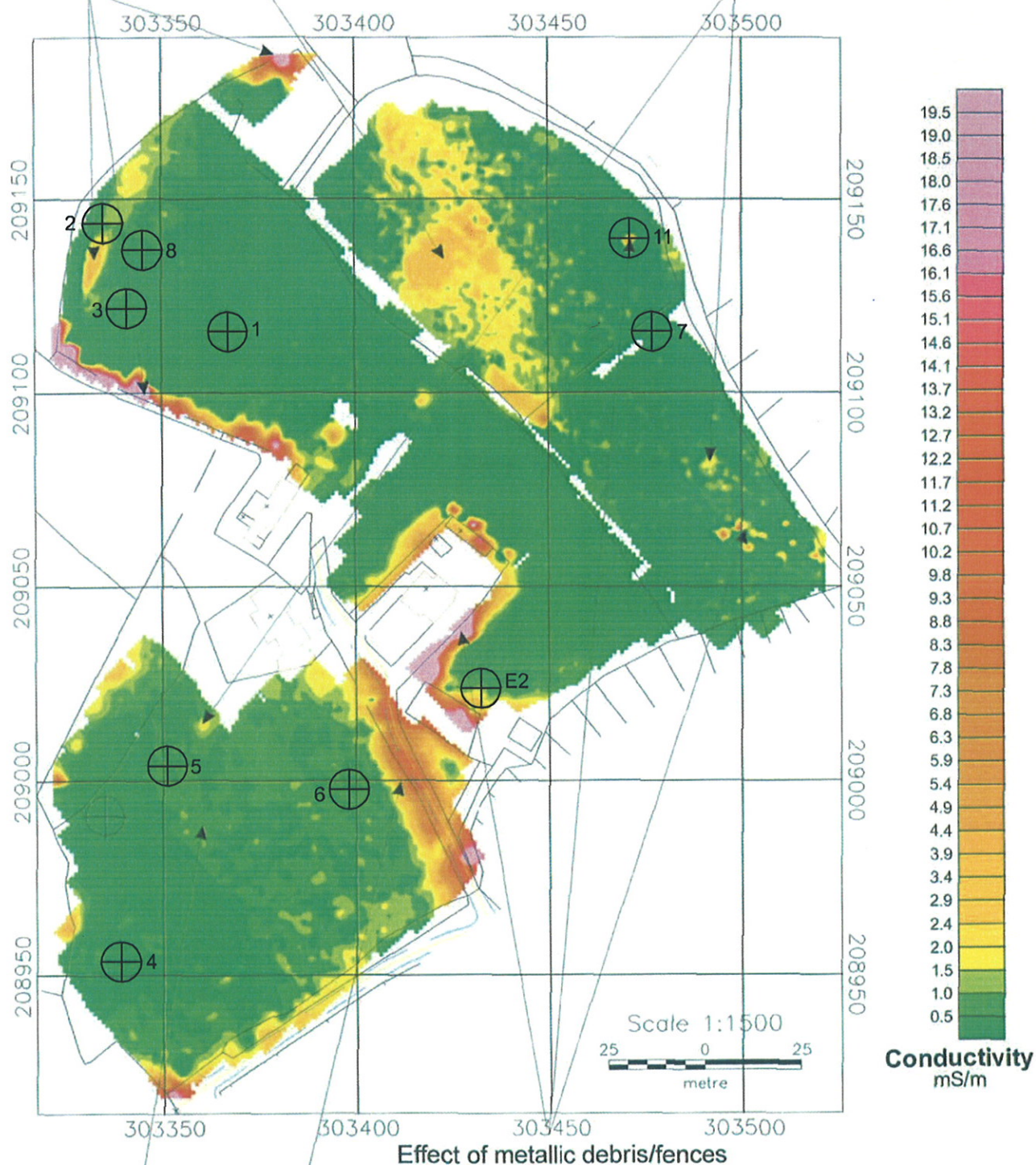
Figure 3 Geology Plan

Figure 4 Survey Plan with T.P Locations

Broad area of increased conductivity values
indicative of a broad thickening of clay-rich overburden

Localised increase in conductivity may be associated with
thickening of overburden over a solution feature

Effect of fences



Linear conductive feature may be
related to services associated with road

Slight rise in conductivity values
may be indicative of an increase
in thickness of relatively clay-rich overburden

⊕ - Previously observed features

Geophysical Survey Results

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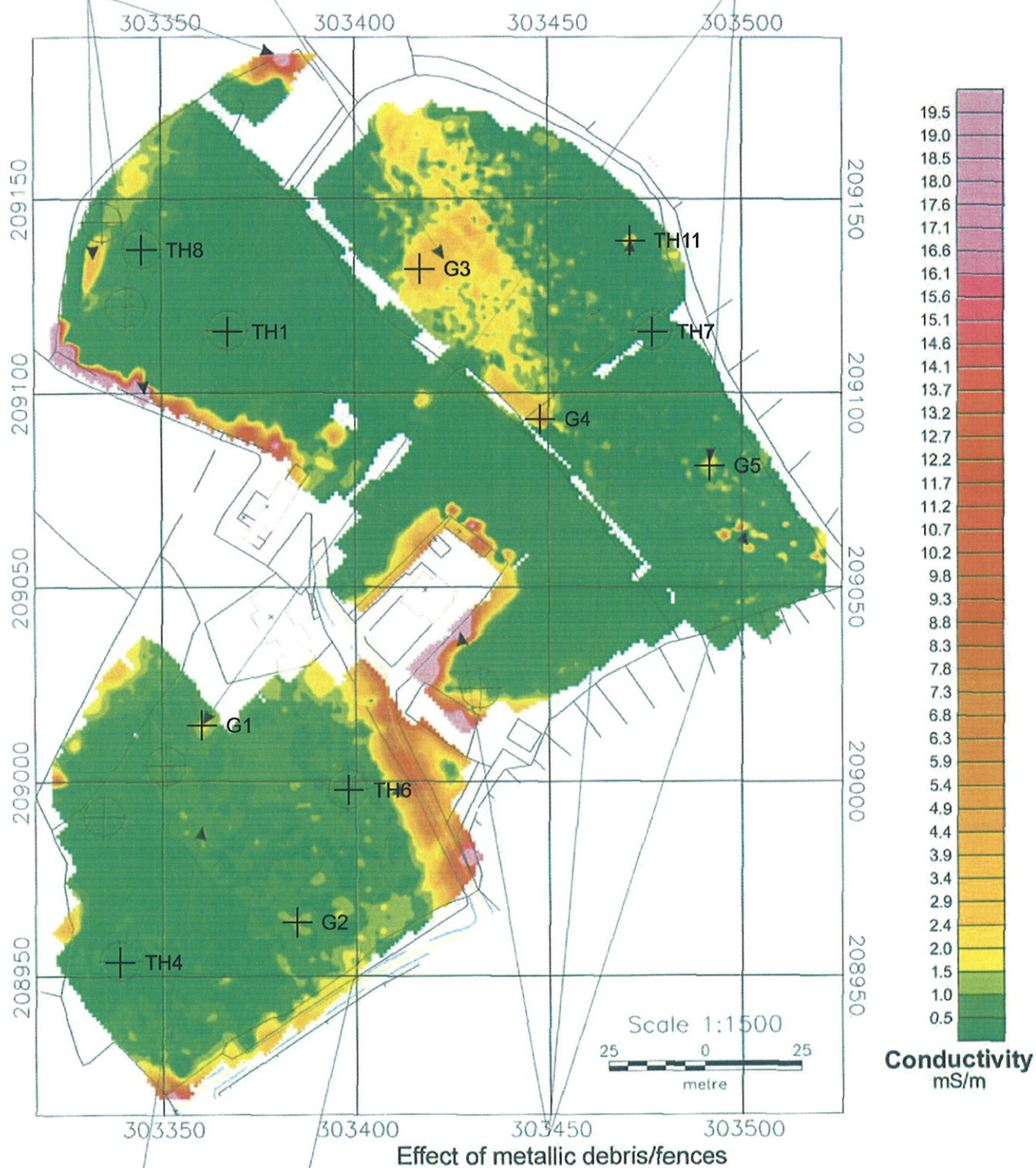
FIGURE

1

Broad area of increased conductivity values
indicative of a broad thickening of clay-rich overburden

Localised increase in conductivity may be associated with
thickening of overburden over a solution feature

Effect of fences



Effect of metallic debris/fences

Linear conductive feature may be
related to services associated with road

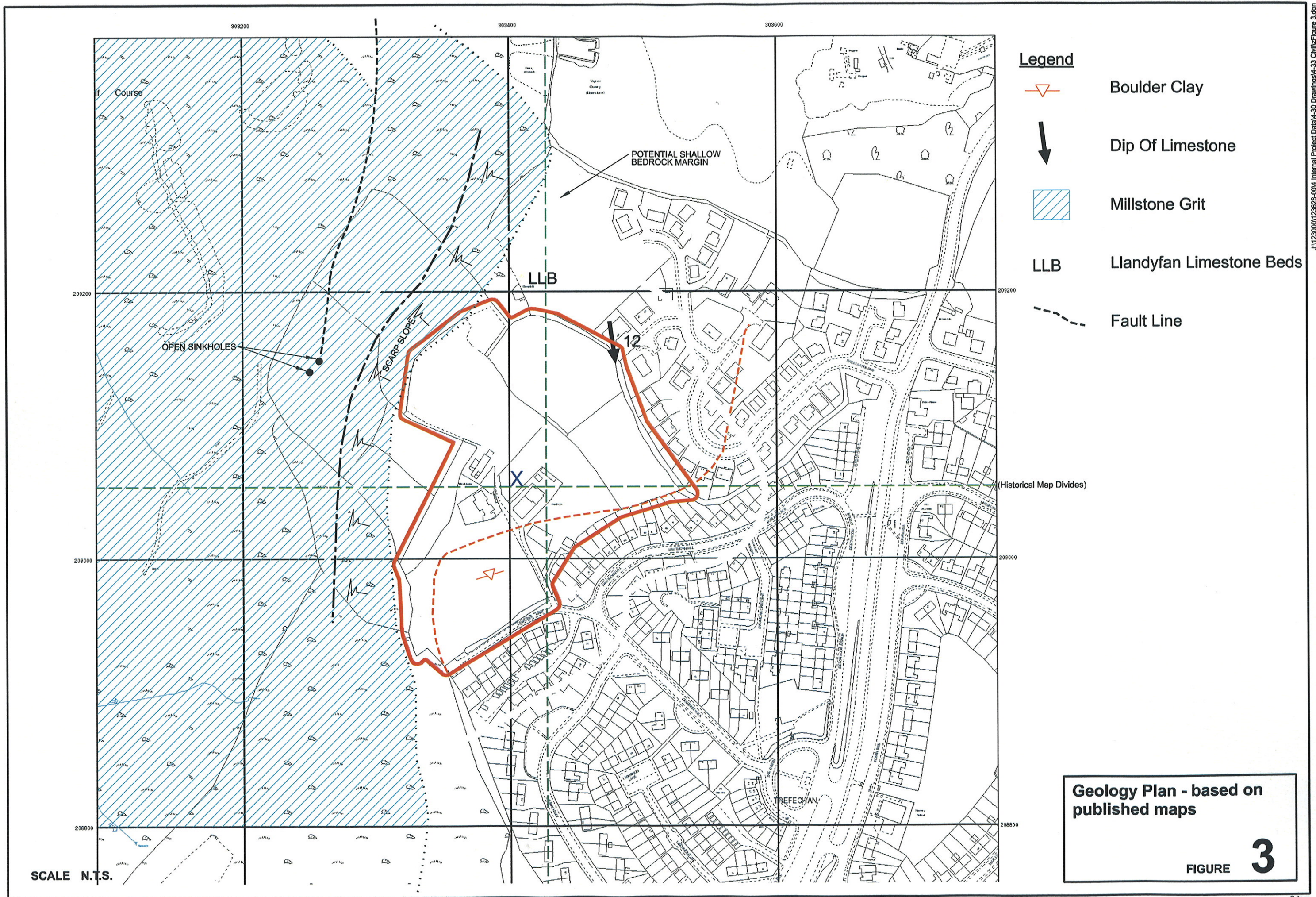
Slight rise in conductivity values
may be indicative of an increase
in thickness of relatively clay-rich overburden

Trial Pit Location Plan

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FIGURE

2





Foot of Millstone Grit Scarp



SCALE 1:1000

Ground Level
Survey Results

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FIGURE

4

Appendix A

**Geotechnical Desk
Study Report**

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Geotechnical Desk Study

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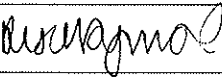
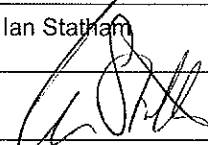
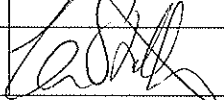
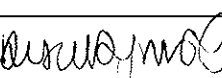
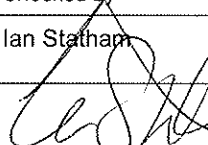
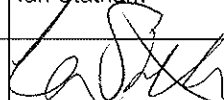
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Appendices

Appendix A
Aerial Photograph List

1 Introduction

Landare investments Ltd propose to develop an area of land at Trefechan (north of Merthyr Tydfil) for residential use.

Arup have been commissioned by Landare Investments Ltd to undertake an initial desk top survey of the site, in order to assess the current ground conditions, including the potential for sink holes and solution features associated with the underlying geology, and identify any further issues with regard to the proposed end use of the site.

As part of this study Arup have undertaken a site walkover, a historic review of the site area, and examined relevant geological memoirs pertaining to the site.

This report presents the findings of the geotechnical desk study and the recommendations for further work to be undertaken prior to development of the site.

2 Site Location and Layout

The site is located at Trefechan, North of Merthyr Tydfil in South Wales. It comprises approximately 3.76 hectares of land centred on National Grid Reference (NGR) 303400, 209100, as shown on Figure 1.

The site currently comprises open rough pastureland and scrubland divided by stone wall boundaries and fencing. Caerllwyn Farm and a bungalow located in the central site area are the only two dwellings currently occupying the site. The buildings are accessed via the only existing site road which runs from the south of the site, northwards before passing between the two buildings. Rough tracks are located around the farmhouse, however generally no designated walkways exist within the site area, and hence access across the site is limited by dense vegetation growth (particularly in western regions) and the field boundaries. To the south the site is bounded by a residential estate, within which Crabtree Walk runs northwards, leading onto the main site access road. Further residential development is under construction immediately east of the site boundary, while to the north and west, grassland and scrub extend over the hillside. The current layout of the site is shown on Figure 2.

The site slopes from the north-west to the south and south east, the ground level varying between 317mAOD (north western perimeter), to 287mAOD (south eastern perimeter). To the north-west and north of the site the ground steepens onto a low scarp slope before levelling out again onto the mountain top.

3 History

The history of the site has been researched from historical Ordnance Survey (OS) maps dated between 1885 and 1999, and from aerial photographs dated between 1947 and 2000. The aerial photographs were viewed at the Central Register of Air Photography for Wales, National Assembly Building in Cardiff. The list of photos viewed is enclosed within Appendix A.

3.1 Ordnance Survey

In 1885 the site predominantly comprised fields of rough pasture divided by trees, with the exception of the northern field of the site which comprised rough grassland with boulders and rock at surface level (see Figure 3a). Small buildings, likely to be farm holdings existed on the south eastern perimeter, and a sheepfold was located on the northern perimeter. Rough grazing and pasture land surrounded the site to the northeast, and southeast, while rough grassland and rock scarp extended to the west across the hillside. Vaynor House was located to the south of the site while Ty Newydd Farm existed to the east. A well was located adjacent to the Ty Newydd farm building, and a small stockpile, likely to be related to the farm, existed approximately 15m from the eastern site boundary. A limekiln and Vaynor Quarry were located over 350m north east of the site, while a further limekiln and two quarries existed 400m south of the site. A small depression/sinkhole in the landscape was evident 150m west of the site boundary.

By 1900 little change had occurred to the site and it remained undeveloped rough pastureland, as did the surrounding area. The stockpile of material adjacent to Ty Newydd Farm was no longer shown, and the limekilns north east and south of the site were annotated as "old". Vaynor Quarry had expanded significantly, and two further quarries had been developed to the north and south of the site boundary; the southern quarry replacing one of the formerly identified which was now annotated as old. The rough grassland west of the site was annotated as a rifle range.

A number of trees previously bordering the fields within the site had been removed by 1919, and the rock and boulders at surface level in the north of the site were no longer annotated on the plan (See Figure 3b). The collection of small buildings on the south eastern perimeter remained, as did Vaynor House and Ty Newydd Farm to the south and east. The well previously adjacent to Ty Newydd was no longer shown. Quarries remained to dominate the landscape surrounding the site. A number of gravel pits existed in the location of the now closed quarries to the south of the site. The depression/sinkhole was still evident west of the site boundary in the rough grassland.

The site remained relatively unchanged from this date until 1961, although residential development east of the site boundary had started by 1952.

The 1961 historic plan is enclosed as Figure 3c and showed that residential development had extended to border the site in the south and east. Caerllwyn Farm and the currently existing bungalow had been built in the centre of the site. The small holdings on the south eastern perimeter had been extended; likely to be associated with the construction of Caerllwyn Farm. The site access road (previously a path between fields) had been constructed and ran northwards towards the new dwellings. The north western field appeared as pastureland, the rough grassland and sparse trees being no longer annotated. Vaynor House had been demolished as part of the extensive residential development south of the site boundary; however Ty Newydd Farm remained to the east. The sink hole west of the site remained. Vaynor Quarry was the only remaining quarry to be annotated outside the site boundary. All the others had been closed, although their outlines remained visible on the landscape.

Little change to site and surrounding area occurred between 1961 and 2006. The rifle range west of the site had become disused by 1964, and by 1993, Ty Newydd Farm had been demolished and replaced with further residential development extending along the east and south east of the site boundary (see Figure 3d). A sports ground had been constructed in the location of the former quarries south of the site, however Vaynor limestone quarry remained and is currently still operational.

On the 1993 plan, two springs were annotated approximately 300m from the western site boundary, the stream water from which ran towards the south east, following the topography of the landscape. By 1999 sinks were indicated downstream from the springs south west of the site boundary and Caerllwyn Farm had been slightly extended. Residential development continued to extend along the east of the site area, encompassing the north east of the site by 2006.

3.2 Aerial Photography

In 1947 Caerllwyn Farm existed in its present day location in the central site area. In the field south west of the farmhouse, the land appeared as rough grassland, bordered by dense shrubbery and sparse woodland. On the south western perimeter of the field, a prominent circular clearing existed. Un-vegetated, the area appeared to consist of rock at surface level. A further clearing was observed to exist in the north of the field, west of the farm building. Although not notably circular, the area appeared similar to that on the south west perimeter, appearing as a clearing amongst rough vegetation, with rock at surface level.

The northerly site field appeared divided in two; the western half appearing worked and relatively un-vegetated, while the eastern side appeared well kept farmland. Within the western field area, three features were observed to exist, indicative of slight depressions on the landscape. The eastern area of the site was well kept grassland, divided into two fields by a line of trees. In the south east of the site farmland with limited vegetation cover existed.

By 1967 Caerllwyn Farm had been slightly extended, and the bungalow had been constructed, the buildings separated by intermittent woodland. The areas of un-vegetated rock at surface level remained along the south western field boundaries and a further area of clearance was observed just west of the south western tip of the site (outside the site boundary). Opposite the areas of clearance in the south western field, close to the south eastern site boundary, a small dark circular feature was observed, within the grassland.

The northern field was no longer divided in two, but appeared as one area of open rough grassland. The three previously observed possible depression features now appeared as four distinct areas of slightly elevated rock piles, prominent within the thick vegetation cover. It is anticipated that the most northerly depression feature observed on the 1947 photograph is represented by the two most northerly rock piles observed on the photo. The remaining site area remained an assortment of rough grassland and well kept farmland.

To the north west of the site, two distinct sink holes existed side by side, their depressions on the landscape clearly visible as a result of the shadows cast by the sunlight. These prominent features, which exist today, are plotted on Figure 2.

Little change had occurred to the site by 1972, the most southerly possible rock infilled depression in the northern field of the site appeared circular in shape, and some clearance of vegetation on the north eastern site perimeter had occurred. The previously observed dark circular feature in the south west field (close to south eastern boundary) was no longer visible. A further small possible depression was observed to exist on the landscape in the north eastern site area, however this was not observed on the following 1975 photograph, which showed little other change to the site.

By 1985 the site remained predominantly open rough grassland and farmland with the farm building and bungalow located in its centre. The field south west of the farm building still contained "clearings" where rock appeared at surface level on its south western and north western field boundary. The four rock piles in the northern site area remained, and the two large sink hole features west of the site (outside the site boundary) remained prominent. A small stockpile of what is interpreted as soil existed in the south east of the site.

By 1989 a distinct brown circular feature was observed to exist in the south western field, south of the farm building. The feature appeared relatively close to the possible depression feature observed on the 1967 aerial photo. Dense vegetation appeared to cover the western regions of the site, while the eastern site area remained as well kept farmland. Just south of the line of trees dividing the eastern site area, two possible circular depressions in the landscape were observed. These features were not observed on any photos after this date.

In 1991 construction of the housing along the eastern site perimeter was underway, and the farm building in the central site area appeared to have undergone some minor extensions and alterations. A small clearing within the woodland and shrubbery between the farm buildings existed towards the east of the site. The potential circular sink hole remained south of the farm buildings in the south western field, as did the un-vegetated rock areas on the south western and north western field perimeters. The four rock piles in the northern field remained, the most southerly continuing to display a prominent circular shape.

By 2000, the area of rock at surface level on the northern boundary of the south western field was no longer visible, appearing to have been covered in vegetation. The clearance on the south western perimeter and possible sink hole south of the farm building remain prominent features on the landscape. The former piles of rock in the northern field appeared to have been vegetated over, although remained visible.

3.3 Historical Features Summary

The review of available historic O.S plans and aerial photos indicated that a number of potential solution features exist on and in the vicinity of the site. The features noted from the historic review are summarised in the table below and are plotted on Figure 4.

Table 3.3 Historical Review Summary

I.D	Initial Observation Date	Feature	Source	Notes
1	1947	Possible Infill of surface depression with M.G./rubble	NAW Aerial Photos 1947-2007 Indicated on historical O.S plans from 1885-1900	Remains prominent at surface level on current aerial photos. Distinct circular shape
2 & 3	1947	Possible Infill of surface depression with M.G./rubble	NAW Aerial Photos 1947-2007 Indicated on historical O.S plans from 1885-1900	Remains on current aerial photos. I.D 2 has decreased in size since 1947 (see feature 8.)
4	1947	Circular un-vegetated area amongst rough vegetation. Possible infill of depression	NAW Aerial Photos 1947-2007	Remains prominent at surface level on current aerial photos.
5	1947	un-vegetated area amongst rough vegetation. Possible infill of depression	NAW Aerial Photos 1947-1991	Not visible on aerial photos after 1991
6	1967/1989	Possible sink hole	NAW Aerial Photos 1967-2007	Distinct sink hole shape apparent at later date
7	1989	Possible sink holes	NAW Aerial Photo 1989	Not evident from any other photo or source prior to or after 1989
8	1947/1967 (see notes)	Possible infill of likely depression	NAW Aerial Photos 1967-2007	Likely to have once been part of feature 2.
9	1967	Sink Hole	NAW Aerial Photos 1967-2007	Remains evident on current aerial photos. Outside site boundary
10	1967	Sink Hole	NAW Aerial Photos 1967-2007	Remains evident on current aerial photos, outside site boundary
11	1972	Possible Evidence of Depression	NAW Aerial Photo 1972	Not observed prior to or after 1972

4 Geological Summary

4.1 Published Geology

The geology of the site has been reviewed from the British Geological Survey, 1:50000 scale sheet 231 and 1:10560 scale sheet SO 00NW of Merthyr Tydfil, and the geological memoir "Geology of the South Wales Coalfield, Part V, the Country around Merthyr Tydfil" (Reference 1).

4.1.1 Drift

From the geological map, no superficial deposits are indicated to exist in the north, north east and north west of the site. Glacial boulder clay is shown in the southern reaches of the site, the boundary of which runs along both the south eastern and south western site perimeter, and across the central site area. A thin layer of glacial drift was reported to exist at the site in a previous desk study (reference 2), and it is known that drift deposits (rather than "rock") were encountered during construction of the bungalow in the central site area (through discussions with occupier).

It is anticipated that local pockets of glacial drift or made ground may also exist at the site within bedrock depressions.

4.1.2 Solid

The site is underlain by Carboniferous Limestone, which is capped by the overlying Millstone Grit on the extreme western and north western site areas. The Millstone Grit dips towards the south and south east of the site, and comprises marine and fluvial deposits of quartzitic sandstones, mudstones, and conglomerates. The limestone underlying the Millstone Grit and existing at outcrop in the remaining site area is predominantly that of the Upper Penwyllt Limestone (Llandyfan Limestone beds), which consist of dark grey limestones in which the beds are locally sandy and chert layers and nodules are abundant. The upper limestone shales are also indicated to exist beneath the site, predominantly close to the boundary between the Millstone Grit and the main Penwyllt limestone. They consist of 2 to 3m of dark grey, thinly bedded impure limestone, micrites and shale. The beds are known to weather to "rotten stone" at out crop; a fine siliceous powder. The limestone beds are shown on the 1:10560 scale map to dip at about 10° to 12°, towards the south.

A fault is shown on the map trending NW-SE and trending towards the north western site corner.

The Carboniferous Limestone in the area of Merthyr forms a series of scarps and dip slopes between the upland areas of the Old Red sandstone (underlying the limestones) and the escarpment of the Millstone Grit. Such scarps are reflected by both the geological maps of the area and the site topography, both of which indicate relatively steep south to south-eastern dips of both the grits and the limestone strata.

The geology of the site has been summarised on Figure 2.

4.2 Swallow Holes and Solution Collapse Features

Swallow holes and sink holes are inverted conical depressions common over much of the basal Carboniferous Dinantian and Namurian (limestones and Millstone Grit) outcrops, spanning in some instances to over 100m in diameter. They are caused by collapse into underground cavities formed by solution of the limestone. Collapses occurring on the limestone outcrop commonly contain blocks of basal grit, indicating that they were formed while there was still a cover of that rock while collapses on the basal grit outcrop (and in some instances the limestone) may contain glacial till. Individual swallow holes are commonly aligned along the course of faults.

The desk study, particularly aerial photograph information described in section 3.2 (also Figure 4 and Table 3.3), identified a number of features on and near to the site that may possibly be swallow holes, formed by dissolution and collapse into the limestone. These features were therefore specifically visited in the site walkover; see Section 5.

5 Site Walkover

Further to the observations made during the historical review of the site, a site walkover was undertaken on the 22nd September 2007. The objectives of the walkover were to gain an understanding of current site conditions and terrain, identify any further potential dissolution features within and in the vicinity of the site (not previously identified during the historic review), and confirm the locations and form of all previously identified possible features. A GPS was used during the site walkover to obtain co-ordinates of any potential solution feature, or potentially significant landform observed.

5.1 Site Conditions

The site was accessed initially from the narrow "dead end" road, south of the south western boundary. Access to the western regions of the site was slightly hindered as a result of the stone wall and barb wire fencing surrounding the site perimeter and inner site field boundaries. Generally the western regions of the site are densely vegetated with thick bracken and shrubbery. The site was observed to slope steeply from its north eastern edge, indicative of the scarp slope of the Millstone Grit overlying Limestone strata, which despite the vegetation cover, was clearly visible across much of the western site region (See Figure 2).

The central and eastern areas of the site were accessible via the main site access track running from Crabtree Walk toward Caerllwyn Farm. A small easterly trending track behind the farmhouse led toward the north eastern and south eastern fields. The eastern site area appeared slightly less overgrown than the west, predominantly occupied by grass and occasional bracken with intermittent woodland and hedgerows around the perimeter of the farm grounds and along the eastern field boundaries.

The southern regions of the site extend towards the back gardens of the neighbouring housing estate. A number of discarded household items were observed to have been tipped in the southern edges of the site, along the line of the residential estate.

5.2 Potential Solution Features

The possible solution features previously observed on the aerial photos and O.S plans (I.D 1-11) as well as any additional potential solution features observed during the site walkover (I.D E1, E2) are summarised in Table 5.2.

The locations of the possible solution features observed during the walkover have been plotted using the GPS co-ordinates, and are shown on Figure 5.

Table 5.2. Walkover Observations Summary

I.D	OS Co-ordinates	Notes
1	SO 0336709116	Large mound of artificially placed loose rocks partly vegetated with fern and bracken. Possible infill of depression.
2	SO 0333509144	Located at bottom of scarp slope (on steeper and higher land than features 1,3 & 8), pile of artificially placed loose angular rocks covered by bracken and fern shrubbery. Possible infill of shallow depression.
3	SO 0334109122	Deliberate mound of artificially placed loose rocks close to distinct break in slope (scarp dip) covered by bracken and fern shrubbery. Possible infill of shallow depression.
4	SO 0333908954	10m diameter circular pile of artificially placed angular cobbles and boulders of quartzite, indicating infilling of shallow depression. Depression follows line of scarp.
5	SO 0333508991	No evidence of unvegetated area with possible rock at surface (1947-1991); area currently well vegetated.
6	SO 0339808998	Possible identified sink hole (1967-2007) in approximate location of circular 4m diameter bonfire mark.
7	SO 0347709116	No evidence of formerly identified possible two sink holes (1989)
8	SO 0334509137	Slightly smaller mound of artificially placed loose rock with slight vegetative cover.
9	SO 0326509136	10m diameter 4-5m deep sink hole (outside site boundary). Sink located in vicinity of geologic fault as shown on published geologic map
10	SO 0325509123	Smaller sink hole, approximately 3m deep. Sink located in vicinity of geologic fault as shown on published geologic map
11	SO 0345709148	No evidence of formerly identified possible depression (1972)
E1	SO 0335109004	Slight but noticeable dip in gradient of landscape
E2	SO 0343209024	Line of stone wall from farm house falling towards south leading into a slight depression with a large pile of loose rocks.

6 Additional Environmental Issues

6.1 Contamination Potential

Given the limited historic development of the site, no significant sources of potential contamination were identified to have previously existed or currently exist within the site area. Some minor potential sources of contamination were however identified during the site walkover and are discussed below.

The site walkover revealed evidence of a fire in the eastern region of the south western field (I.D 6). Although it is impossible to ascertain what materials were burnt, some remnants of rubber and metal were observed within the fire footprint. A minor localised hotspot of associated contamination may therefore exist within this area consisting of combustion residues from the burnt materials.

Further localised hotspots of contamination may exist within the southern regions of the site, where discarded household items were observed. Although no immediate potential source of contamination was identified within the discarded materials (furniture, wood and some tyres) during the site walkover, it is possible that dumping of household items constituting potential sources of contamination may have previously occurred at the site.

Although the possible solution features identified at the site appear to have been infilled with loose rock and boulder fragments, further infilling, not apparent from the walkover may have occurred. The backfill (if any) is of unknown composition and therefore potential for contamination exists within the subsurface of the depressions on site.

6.2 Radon

From the British Geological Survey National Geosciences Information Service, full radon protective measures have been deemed necessary in the construction of new dwellings or extensions on the site.

6.3 Site Sensitivity

The Brecon Beacons National Park exists approximately 50m North West of the site boundary.

7 Conclusions and Recommendations

The findings of the desk study undertaken at the Trefechan site have been summarised as follows;

The site comprises approximately 3.76Ha of predominantly unoccupied rough vegetation and grass fields with the exception of the farm and residential buildings located in the central site area. Western parts of the site are relatively overgrown with bracken and shrubbery while the southern and eastern fields are predominantly grassy separated by intermittent trees. Topographically the site is reflective of the scarp slopes of the boundary between the Millstone Grit and Carboniferous limestone, which is present along the western and north western extremities of the site. Although the site generally slopes towards the south and south east, the face of the scarp slope is prominent, and relatively steep in the west of the site.

Given that the site has been classified by the British Geological Survey National Geosciences Information Service as an area where full radon protective measures are necessary in the construction of new dwellings, it is advised that a full radon report is obtained prior to site works.

Potential for contamination at the site is very limited as a result of its limited historic development. The site walkover revealed that there is some potential for localised hotspots of contamination; predominantly in the south of the site. However such hotspots, if they exist, are anticipated to be minor and unlikely to have a significant impact on the proposed development.

The main geotechnical issues revealed by the desk study which require further investigation are;

- Shallow bedrock of the Millstone Grit and Carboniferous Limestone. These rocks are usually strong and very strong and will have an impact on excavations for foundations, service runs and platforms for buildings and roads. They are anticipated to be at shallow depth in the western and northern parts of the site.
- Possible solution features which may cause local lowering of the bedrock surface. Such features may be infilled and not immediately obvious at the surface. However, a number of features that may be of solutional origin have been identified by the desk study and site walkover; these are apparent either as depressions or as artificially constructed mounds of stones. The depressions may have been used by farmers as convenient locations to place rocks gathered up from the fields. Solution features may be relatively minor, associated with widening of fissures and joints by infiltrating rainwater, or larger depressions connected to voided ground in the limestone beneath. As such they have a potential to cause instability and also to impact on the design of roads and foundations.
- In the centre of the site it is anticipated that glacial deposits overlie the bedrock. Whilst not expected to be a restraint on development, its characteristics will need to be determined in order to inform the design of foundations and hardstandings in this area.

Given that the desk study has identified potential solution features existing at the site, and the risk of further features not immediately obvious at the surface, it is recommended that further investigation be undertaken to characterise the identified features and help to locate any others which are not obvious at the surface.

Geophysical surveys have been identified as the most effective means of further investigation at the Trefechan site. A number of different geophysical surveys can be used to map subsurface conditions. Those most appropriate to the Trefechan site are summarised below.

- **Electromagnetic Survey;** It is recommended that an initial Electromagnetic (conductivity) survey is undertaken at the site. Such a survey can be applied to the whole site area and is used predominantly to define variations in rock head profile and specifically to identify suspected solution features at the bedrock /drift interface. The outcome of the survey; which can be done on foot or by quad bike therefore being adaptable to many types of terrain, is the acquisition of data obtained on a grid format across the survey area with the results produced in plan view. This application hence identifies lateral areas of bedrock change across a whole survey area. The survey is not however, used for the production of three dimensional sections showing the depth of features.

An electromagnetic survey can be used as an initial survey to identify specific areas of potential solution features. Although a number of potential features have already been recognized during the desk study, it would allow identification of any further features existing at the site, not evident at surface level. Subsequently, more specialised follow up work could be undertaken in specific areas where solution features or variations in rock head profiles have been identified.

- **Resistivity Tomography Surveys;** Undertaken as part of follow up work, resistivity surveys record variations in conductivity, which typically correlate with variations in lithology, water saturation, fluid conductivity, porosity and permeability. A non invasive technique, it comprises the deployment of an array of regularly spaced electrodes which are connected to a central control unit. The surveys can be presented as a tomography profile (cross section) or a 3D profile showing lateral and vertical extents of subsurface features. Such surveys can be undertaken to map up to 60m beneath the subsurface, and can be undertaken across specific areas of known rock variations and potential solution features (as identified during the initial electromagnetic survey).
- **Gravity Survey;** Also constituting follow up work, gravity surveys are based on measuring localised variations in the earths gravitational field caused by the presence of materials of different densities or voids in the subsurface. Gravitational techniques are commonly used in the detection of subsurface voids and mapping bedrock lithology. Results of gravitational surveys are presented to show both vertical and lateral extent of subsurface features. As in the case of resistivity surveys, gravity surveys can be used to define specific known features identified during the initial Electromagnetic survey.

It is recommended that a phased approach to further investigation at the site is undertaken, which is summarised below.

Phase 1; An electromagnetic survey is recommended in order to initially identify both the identified and previously unidentified potential solution features existing across the site area. The survey should be undertaken in conjunction with a trial pitting investigation. Trial pitting is recommended in order to calibrate the results of the electromagnetic survey, and in addition to aid in the characterisation of any features encountered. It should be noted however that as a result of the difficult site topography and terrain, such intrusive investigation may not be possible across the entire site area.

Further investigation (i.e. Phase 2) will be dependent entirely on results of Phase 1. Should Phase 1 reveal potentially significant solution features, these should be investigated more specifically in Phase 2.

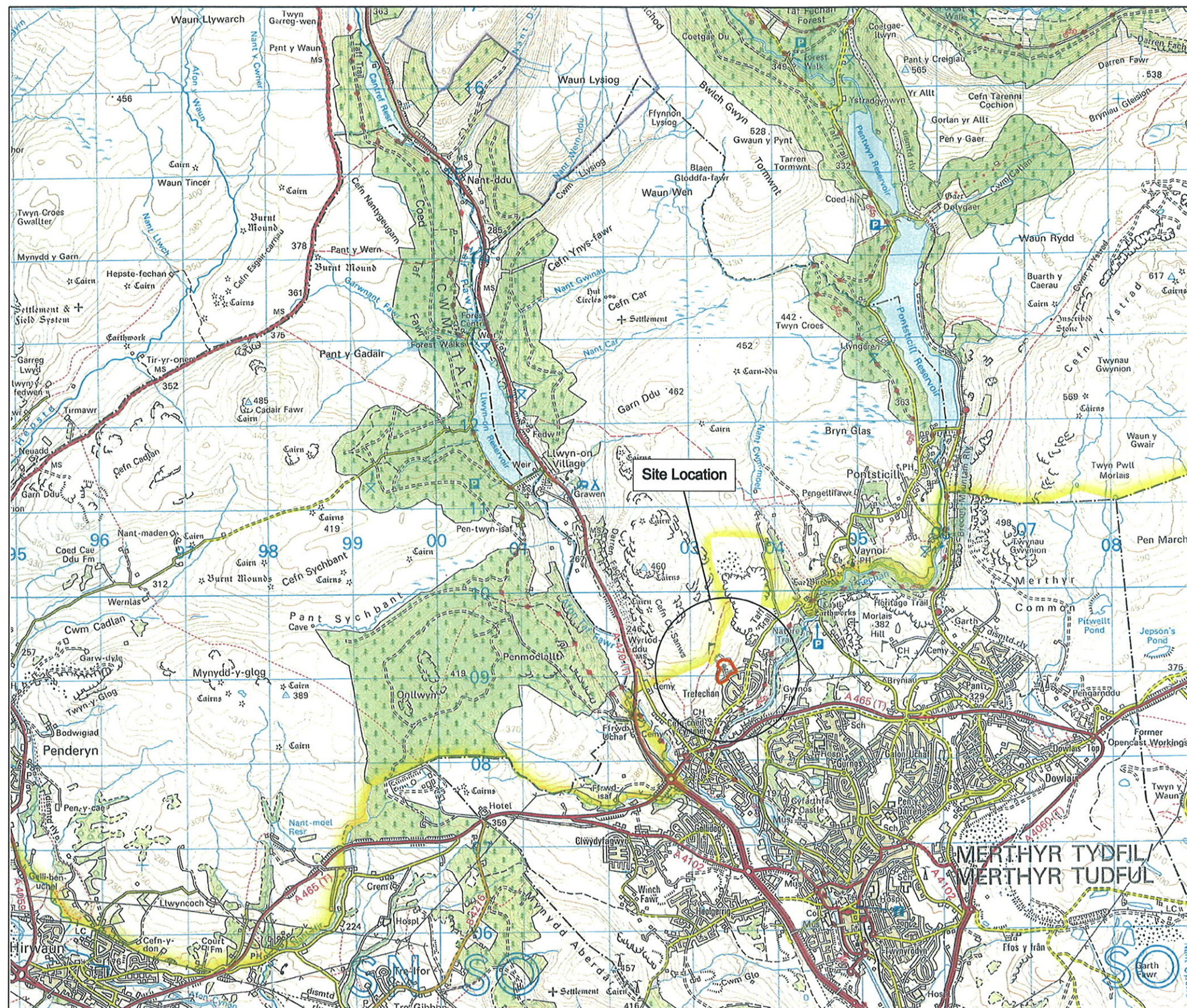
Phase 2; It is recommended that more detailed investigation be undertaken should Phase 1 reveal significant solution features likely to have an impact on the proposed housing development. Resistivity and gravity geophysical surveys would therefore be recommended at this stage. The main objectives of the Phase 2 surveys, (whether resistivity or gravity), would be to focus specifically on defining the lateral and vertical extent of any identified

features, and subsequently to identify the procedures necessary for their stabilisation during site development.

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- [2] Ateb Consulting, Land at Trefechan Site Investigation Desk Study January 2001

FIGURES



SCALE N.T.S

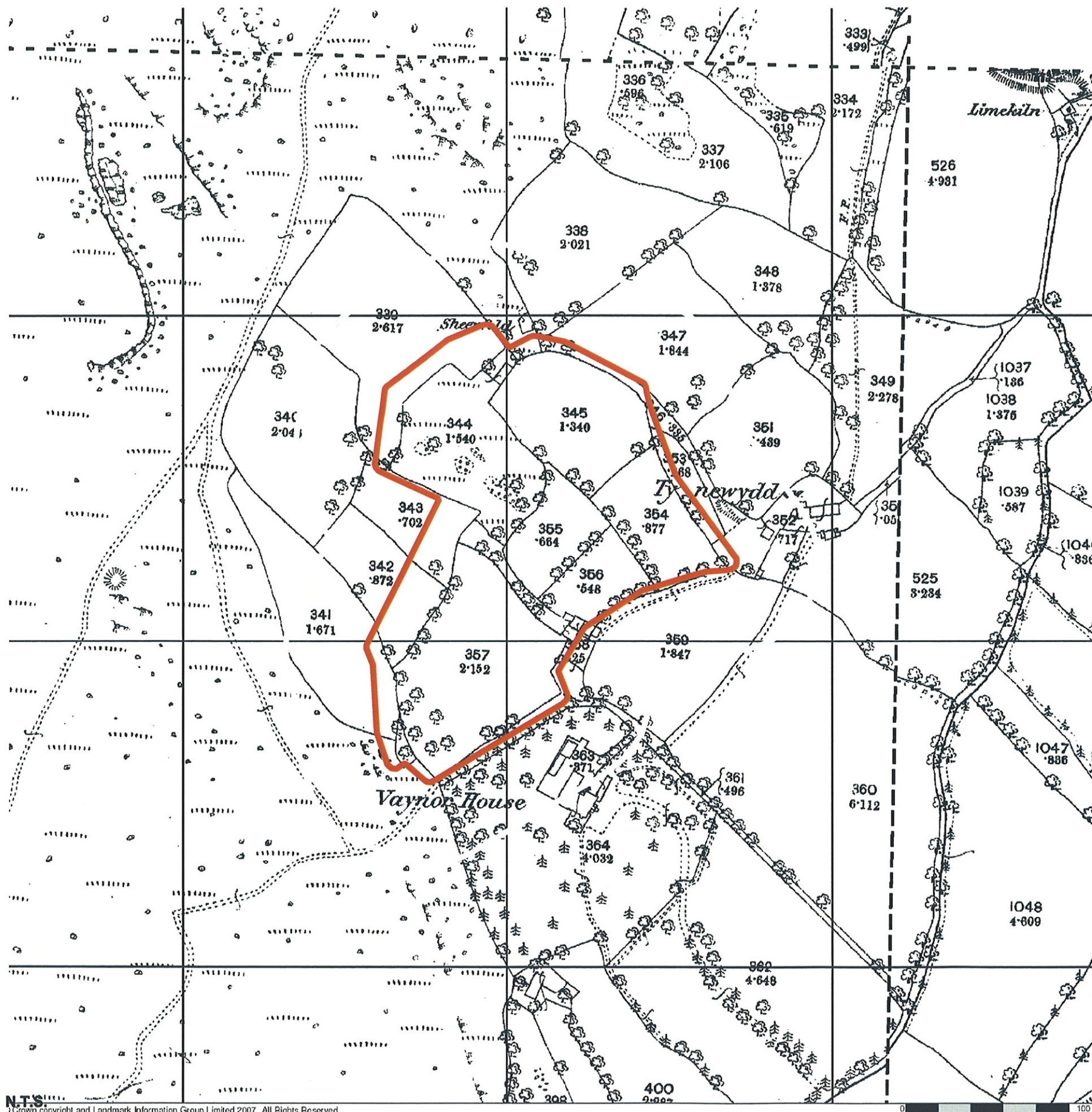
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FIGURE

1





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Trefechan Historical
Plans 1885

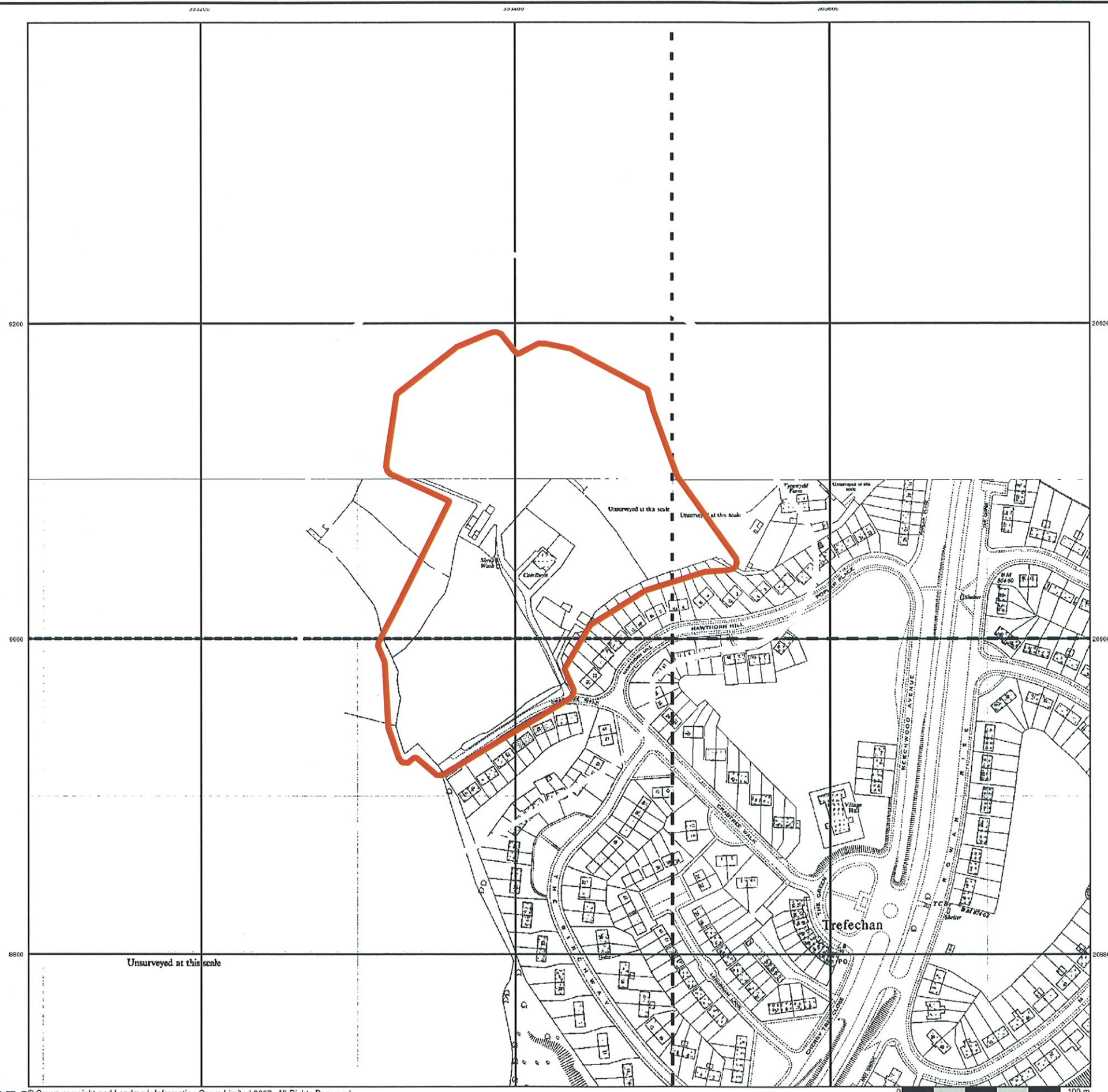
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FIGURE **3a**



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FIGURE 3b

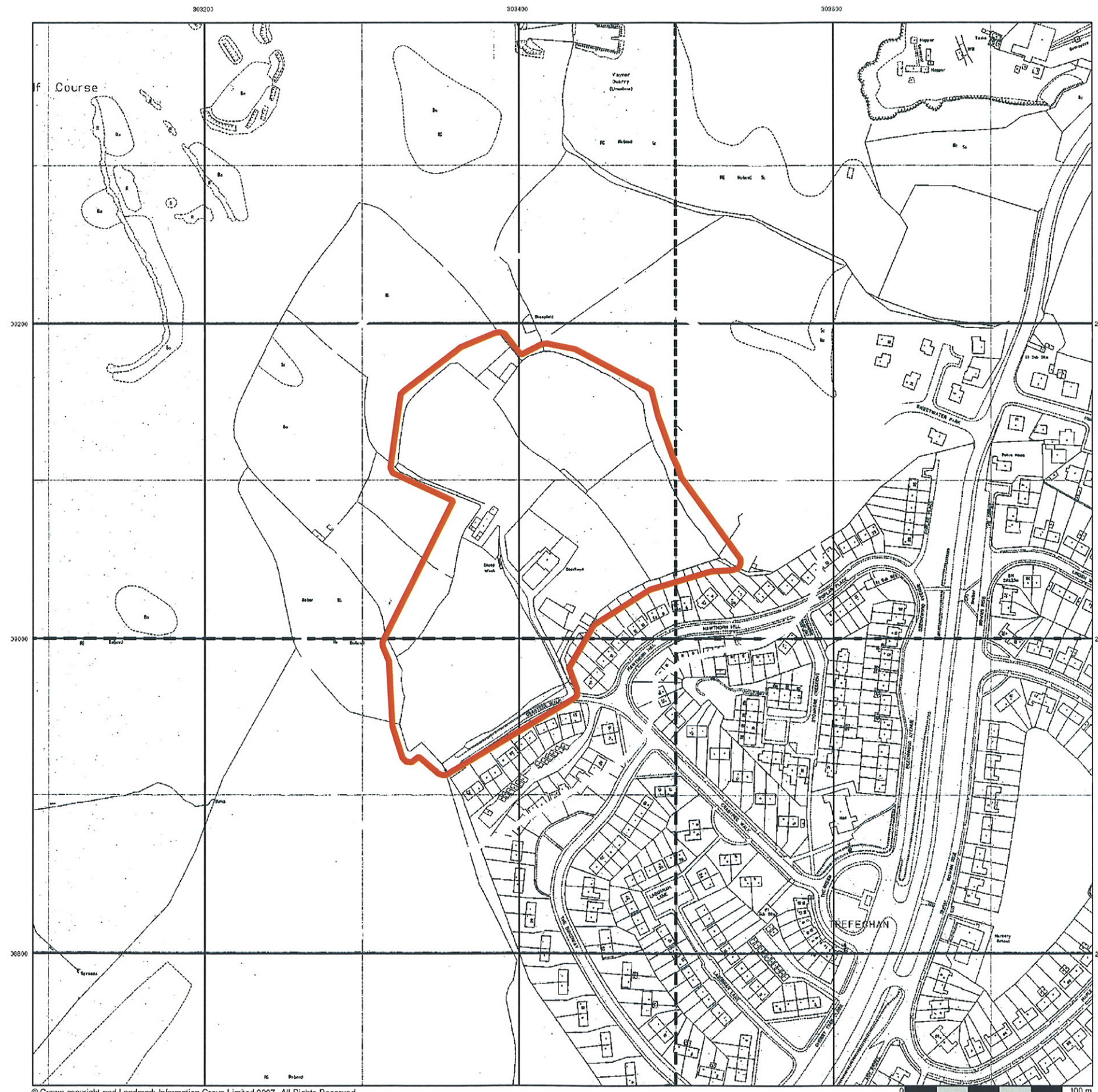


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**Trefechan Historical
Plans 1961**

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FIGURE **3c**



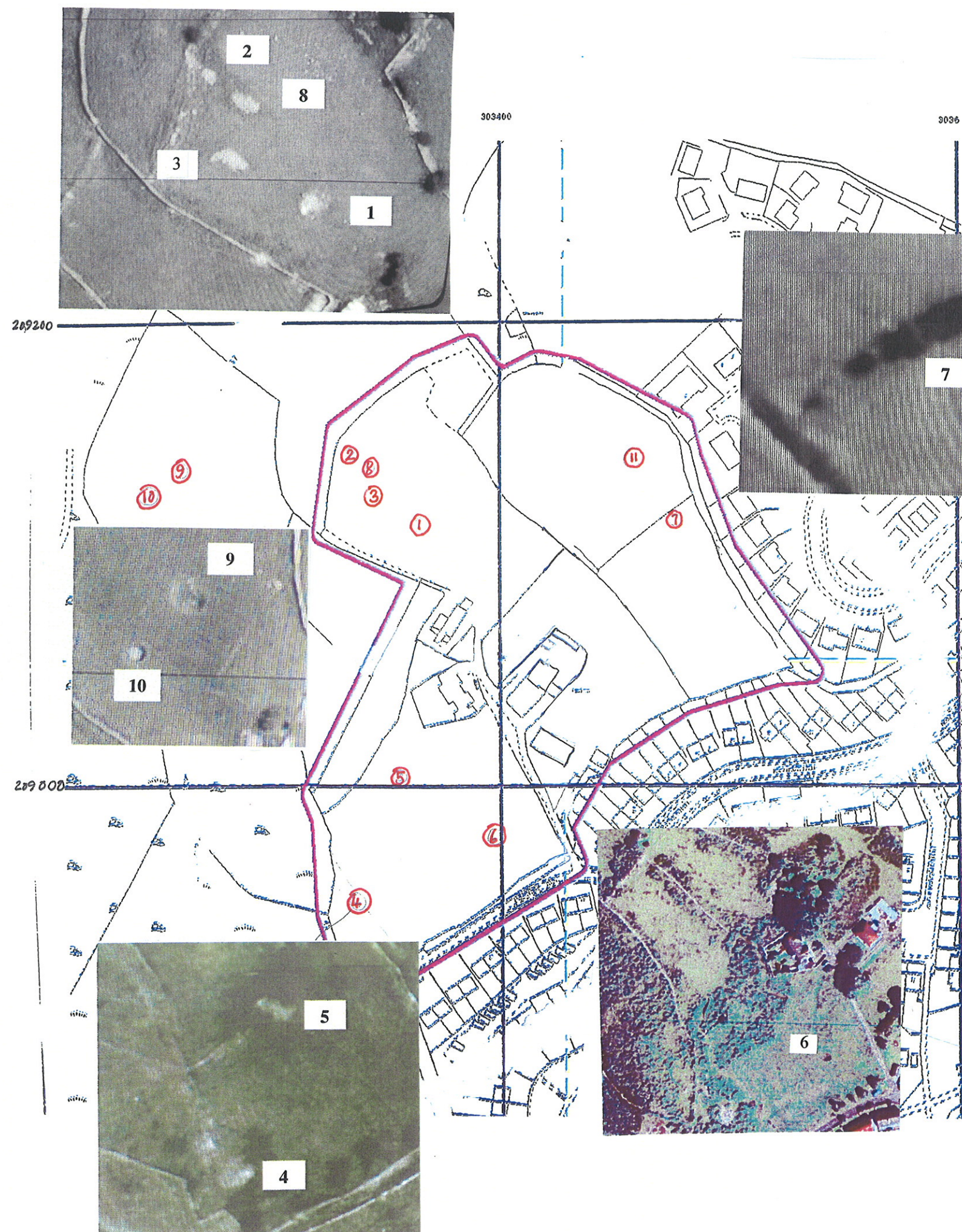
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SCALE N.T.S.

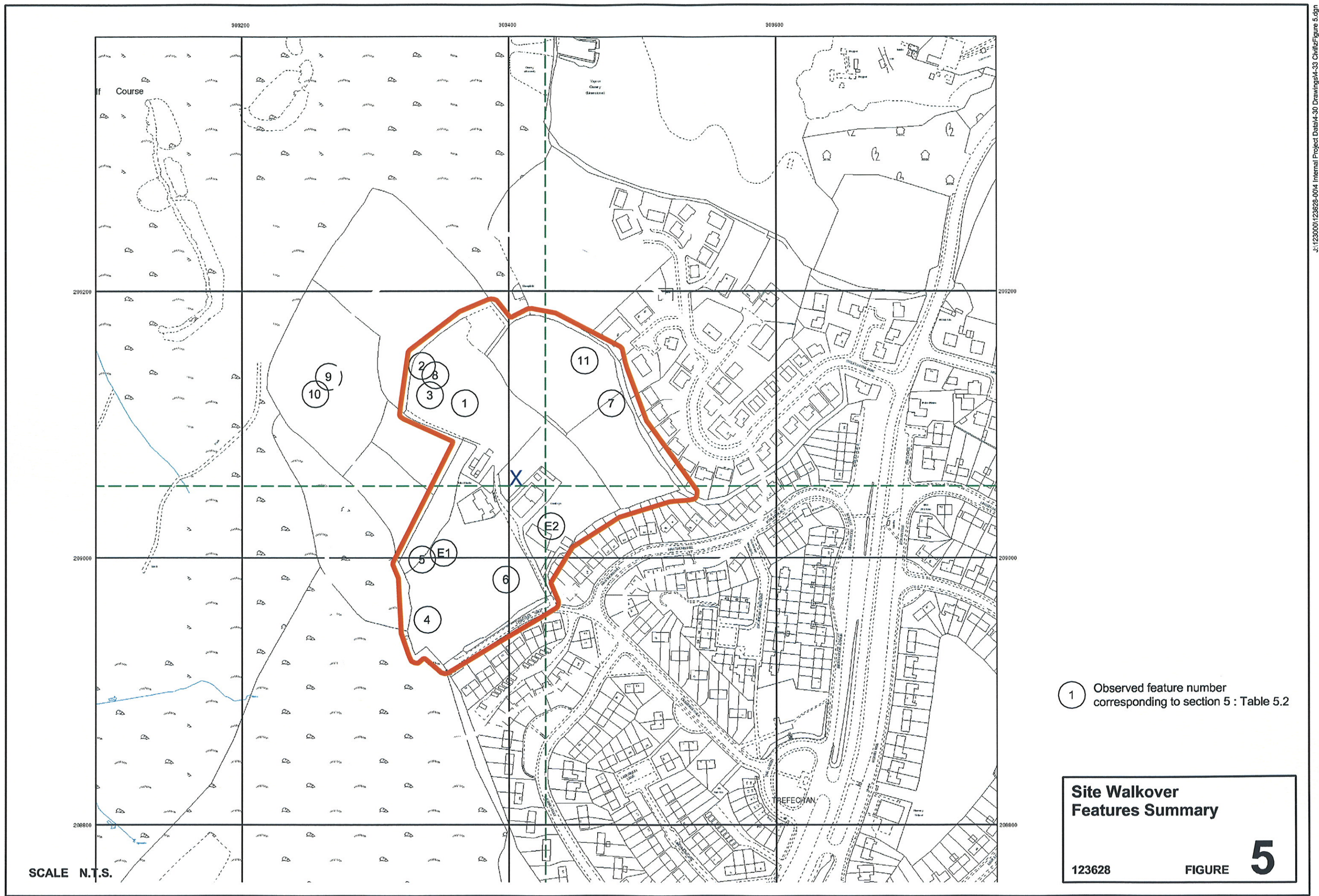
**Trefechan Historical
Plans 1993**

123628

FIGURE **3d**



I.D	Initial Observation Date	Feature	Source	Notes
1	1947	Possible Infill of surface depression with M.G./rubble	NAW Aerial Photos 1947-2007 Indicated on historical O.S plans from 1885-1900	Remains prominent at surface level on current aerial photos. Has decreased in size since 1947 (see feature 8.)
2 & 3	1947	Possible Infill of surface depression with M.G./rubble	NAW Aerial Photos 1947-2007 Indicated on historical O.S plans from 1885-1900	Remains prominent at surface level on current aerial photos.
4	1947	Circular un-vegetated area amongst rough vegetation. Possible infill of depression	NAW Aerial Photos 1947-2007	Remains prominent at surface level on current aerial photos.
5	1947	un-vegetated area amongst rough vegetation. Possible infill of depression	NAW Aerial Photos 1947-1991	Not visible on aerial photos after 1991
6	1967/1989	Possible sink hole	NAW Aerial Photos 1967-2007	Distinct sink hole shape apparent at later date
7	1989	Possible sink holes	NAW Aerial Photo 1989	Not evident from any other photo or source prior to or after 1989
8	1947/1967 (see notes)	Possible infill of likely depression	NAW Aerial Photos 1967-2007	Likely to have once been part of feature 2.
9	1967	Sink Hole	NAW Aerial Photos 1967-2007	Remains evident on current aerial photos. Outside site boundary
10	1967	Sink Hole	NAW Aerial Photos 1967-2007	Remains evident on current aerial photos, outside site boundary
11	1972	Possible Evidence of Depression	NAW Aerial Photo 1972	Not observed prior to or after 1972



Appendix A

Aerial Photograph List

COVER SEARCH

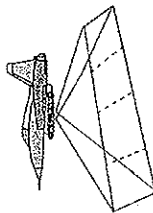
Date: 19/07/2007

Our ref. W-AP-PR 07-177



CENTRAL REGISTER OF AIR PHOTOGRAPHY FOR WALES

The National Assembly for Wales, Room G003, Cathays Park, Cardiff CF10 3NQ Tel. 029 2082 3819 Fax 3080



(this form is available in larger print on request)

Name Lisa Dymock,		Location Trefechan, Merthyr Tydfil	OS Map Sheet No
Address ARUP, 4 Pierhead Street, Capital Waterside, CARDIFF.		Date of photos required All to view	National Grid Ref 303400/209100
Postcode CF10 4QP		Note: RAF, Meridian and pre-1979 O.S. reprints are available from the National Assembly for Wales. NPH = No Prints Held	
Telephone 029 2047 3727		signed <i>Lisa Dymock</i>	
		Your ref. 123628	

VIEWING BY APPOINTMENT ONLY

WO Lib No:	Old Lib No:	Sortie Number:	Date Flown:	Scale:	Air Survey Org:	Photo Type:	Film Loc:	Print Loc:	Prints Available to View:
200029	0	Various	01/08/2000	1:10000	Geotmapping	Colour	APU CD rom		Digital Available from Bluesky International
200601		Various	01/06/2006	1:10000	COWI	Colour			Digital Available from Bluesky International
4626	163	106G UK 1120	14/01/1946	1:10000	RAF	B & W	WO G022c 5/4 x2	WO G074 1/2	Yes 4010
4709	589	CPE UK 1997	13/04/1947	1:9800	RAF	B & W	WO G022c 6/5 x4	WO G074 3/4	Yes 4364 - 65
4814	781	CPE UK 2487	10/03/1948	1:16600	RAF	B & W	WO G022c 5/5 x2	WO G074 3/6	Yes 4092 - 93
5504	1646	58 RAF 1715	14/04/1955	1:10000	RAF	B & W	WO G022c 6/3 x2		Yes F22: 266 - 67
6711	0	Meridian 71/67	23/07/1967	1:5000	Meridian	B & W	WO M002 13/1	WO G074 6/6	Yes 71/67: 52 - 53
7297	0	OS 72 329	21/08/1972	1:7700	Ordnance Survey	B & W	WO M002 18/4	WO G022b 2/1	Yes- 414 (poss)
75146	0	OS 75 071	24/04/1975	1:26000	Ordnance Survey	B & W	WO M002 18/1	WO G022b 3/2	162
7576	0	OS 75 037	24/04/1975	1:24000	Ordnance Survey	B & W	WO M002 18/1	WO G022b 3/2	92
8402	0	MAFF	10/06/1984	1:12000	MAFF		MAFF		201: 71 + 56
8601	0	J A Story 0885	28/04/1985	1:20000	JAStory(NRSC)	Colour	NRSC	WO G074 10/1	Yes 1285: 107 - 108
8725	0	OS 87 049	06/05/1987	1:13000	Ordnance Survey	B & W	Ordnance Survey		42 (end of run)
8928	0	OS 89 120	04/05/1989	1:12800	Ordnance Survey	B & W	Ordnance Survey		950 - 51
8929	0	OS 89 121	04/05/1989	1:6000	Ordnance Survey	B & W	Ordnance Survey		568 - 69
9139	0		01/08/1991	1:10000	Geonex(NRSC)	Colour	NRSC	WO G074 10/3	Yes 14991: 97 - 98
9683	0	OS 96 145	14/06/1996	1:9100	Ordnance Survey	B & W			28 - 29 no prints held

Appendix B

**Terradat Geophysical
Survey Report**

GEOPHYSICAL SURVEY REPORT

Project

MAPPING POTENTIAL SOLUTION FEATURES

Location

TREFECHAN, MERTHYR TYDFIL

Client

ARUP

Head Office
Ocean House
Hunter Street
Cardiff Bay
Cardiff Cf10 5FR
United Kingdom



geophysical **innovation**

Telephone: +44 (0)8707 303050
Fax: +44 (0)8707 303051
www.terradat.com

Job reference: 2172
Date: October 2007
Version: 1

GEOPHYSICAL SURVEY REPORT

Project

MAPPING POTENTIAL SOLUTION FEATURES

Location

TREFECHAN, MERTHYR TYDFIL

Client

ARUP

Project Geophysicist: C Bird BSc _____

Reviewer: S Hughes PhD BSc FGS _____

Job Reference: 2172

Date: October 2007

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1.2	Survey design	4
2	SURVEY DESCRIPTION.....	5
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1 INTRODUCTION

This report describes a geophysical survey carried out on an area of land near Trefechan, Merthyr Tydfil between the 18th and 19th of September 2007. The survey area consisted of an area of land to the west of the village. The survey work was commissioned by Arup and was primarily designed to map anomalous features that may be related to karstic processes.

1.1 Site description

The survey area consisted of a rough hillside. Much of the site was heavily vegetated and in some parts the density of the vegetation prevented the survey from being carried out completely. Across the site are piles of loose rock thought to represent backfilled solution features. In the south eastern-most part of the survey area was found a lot of near-surface metallic debris such as burned mattresses and corrugated steel. As much of this was removed as possible prior to the survey but some remained undetected at the commencement of the survey.

Survey objectives;

The primary objectives of the survey are as follows:

- Locate anomalous features that may be associated with Karstic processes.
- Provide information on the character of the shallow geological sequence.

1.2 Survey design

Given the scope of the survey brief, it was decided to utilise ground conductivity mapping (GEM-2) to map variations in the near surface material across the site. Background information for this survey method is provided in the appendix.

2 SURVEY DESCRIPTION

2.1 Ground conductivity survey (GEM-2)

A ground conductivity survey involves transmitting an electromagnetic field into the subsurface and picking up returning signal via a receiver in the same instrument. Data are acquired on a grid covering the area of interest and a contoured plan of the variation in ground conductivity across the site is produced. The presence of conductive materials in the subsurface such as clay, water, mudstone, ash, leachate, metal etc. will be evident as regions of high values on the ground conductivity plan while materials such as coarse grained sediments, dry zones and many bedrock types will appear as regions of low values. A description of the field activity is provided below and some background information on the survey method is found in the appendix.

2.1.1 Ground conductivity survey field activity

The conductivity data were acquired using a multi-frequency *GEOPHEX GEM-2* (Plate 2) instrument and data were acquired at a nominal 0.5m interval over all accessible areas of the survey area at a nominal line spacing of approximately 5m. In order to normalise the data between each survey grid base lines were taken and the data processed to compensate for any instrumental shifts. The data were acquired under dGPS control with a horizontal accuracy of +/- .5m (plate 1).

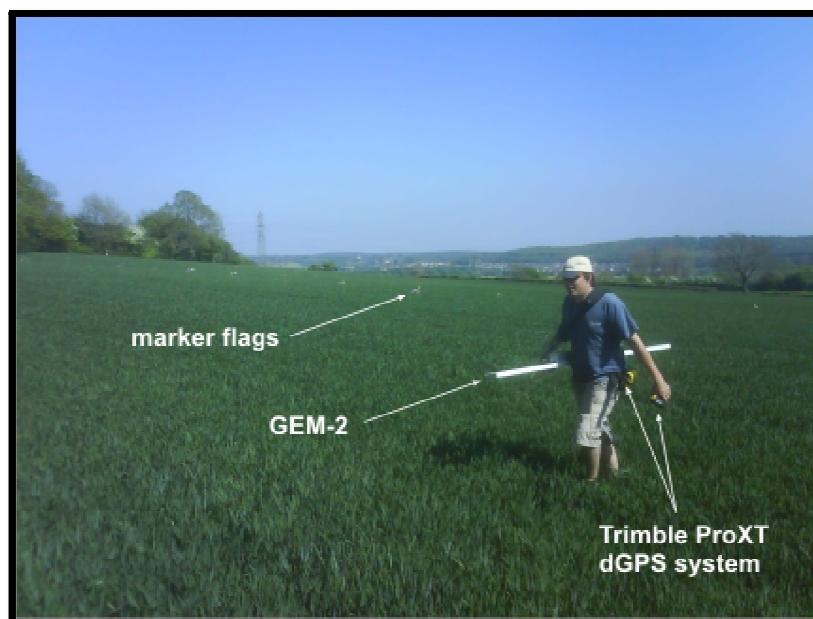


Plate 1 – Ground conductivity (*GEM-2*) survey by foot (library photo)

2.1.2 Ground conductivity (GEM-2) survey data processing

The data were downloaded from the instrument using *WinGem* software, and then exported as xyz files that can be read into *Excel*, each data file was then processed to compensate for any instrumental drift. The final data set was then read in to *Oasis Montaj* where it was gridded and displayed before having a site survey plan overlain.

3 RESULTS and DISCUSSION

The results of the GEM-2 survey are presented as a colour contoured ground conductivity plot In Figure 1.

3.1 Ground conductivity (GEM-2)

Following a review of the electromagnetic data, it was decided only to consider the response from the highest frequency channel (47 MHz). A localised increase in conductivity values usually indicates a relative increase in the clay content or groundwater saturation. Extreme fluctuations in the conductivity values are indicative of instrument 'overload' due to interference from nearby metal structures/debris. The interpretation of the conductivity data is generally based on both published electrical properties of typical sub-surface materials (Table 1) and when available, correlation with on-site information.

Conductivity (mS/m)	Typical geological setting
Low	Dry, granular, clay-deficient material: Air-filled voids: bedrock
Intermediate	Mixed sediments; Weathered bedrock;
High	Clay-rich, water saturated sediments; metallic features

Table 1-simplified relationship between conductivity and geological setting

The most striking anomalies that can be seen on the conductivity plot is the “halo” effect of the response of the meter to the metal fences around the edges of the fields which has shown up as a pink fringe.

In the south western-most field there is a gentle rising gradient across the site to the northeast. This may be indicative of a gradual change in lithology or subtle thickening of the overburden. To the east of the field can be seen a distinct linear conductive feature that is coincident with the road and may represent services related to the road serving the buildings in the centre of the site.

In the north western-most field there is, again, an effect from a northern boundary fence. The majority of the field seems clear of anomalies except in the southernmost corner where demolition debris is present causing a rise in conductivity values.

In the central field there is also a lack of any significant features that can be attributed to karstic processes. The high values are the effect of the buildings.

In the north east of the site there are two fields that display a significantly more anomalous character. The northern most has a broad increase in conductivity that may be attributed to a thickening of relatively clay rich material, or an increase in moisture. In the east of the northern-most field there is a point anomaly related to an item of metal debris, in this case an old motorcycle.

Finally, the eastern-most field has a broad scattering of anomaly, much of the high amplitude anomalies may be related to some of the metal debris present in the field though there is a more subtle anomaly near the centre that may be related to a geological process and would benefit from further investigation.

Significantly, none of the geophysical anomalies are coincident with any of the previously observed features. The lack of conductivity anomalies associated with these features may be attributed to the dense backfilling of any void with the same material as the bedrock producing a low conductivity anomaly with similar values to the bedrock, however, it would be expected that any voids not infilled by human activity but by geological processes would appear as conductive anomalies.

4 CONCLUSIONS

- The conductivity mapping technique was chosen because it provides the most cost effective and rapid means of characterising large areas of land. This survey technique has proven to be very successful at other nearby sites of similar geology.
- The resulting ground conductivity plots have delineated a number of features that appear to relate to both geological and artificial processes.
- In terms of identifying solution features, there are some isolated anomalies that may be related to solution features.
- However, this survey approach does not guarantee the absence of solution features beneath the site due to inherent limitations such as insufficient contrasts between the target and surrounding geology and targets being beyond the exploration depth range of the instrument.
- For each identified geophysical feature that may be of concern, it is recommended that an intrusive investigation be carried out in order to provide geological ground-truthing. When intrusive information becomes available the geophysical survey results can be calibrated to ensure accuracy of interpretation.

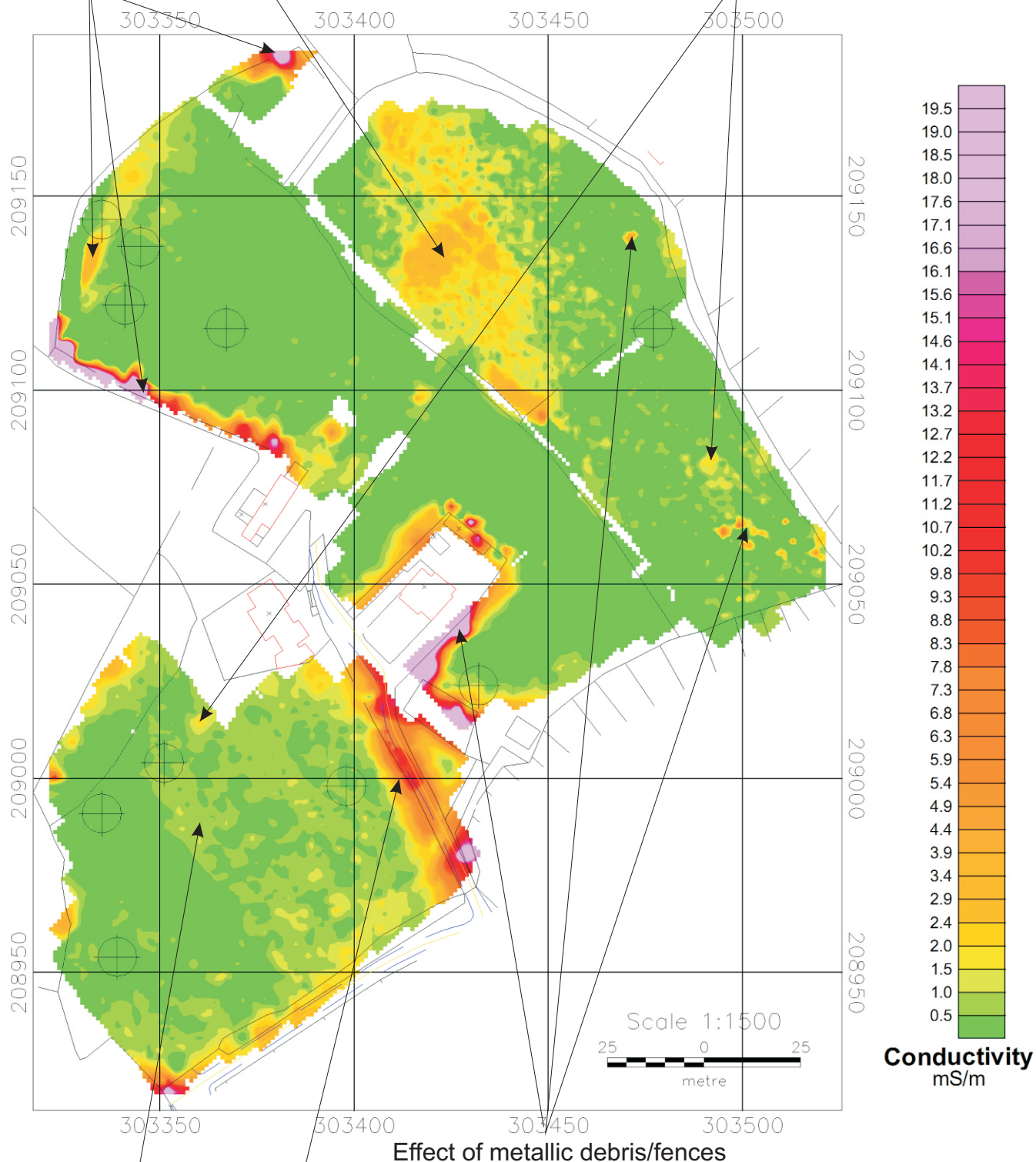
Disclaimer

This report represents an opinionated interpretation of the geophysical data. It is intended for guidance with follow-up invasive investigation. Features that do not produce measurable geophysical anomalies or are hidden by other features may remain undetected. Geophysical surveys compliment invasive/destructive methods and provide a tool for investigating the subsurface; they do not produce data that can be taken to represent all of the ground conditions found within the surveyed area. Areas that have not been surveyed due to obstructed access or any other reason are excluded from the interpretation.

Broad area of increased conductivity values
indicative of a broad thickening of clay-rich overburden

Localised increase in conductivity may be associated with
thickening of overburden over a solution feature

Effect of fences



Linear conductive feature may be
related to services associated with road

Slight rise in conductivity values
may be indicative of an increase
in thickness of relatively clay-rich overburden

⊕ - Previously observed features

Ground Conductivity Survey

Trefechan

TERRADAT (UK) LTD

Scale 1:1500

Figure 1

September 2007

APPENDIX

Appendix - Ground conductivity (EM) survey

A ground conductivity or electromagnetic (EM) survey involves the generation of an EM field at the surface and subsequent measuring of the response as it propagates through the subsurface. The main components of the instrument are a transmitter coil (to generate the primary EM field) and receiver coil (to measure the induced secondary EM field). The amplitude and phase-shift of the secondary field are recorded and are then converted into values for ground conductivity and in-phase component (metal indicator).

The ground conductivity (EM) instruments are either hand carried or mounted/towed behind a quad bike. Readings are usually taken on a regular grid or along selected traverse lines and positional control can be provided by dGPS if there is sufficient satellite coverage.

The selection of the particular EM instrument (EM-38/EM-31/GEM-2) is primarily based on the required penetration depth of the survey. However for most conductivity surveys the GEM-2 has replaced the more conventional EM-31 instrument due to its ability to simultaneously acquire data at different frequencies (i.e. different depth levels) and a greater depth of penetration. At the end of each survey, the survey data is downloaded to a field computer and corrected for instrument, diurnal and positional shifts. Additional editing may be carried out to remove any 'noisy' data values/positions.

The results from the EM survey can be presented as colour contoured plots of conductivity and inphase (metal response) data. In general terms, a relative increase in conductivity values usually indicates a local increase in clay content or water saturation. However, if there is a corresponding increase in the inphase response, the influence of some artificial source is likely (i.e. metal).



EM-38
Single frequency
Exploration depth ~1.5m

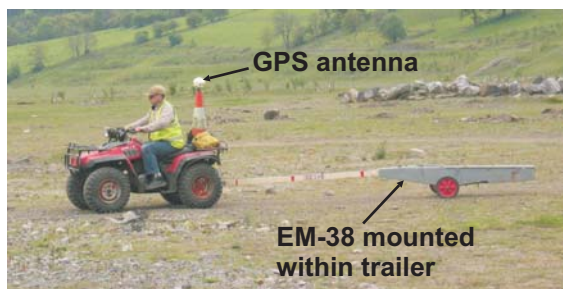


EM-31
Single frequency
Exploration depth ~3 to 5m

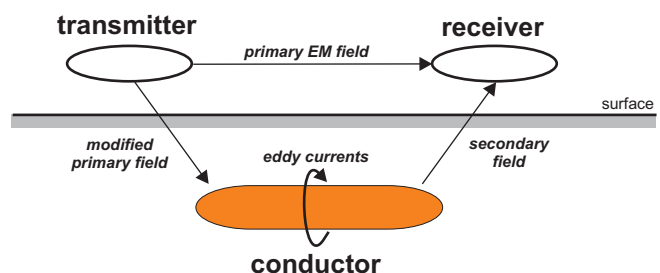


GEM-2
Multi-frequency
Exploration depth up to 10m

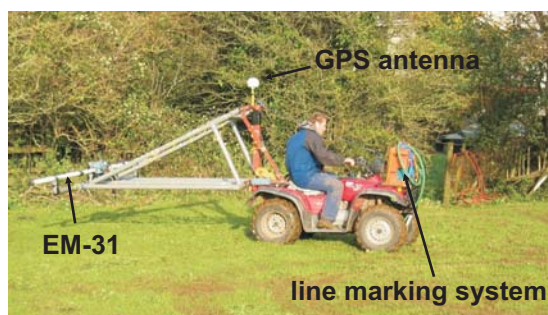
Towed EM-38 with dGPS



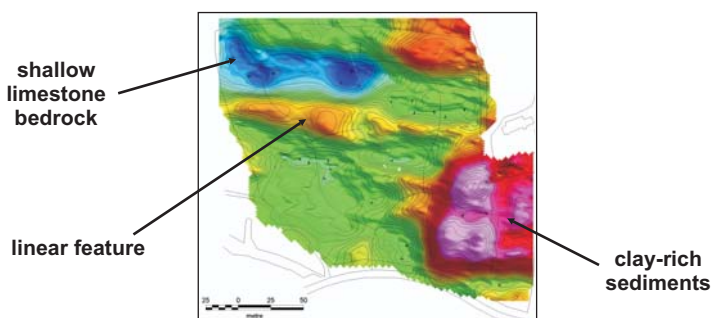
General principle of EM surveying



Mounted EM-31 with dGPS



Ground conductivity data plot



Constraints

Power lines, buildings, metal structures (fences, rebar, vehicles, debris etc.) and buried services can interfere with the electro-magnetic measurements.

Appendix C

Trial Pit Logs

Trial Hole 8; SO 03346, 09137

Depth (m below ground level)	Strata
0-0.25	Loose quartzite and limestone rocks, decaying vegetation, rootlets, and dark brown/black silty soil
0.25-0.45	Soft to firm brown/red slightly clayey sandy SILT with some roots (Topsoil and Glacial Deposits)
0.45-1.7	Loose to medium dense light brown slightly clayey silty fine SAND with many pebbles and limestone/quartzite fragments and occasional cobbles. (Glacial Deposits)
1.7-2.35	Loose to medium dense brown slightly clayey slightly gravelly SAND with many cobbles and occasional boulders of limestone and quartzite (Glacial Deposits)
2.35-2.8	Limestone boulders and slabs with brown slightly clayey sands and fine gravel. (Possible disturbed rock head)

Notes

1. No groundwater encountered. Soil damp between 0.25-0.45m
2. Slight spalling of trial pit sides during excavation; otherwise pit stable
3. Very difficult to excavate through large slabs and boulders 2.8m

Trial Hole 1; SO 03365, 09118

Depth (m below ground level)	Strata
0-0.15	Loose brown clayey silts with many rootlets (Topsoil)
0.15-0.95	Soft to firm brown/orange slightly gravelly sandy SILT with many cobbles of limestone (Glacial Deposits)
0.95-2.2	Loose to medium dense brown slightly clayey slightly silty gravelly fine-medium SAND with many limestone cobbles and occasional boulders (Glacial Deposits)
2.2-3.0	Brown slightly silty clayey gravelly SAND with many cobbles and occasional boulders of limestone (Glacial Deposits)
3.0-3.3	Loose to medium dense Brown slightly silty clayey gravelly SAND with many cobbles and boulders (Glacial Deposits)
3.3-3.5	Limestone cobbles, boulders and slabs with brown clayey gravelly SAND. (Possible disturbed Rock head)

Notes

1. No groundwater encountered. Sand damp from 0.95-2.2
2. Trial Pit stable
3. Very difficult to excavate through large slabs and boulders 3.5m

Trial Hole 6; SO 03398, 08998

Depth (m below ground level)	Strata
0-0.1	Dark brown/black burnt topsoil (fire mark) with pine needles, some rootlets, and charcoaled wood.
0.1-0.35	Brown slightly sandy clayey SILT (Topsoil and Glacial Deposits)
0.35-0.5	Soft to firm orange/brown sandy slightly gravelly SILT (Glacial Deposits)
0.5-1.0	Brown sandy clayey SILT (Glacial Deposits)
1.0-1.8	Soft to firm brown silty sandy CLAY with some cobbles and occasional boulders of limestone and quartzite (Glacial Deposits)
1.8-2.3	Loose brown, slightly clayey silty SAND with fine gravel and many boulders at base of excavation. (Glacial Deposits)
2.3-2.6	Boulders and cobbles of limestone, quartzite and occasional conglomerate with brown slightly clayey silty sand and fine gravel. Boulders up to 1m in diameter. (Possible Disturbed Rock head)

Notes

1. No groundwater encountered. Pit damp from 0.1 to 1.8m
2. Spalling of trial pit sides from 1.8m. Trial pit collapsing at 2.6m

Trial Hole 11; SO 03456, 09148

Depth (m below ground level)	Strata
0-0.25	Loose brown clayey silt with many rootlets (Topsoil)
0.25-0.65	Soft to firm brown clayey SILT with some pebbles of limestone, and occasional rootlets. (Glacial Deposits)
0.65-1.0	Soft to firm brown sandy CLAY with some cobbles and occasional boulders of limestone. (Glacial Deposits)
1.0-1.7	Loose to medium dense brown/orange, slightly silty clayey fine SAND (Glacial Deposits)
1.7-2	Brown slightly clayey SAND with fine gravel and many cobbles, boulders and slabs of limestone. (Glacial Deposits)
2.0-2.1	Limestone boulders and slabs with brown sands and fine gravel (Possible disturbed rock head)

Notes

1. No groundwater encountered
2. Minor spalling of trial pit sides during excavation, otherwise trial pit stable
3. Very difficult to excavate through large slabs and boulders from 2m.

Trial Hole 7; SO 03476, 09116

Depth (m below ground level)	Strata
0-0.4	Brown slightly clayey SILT with many rootlets and occasional cobbles (Topsoil)
0.4-1.0	Soft to firm light brown slightly sandy clayey SILT with many cobbles of limestone (Glacial Deposits)
1.0-2.5	Loose to medium dense, brown slightly silty clayey SAND with occasional fine gravel and many cobbles and occasional boulders of limestone. (Glacial Deposits)
2.5-2.7	Limestone boulders/slabs with brown sands and fine gravel (Possible disturbed Rock head)

Notes

1. No groundwater encountered. Soils damp throughout
2. Minor spalling of pit sides during excavation, otherwise stable
3. Very difficult to excavate through large slabs and boulders from 2.5m

Trial Hole 4; SO 03339, 08954

Depth (m below ground level)	Strata
0-0.8	Loose, deliberately placed quartzite cobbles and boulders
0.8-0.9	Very dark black SILT with rootlets and decaying vegetation matter.
0.9-1.6	Soft to firm grey sandy CLAY with small quartzite cobbles
1.6-3.8	Loose to medium dense red/brown slightly clayey slightly gravelly medium-coarse SAND with some cobbles and occasional boulders of quartzite and limestone.
3.8-4.1	Brown slightly clayey slightly gravelly SAND, with many boulders and cobbles.

Notes

1. No groundwater encountered. Soils damp at 0.9m
2. Trial pit stable
3. Difficult to excavate through boulders from 4m

Trial Hole G1; SO 03356, 09016

Depth (m below ground level)	Strata
0-0.6	Dark brown/black slightly clayey SILT with many cobbles, occasional boulders, rootlets and organic matter. (Topsoil and glacial deposits)
0.6-1.2	Soft to firm brown/red fine slightly clayey SILT with many cobbles and some boulders of limestone and quartzite. (Glacial Deposits)
1.2-3.1	Loose to medium dense brown slightly clayey silty SAND with many clasts, pebbles, cobbles and occasional boulders of quartzite and limestone (Glacial Deposits)

Notes

1. No groundwater encountered, soils damp to 0.6m
2. Trial pit sides stable

Trial Hole G2; SO 03382, 08962

Depth (m below ground level)	Strata
0-0.3	Loose to medium brown slightly clayey silt with rootlets (Topsoil)
0.3-0.6	Soft to firm orange/brown sandy clayey SILT (Glacial Deposits)
0.6-1.9	Loose to medium dense light brown slightly silty gravelly SAND. Gravel fine, cobbles and boulders at base. (Glacial Deposits)
1.9-2.2	Soft to firm brown slightly sandy gravelly SILT with some pebbles, cobbles and boulders of limestone (Glacial Deposits)
2.2-3.0	Loose to medium dense light brown slightly silty, clayey SAND with occasional fine gravel of limestone and some conglomerate fragments, with many cobbles and occasional boulders (Glacial Deposits)
3.0-3.70	Boulders and cobbles of limestone with medium dense brown clayey sand with fine gravel. (Possible disturbed rock head)

Notes

1. No groundwater encountered
2. Trial pit stable (some minor spalling during excavation)
3. Very difficult to excavate through boulders and cobbles from 3.5m

Trial Hole G3; SO 03419, 09113

Depth (m below ground level)	Strata
0-0.3	Dark brown clayey SILT with rootlets (Topsoil).
0.3-0.55	Soft to firm orange/brown slightly clayey gravelly SILT with some pebbles and fragments of limestone. (Glacial Deposits)
0.55-1.6	Loose to medium dense brown slightly silty clayey SAND with occasional fine gravel. From 1.4m frequent cobbles and boulders of limestone and conglomerate. (Glacial Deposits)

Notes

1. No groundwater encountered soils damp to 0.55m.
2. Trial pit stable
3. Pit terminated on large boulder at 1.6m

Trial Hole G4; SO 03447, 09096

Depth (m below ground level)	Strata
0-0.15	Brown clayey SILT with rootlets (topsoil)
0.15-1.0	Soft to firm brown slightly sandy clayey SILT with pebbles and some cobbles of limestone. (Glacial Deposits)
1.0-2.6	Soft to firm brown clayey SILT, sandy in places, with many cobbles and occasional limestone boulders. (Glacial Deposits)
2.6-3.1	Boulders and cobbles of limestone with dark brown slightly silty clayey sand (Possible disturbed rock head)

Notes

1. No Groundwater encountered, soils damp from 1.0m
2. Trial pit stable
3. Very difficult to excavate through boulders from 3m

Trial Hole G5; SO 03490, 09080

Depth (m below ground level)	Strata
0-0.4	Brown slightly clayey SILT with rootlets (Topsoil)
0.4-0.5	Orange slightly sandy clayey SILT band.
0.5-2.0	Soft to firm brown slightly silty very sandy CLAY with many cobbles of limestone (Glacial Deposits)
2.0-2.5	Loose to medium dense brown, slightly silty clayey SAND with many cobbles, some boulders, and one piece of wood. Boulders up to 0.6m in diameter. (Glacial Deposits)
2.5-2.8	Limestone boulders and slabs with brown clayey sand (Possible Disturbed Bedrock)

Notes

1. No groundwater encountered
2. Trial pit Stable
3. Wood encountered likely to have fallen in to pit during excavation
4. Very difficult to excavate through large slabs and boulders from 2.5m

Appendix D

Trial Pit Photographs

Trial Pit G2



Trial Pit G3



Trial Pit G4



Trial Pit G5



Trial Pit TH1



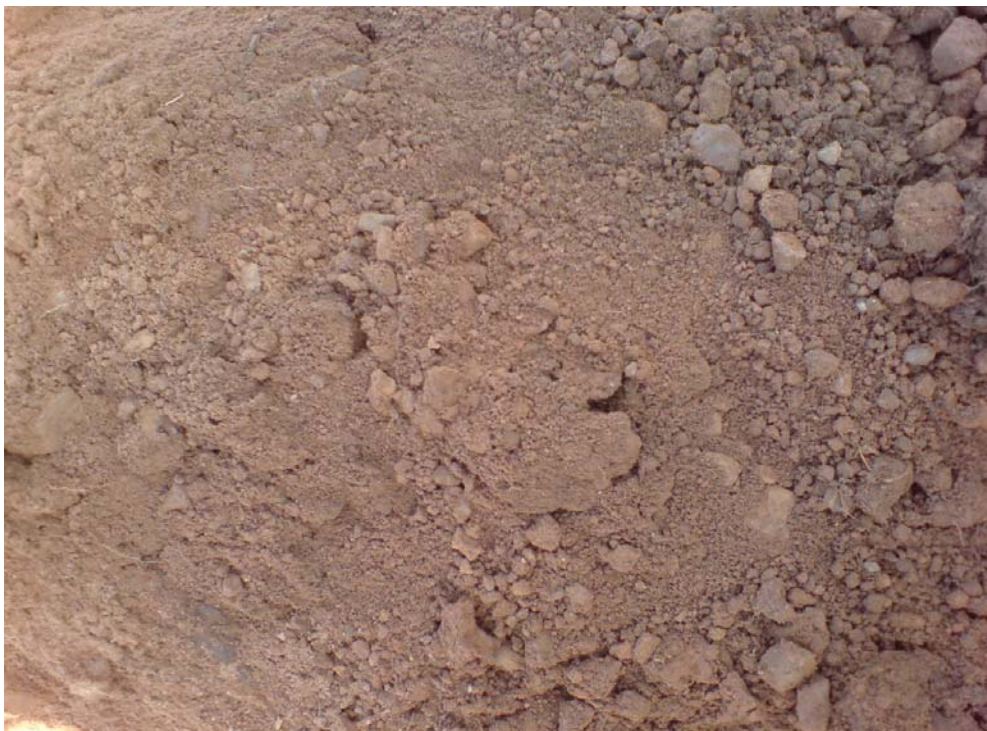
Trial Pit TH4



Trial Pit TH6



Trial Pit TH7



Trial Pit TH8



Appendix E

**Chemical Analysis
Results**

Our Ref: EFS/074885M (Ver. 1)

Your Ref:

October 27, 2007



TES Bretby

PO Box 100

Bretby Business Park

Ashby Road

Burton-on-Trent

Staffordshire

DE15 0XD

Telephone: 01283 554400

Facsimile: 01283 554422

Ms L Dymock
Arup
4 Pierhead Street
Capital Waterside
Cardiff
CF10 4QP

For the attention of Ms L Dymock

Dear Ms Dymock

SOIL Sample Analysis - Tkefechan

Samples from the above site have been analysed in accordance with the schedule supplied.

The sample details and the results of analyses for these samples are given in the appended report.

An invoice for this work will follow under a separate cover.

Where appropriate the samples will be kept until 22/11/07 when they will be discarded. Please call 01283 554403 for an extension of this date.

Please be aware that from 1 January 2003 our policy for the retention of paper based laboratory records and analysis reports will be 6 years.

The work was carried out in accordance with Environmental Services Group Standard Terms and Conditions of Contract.

If I can be of any further assistance please do not hesitate to contact me.

Yours sincerely

for TES Bretby

A handwritten signature in black ink, appearing to read "J. Hannah".

J Hannah
Project Co-ordinator
01283 554403

TES Report No. EFS/074885M (Ver. 1)

Arup
4 Pierhead Street
Capital Waterside
Cardiff
CF10 4QP

Site: Tkefechan

The 4 samples described in this report were logged for analysis by TES Bretby on 11-Oct-2007.
The analysis was completed by: 27-Oct-2007

Tests where the accreditation is set to N or No, and any individual data items marked with a * are not UKAS or MCERTS accredited
Any opinions or interpretations expressed herein are outside the scope of any UKAS accreditation held by TES Bretby Laboratories.

The following tables are contained in this report:

Table 1 Main Analysis Results (Pages 2 to 3)
Table of PAH (MS-SIM) (80) Results (Pages 4 to 7)
GC-FID Chromatograms (Pages 8 to 11)
Table of Report Notes (Page 12)

On behalf of
TES Bretby :
J Hannah

J. Hannah
Project Co-ordinator

Date of Issue: 27-Oct-2007

Accreditation Codes: **N** (Not Accredited), **U** (UKAS), **UM** (UKAS & MCERTS)

Tests marked '*' have been subcontracted to another laboratory.

(NVM) - denotes the sample matrix is dissimilar to matrices upon which the MCERTS validation was based,
and is therefore not accredited for MCERTS.

All results are reported on a dry weight basis at 105°C unless otherwise stated. (except QC samples)
TES Bretby accepts no responsibility for any sampling not carried out by our personnel.

Sample Descriptions

Client : Arup
Site : Tkfechan
Report Number : S07_4885M

[illegible]

[illegible]

[illegible]

Polycyclic Aromatic Hydrocarbons

GC/MS (SIM)

Customer and Site Details:	Arup: Tkefechan	Job Number:	S07_4885M
Sample Details:	TH1 0.3	Date Booked in:	11-Oct-07
LIMS ID Number:	CL0729057	Date Extracted:	16-Oct-07
QC Batch Number:	3235	Date Analysed:	17-Oct-07
Quantitation File:	Initial Calibration	Matrix:	Soil
Directory:	1016PAH.MS9\	Ext Method:	Ultrasonic
Dilution:	1.0		

Accredited?: No

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit	Accr. code
Naphthalene	91-20-3	-	< 0.09	-	N
Acenaphthylene	208-96-8	-	< 0.09	-	N
Acenaphthene	83-32-9	-	< 0.09	-	N
Fluorene	86-73-7	-	< 0.09	-	N
Phenanthrene	85-01-8	-	< 0.09	-	N
Anthracene	120-12-7	-	< 0.09	-	N
Fluoranthene	206-44-0	-	< 0.09	-	N
Pyrene	129-00-0	-	< 0.09	-	N
Benzo[a]anthracene	56-55-3	-	< 0.09	-	N
Chrysene	218-01-9	-	< 0.09	-	N
Benzo[b]fluoranthene	205-99-2	-	< 0.09	-	N
Benzo[k]fluoranthene	207-08-9	-	< 0.09	-	N
Benzo[a]pyrene	50-32-8	-	< 0.09	-	N
Indeno[1,2,3-cd]pyrene	193-39-5	-	< 0.09	-	N
Dibenzo[a,h]anthracene	53-70-3	-	< 0.09	-	N
Benzo[g,h,i]perylene	191-24-2	-	< 0.09	-	N
Total (USEPA16) PAHs	-	-	< 1.50	-	N

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	71
Acenaphthene-d10	68
Phenanthrene-d10	73
Chrysene-d12	70
Perylene-d12	37

Surrogates	% Rec
Nitrobenzene-d5	N.D
2-Fluorobiphenyl	102
Terphenyl-d14	122

Concentrations are reported on a dry weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Polycyclic Aromatic Hydrocarbons GC/MS (SIM)

Customer and Site Details:	Arup: Tkefechan	Job Number:	S07_4885M
Sample Details:	TH6 0.4	Date Booked in:	11-Oct-07
LIMS ID Number:	CL0729058	Date Extracted:	16-Oct-07
QC Batch Number:	3235	Date Analysed:	17-Oct-07
Quantitation File:	Initial Calibration	Matrix:	Soil
Directory:	1016PAH.MS9\	Ext Method:	Ultrasonic
Dilution:	1.0		

Accredited?: No

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit	Accr. code
Naphthalene	91-20-3	-	< 0.10	-	N
Acenaphthylene	208-96-8	-	< 0.10	-	N
Acenaphthene	83-32-9	-	< 0.10	-	N
Fluorene	86-73-7	-	< 0.10	-	N
Phenanthrene	85-01-8	-	< 0.10	-	N
Anthracene	120-12-7	-	< 0.10	-	N
Fluoranthene	206-44-0	-	< 0.10	-	N
Pyrene	129-00-0	-	< 0.10	-	N
Benzo[a]anthracene	56-55-3	-	< 0.10	-	N
Chrysene	218-01-9	-	< 0.10	-	N
Benzo[b]fluoranthene	205-99-2	-	< 0.10	-	N
Benzo[k]fluoranthene	207-08-9	-	< 0.10	-	N
Benzo[a]pyrene	50-32-8	-	< 0.10	-	N
Indeno[1,2,3-cd]pyrene	193-39-5	-	< 0.10	-	N
Dibenzo[a,h]anthracene	53-70-3	-	< 0.10	-	N
Benzo[g,h,i]perylene	191-24-2	-	< 0.10	-	N
Total (USEPA16) PAHs	-	-	< 1.55	-	N

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	70
Acenaphthene-d10	67
Phenanthrene-d10	71
Chrysene-d12	67
Perylene-d12	32

Surrogates	% Rec
Nitrobenzene-d5	N.D
2-Fluorobiphenyl	108
Terphenyl-d14	131

Concentrations are reported on a dry weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Polycyclic Aromatic Hydrocarbons

GC/MS (SIM)

Customer and Site Details:	Arup: Tkefechan	Job Number:	S07_4885M
Sample Details:	G5 0.35	Date Booked in:	11-Oct-07
LIMS ID Number:	CL0729059	Date Extracted:	16-Oct-07
QC Batch Number:	3235	Date Analysed:	17-Oct-07
Quantitation File:	Initial Calibration	Matrix:	Soil
Directory:	1016PAH.MS9\	Ext Method:	Ultrasonic
Dilution:	1.0		

Accredited?: No

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit	Accr. code
Naphthalene	91-20-3	-	< 0.10	-	N
Acenaphthylene	208-96-8	-	< 0.10	-	N
Acenaphthene	83-32-9	-	< 0.10	-	N
Fluorene	86-73-7	-	< 0.10	-	N
Phenanthrene	85-01-8	5.26	0.11	94	N
Anthracene	120-12-7	-	< 0.10	-	N
Fluoranthene	206-44-0	6.91	0.22	96	N
Pyrene	129-00-0	7.22	0.19	72	N
Benzo[a]anthracene	56-55-3	-	< 0.10	-	N
Chrysene	218-01-9	9.10	0.10	92	N
Benzo[b]fluoranthene	205-99-2	10.61	0.22	74	N
Benzo[k]fluoranthene	207-08-9	10.63	0.10	77	N
Benzo[a]pyrene	50-32-8	11.02	0.10	86	N
Indeno[1,2,3-cd]pyrene	193-39-5	12.38	0.11	58	N
Dibenzo[a,h]anthracene	53-70-3	-	< 0.10	-	N
Benzo[g,h,i]perylene	191-24-2	-	< 0.10	-	N
Total (USEPA16) PAHs	-	-	< 1.99	-	N

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	69
Acenaphthene-d10	67
Phenanthrene-d10	70
Chrysene-d12	62
Perylene-d12	32

Surrogates	% Rec
Nitrobenzene-d5	N.D
2-Fluorobiphenyl	105
Terphenyl-d14	134

Concentrations are reported on a dry weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Polycyclic Aromatic Hydrocarbons

GC/MS (SIM)

Customer and Site Details:	Arup: Tkefechan	Job Number:	S07_4885M
Sample Details:	G3 0.4	Date Booked in:	11-Oct-07
LIMS ID Number:	CL0729060	Date Extracted:	16-Oct-07
QC Batch Number:	3235	Date Analysed:	17-Oct-07
Quantitation File:	Initial Calibration	Matrix:	Soil
Directory:	1016PAH.MS9\	Ext Method:	Ultrasonic
Dilution:	1.0		

Accredited?: No

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit	Accr. code
Naphthalene	91-20-3	-	< 0.09	-	N
Acenaphthylene	208-96-8	-	< 0.09	-	N
Acenaphthene	83-32-9	-	< 0.09	-	N
Fluorene	86-73-7	-	< 0.09	-	N
Phenanthrene	85-01-8	-	< 0.09	-	N
Anthracene	120-12-7	-	< 0.09	-	N
Fluoranthene	206-44-0	-	< 0.09	-	N
Pyrene	129-00-0	-	< 0.09	-	N
Benzo[a]anthracene	56-55-3	-	< 0.09	-	N
Chrysene	218-01-9	-	< 0.09	-	N
Benzo[b]fluoranthene	205-99-2	-	< 0.09	-	N
Benzo[k]fluoranthene	207-08-9	-	< 0.09	-	N
Benzo[a]pyrene	50-32-8	-	< 0.09	-	N
Indeno[1,2,3-cd]pyrene	193-39-5	-	< 0.09	-	N
Dibenzo[a,h]anthracene	53-70-3	-	< 0.09	-	N
Benzo[g,h,i]perylene	191-24-2	-	< 0.09	-	N
Total (USEPA16) PAHs	-	-	< 1.47	-	N

"M" denotes that % fit has been manually interpreted

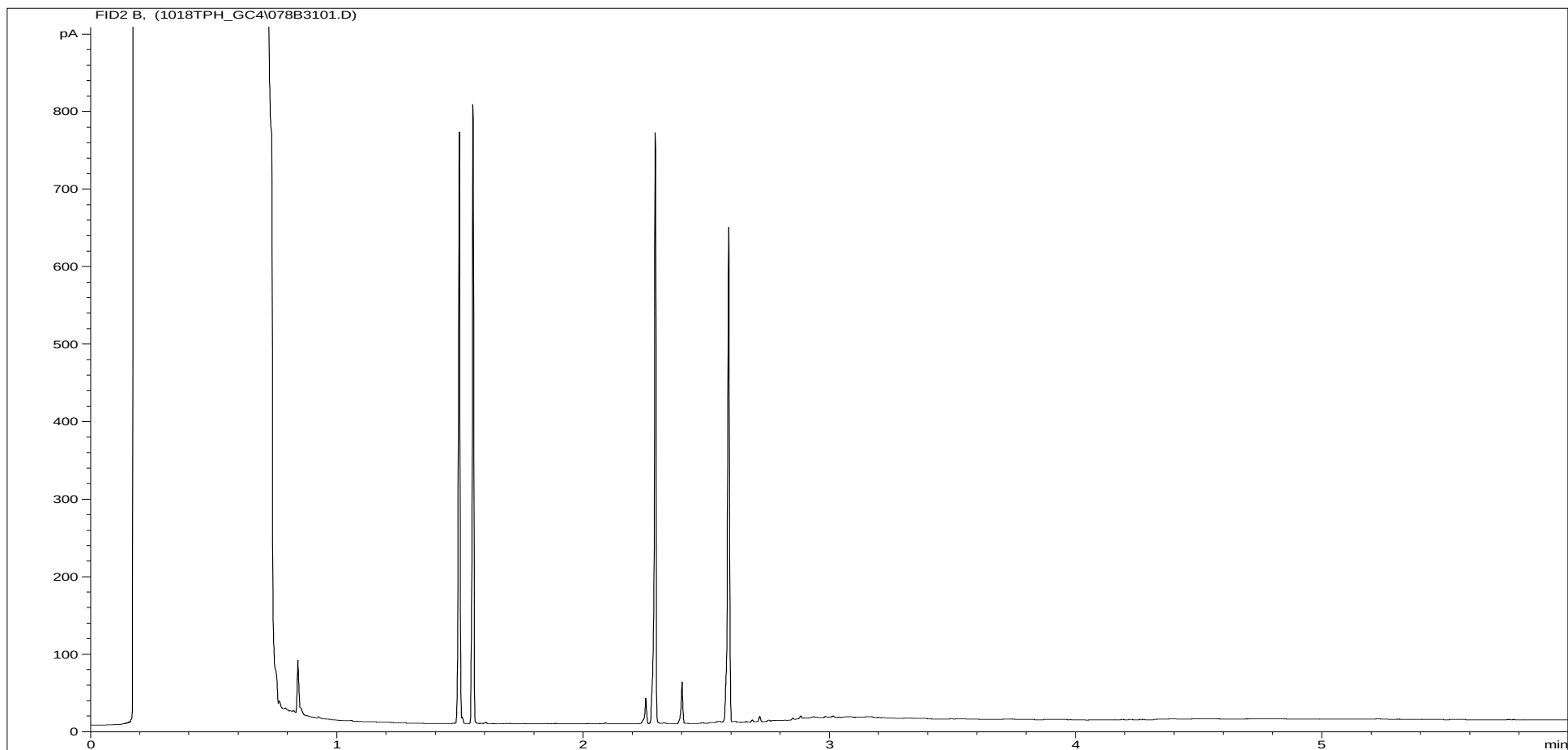
Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	71
Acenaphthene-d10	68
Phenanthrene-d10	72
Chrysene-d12	65
Perylene-d12	34

Surrogates	% Rec
Nitrobenzene-d5	N.D
2-Fluorobiphenyl	87
Terphenyl-d14	108

Concentrations are reported on a dry weight basis.

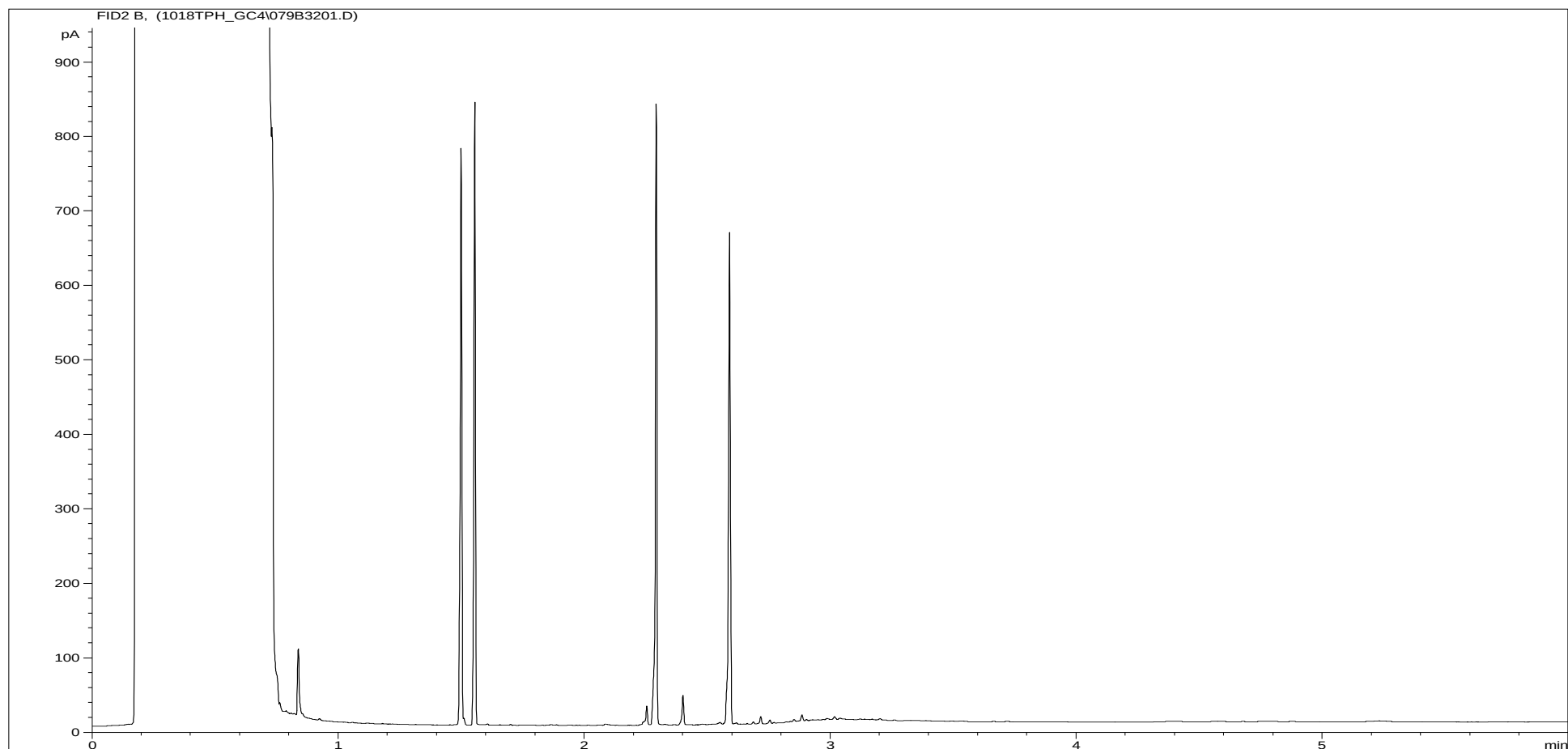
The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Petroleum Hydrocarbons (C8 to C40) by GC/FID



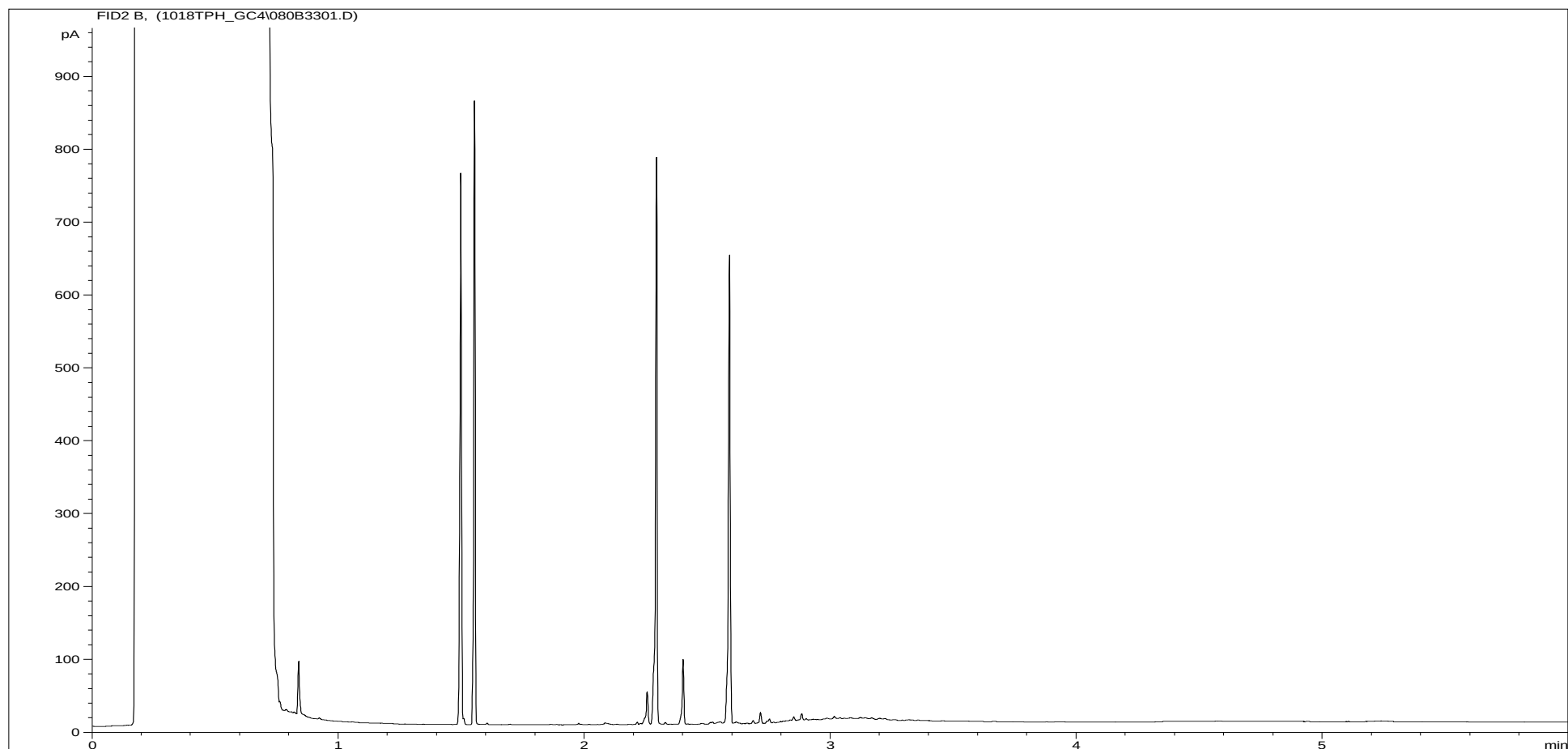
Sample ID:	CL0729057	Job Number:	S07_4885M
Multiplier:	8	Client:	Arup
Dilution:	1	Site:	Tkefechan
Acquisition Method:	MAX_RUNF.M	Client Sample Ref:	TH1 0.3
Acquisition Date/Time:	18-Oct-07		
Datafile:	E:\GC\TES\DATA\Y2007\1018TPH_GC4\078B3101.D		

Petroleum Hydrocarbons (C8 to C40) by GC/FID



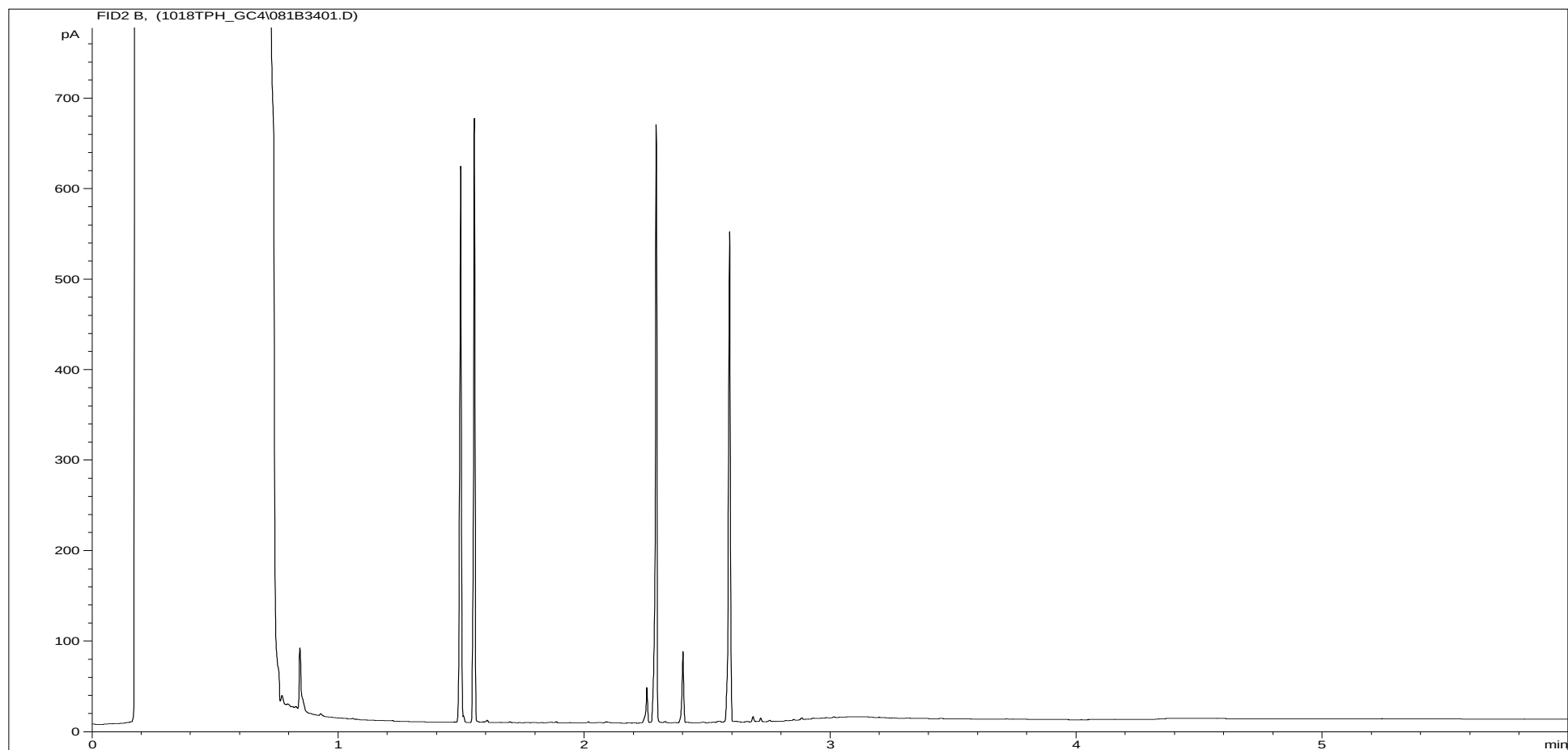
Sample ID:	CL0729058	Job Number:	S07_4885M
Multiplier:	8	Client:	Arup
Dilution:	1	Site:	Tkefechan
Acquisition Method:	MAX_RUNF.M	Client Sample Ref:	TH6 0.4
Acquisition Date/Time:	18-Oct-07		
Datafile:	E:\GC\TES\DATA\Y2007\1018TPH_GC4\079B3201.D		

Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL0729059	Job Number:	S07_4885M
Multiplier:	8	Client:	Arup
Dilution:	1	Site:	Tkefechan
Acquisition Method:	MAX_RUNF.M	Client Sample Ref:	G5 0.35
Acquisition Date/Time:	18-Oct-07		
Datafile:	E:\GC\TES\DATA\Y2007\1018TPH_GC4\080B3301.D		

Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL0729060	Job Number:	S07_4885M
Multiplier:	8	Client:	Arup
Dilution:	1	Site:	Tkefechan
Acquisition Method:	MAX_RUNF.M	Client Sample Ref:	G3 0.4
Acquisition Date/Time:	18-Oct-07		
Datafile:	E:\GC\TES\DATA\Y2007\1018TPH_GC4\081B3401.D		

Report Notes

Soil/Solid analysis specific:

Results expressed as mg/kg on an air dried basis unless stated otherwise
S04 analysis not conducted in accordance with BS1377 unless otherwise stated
Water Soluble Sulphate on 2:1 water:soil extract
AR denotes analysis conducted on the As Received sample

Water analysis specific:

Results expressed as mg/l unless stated otherwise

Oil analysis specific:

Results expressed as mg/kg unless stated otherwise
S.G. expressed as g/cm³ @ 15°C

Filter analysis specific:

Results expressed as mg on filter unless stated otherwise

VOC analysis specific:

Explanatory notes for data flagging
U = undetected above reporting limit
J = concentration at instrument was below lowest calibration standard
E = concentration at instrument was above top calibration standard
B = compound was detected in method blank

Gas (Tedlar bag) analysis specific:

Results expressed as ug/l unless stated otherwise

Air (Carbon tube) analysis specific:

Results expressed as ug on tube unless stated otherwise

Asbestos analysis specific:

CH denotes Chrysotile
CR denotes Crocidolite
AM denotes Amosite
NADIS denotes No Asbestos Detected in Sample
NBFO denotes No Bulk fibres Observed

General notes:

^ this analysis was subcontracted to another laboratory
\$ Within laboratory tolerances
\$\$ unable to analyse due to nature of sample
¥ Results for guidance only, possible interference
& Blank corrected
I.S insufficient sample for analysis
Intf Unable to analyse due to interferences
N.D Not determined
N.R Not recorded
N.Det Not detected
Req Analysis Requested, see attached sheets for results
p Raised detection limit due to nature of sample
***** denotes that all accreditation has been removed by the laboratory for this result.
‡ denotes that Mcerts accreditation has been removed by the laboratory for this result.
Note: The Laboratory may only claim that data is accredited when all of the requirements of our Quality System have been met. Where these requirements have not been met the laboratory may elect to include the data in its final report and remove the accreditation from individual data items if it believes that the validity of the data has not been affected.

If you require further details of the circumstances leading to the removal of the accreditation from any data item please do not hesitate to contact the laboratory

END OF REPORT

Appendix F

Radon Report



Report prepared for:

ATRA 01/01
42 GUN
YSTAL
SWALD
SA 2H

cont

Radon Protective Measures Site Report

Advisory report on the requirement for radon protective measures in
new dwellings

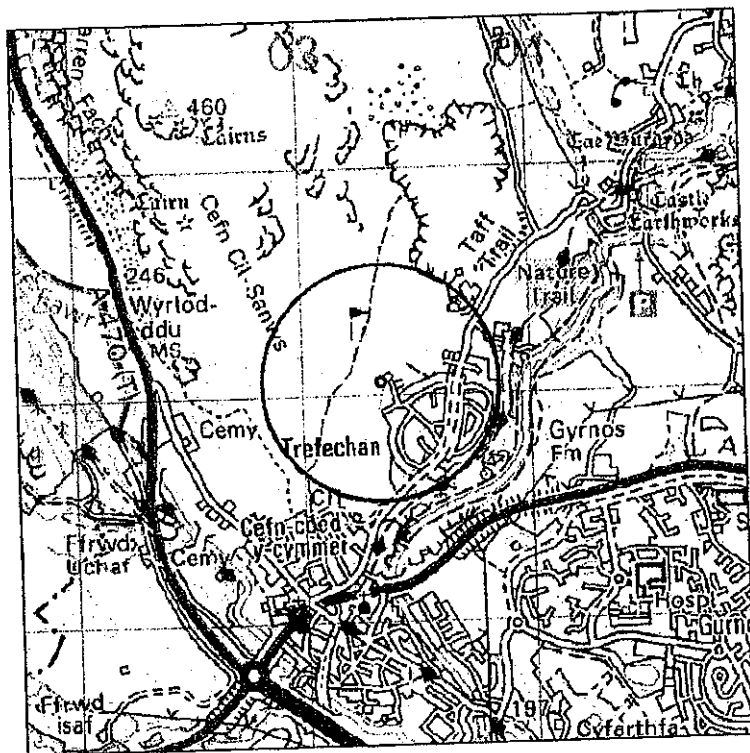
Stage 2 Geological Assessment for BR211 (1999)

Client's Reference:

99/017

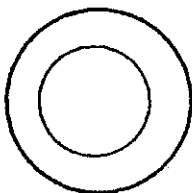
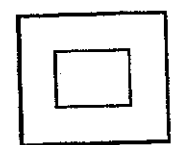
Section 1: Location and extent of report area

Area centred at: 303350 209050
Radius of site area: 20 metres



Topography based on the latest 1:50,000 scale Ordnance Survey Maps with the permission of The Controller of Her Majesty's Stationery Office, Crown Copyright. Ordnance Survey licence number GD272191/2000. Display scale may vary.

KEY:



INNER RECTANGLE or CIRCLE defines site area (details provided by client).
OUTER LINE shows extent of TOTAL SEARCH AREA comprising the site area and automatically generated buffer zone. The requirement for radon protective measures indicated in Section 2 is based on a geological assessment of the Total Search Area.

Please see Section 4 for details of how the search is carried out



Section 2: Requirement for radon protective measures

The RPM GIS has determined that:

FULL RADON PROTECTIVE MEASURES ARE REQUIRED FOR THE REPORT AREA.

This assessment was derived from 1:250,000 scale data.

Where protective measures are indicated, guidance can be found in BR211(1999) *Radon: guidance on protective measures for new dwellings*.

Important note: the level of radon protective measures indicated by the Stage 1 NRPB Map in the BRE publication (BR211, 1999): **Radon: Guidance on protective measures for new dwellings** still applies to this site and should be followed as the minimum requirement. See Section 4 for more details.

Please see Section 4 for details of how the assessment is carried out

Section 3: Geological units within the search area

Below is a listing, if available, of the possible combinations of Solid Geology units and overlying Drift (Superficial) Geology units within the total search area.

These have been derived (as indicated) from searches of either:

- a) Combined 1:250,000 Solid and 1:625,000 Drift geology maps
- b) 1:50,000 Solid, Drift and Artificial geology maps

1:250,000 data

- 1. CARBONIFEROUS LIMESTONE SUPERGROUP(LIMESTONE 4200); No drift
- 2. MILLSTONE GRIT GROUP [SEE ALSO MIGR](SANDSTONE 3D00); No drift

Radon (RPM) Site Report

a British Geological Survey (BGS) product



**British
Geological
Survey**

The geological assessment in this report is produced by the BGS Radon Protective Measures Geographical Information System (RPM GIS), which has been developed to provide Stage 2 Geological Assessments (RPM Site Reports). The assessment is derived from a geologically based interpretation of radon measurements in dwellings which were provided to the BGS by the NRPB without prejudicing confidentiality undertakings to householders and the Department of the Environment, Transport and the Regions (DETR). The reliability of a geological radon potential assessment is approximately proportional to the number of radon measurements available and the scale of the geological maps.

The RPM GIS currently comprises 1:250,000 scale data with more detailed information for twenty 1:50,000 scale geological map sheets covering the most radon-prone parts of Derbyshire, Northamptonshire, Nottinghamshire, Leicestershire, Lincolnshire, Oxfordshire, Shropshire, Somerset and Yorkshire. The RPM-GIS is being upgraded to 1:50,000 scale over the next 12 months as new digital maps become available through the BGS DIGIMAP programme.

The search area (circle or rectangle) for a site is increased by a buffer zone of 50 m in areas with 1:50,000 scale data and 500m in areas with 1:250,000 scale data. This is to allow for potential inaccuracies in the position of the geological boundaries. In many cases a number of combinations of bed rock and drift with differing geological radon potentials will occur within the total search area. Following the precautionary principle, the requirement for protective measures is derived from the highest geological radon potential encountered within the total search area.



Section 5: Follow-up radon protective measures site report

For most parts of the UK, a higher resolution assessment of radon protective measures requirements can also be provided by BGS. This will comprise:

- i. Assessment by a qualified geologist of the relevant 10,000, 1:10,560 or 1:50,000 scale geological map(s) covering the total search area from BGS archives.
- ii. Precise identification of the level of radon protective measures indicated for all geological units encountered within the site and the immediately surrounding area.

The basic charge for a Radon Follow-up Report is **£80+VAT**. Reports for very large or geologically complex sites may, however, have to be supplemented with additional **£40+VAT** increments to allow for each extra half-hour of time taken – in such cases, enquiry staff will confirm with the client before proceeding.

The Radon follow-up reports can be ordered from:-
Geological Enquiries, British Geological Survey, Keyworth, Nottingham NG12 5GG; Tel: 0115-936-3192;
Fax: 0115-936-3192; e-mail: geohelp@bgs.ac.uk. An on-line ordering facility will be available in the near future from Services on the BGS web site <http://www.bgs.ac.uk>.

Section 6: What is radon ?

Radon is a naturally occurring radioactive gas, which is produced by the radioactive decay of radium which, in turn, is derived from the radioactive decay of uranium. Uranium is found in small quantities in all soils and rocks, although the amount varies from place to place. Radon released from rocks and soils is quickly diluted in the atmosphere. Concentrations in the open air are normally very low and do not present a hazard. Radon that enters poorly ventilated enclosed spaces such as some basements, buildings, caves, mines, and tunnels may reach high concentrations in some circumstances. The construction method and degree of ventilation will influence radon levels in individual buildings. A person's exposure to radon will also vary according to how particular buildings and spaces are used.

Inhalation of the radioactive decay products of radon gas increases the chance of developing lung cancer. If individuals are exposed to high concentrations for significant periods of time, there may be cause for concern. In order to limit the risk to individuals, the Government has adopted an Action Level for radon in homes of 200 becquerels per cubic metre (Bq m^{-3}). The Government advises householders that, where the radon level exceeds the Action Level, measures should be taken to reduce the concentration.



Section 7: Radon in workplaces

The Ionising Radiation Regulations, 1999, require employers to take action when radon is present above a defined level in the workplace. Advice may be obtained from your local Health and Safety Executive Area Office or the Environmental Health Department of your local authority. The BRE publishes a guide (BR293): **Radon in the workplace**.

BRE publications may be obtained from Construction Research Communications Ltd, 151 Roseberry Avenue, London EC1R 4QX (Tel: 0171 505 6622; Fax: 0171 505 6606).

Section 8: Radon in existing dwellings

Useful information is given in the following free publications which can be obtained by writing to: DETR Free Literature, PO Box 236, Wetherby, West Yorkshire, LS23 7NB.

Radon - A Householder's Guide

Radon - You Can Test for it

Radon - A Guide for Homebuyers and Sellers

Radon - A Guide to Reducing Levels in Your Home

Information in the booklets is also available on the DETR website at:

<http://www.environment.detr.gov.uk/radioactivity/index.htm>

Householders are recommended to follow advice in **Radon - a householder's guide**. The guide outlines simple solutions for dealing with the radon problem depending on whether or not the home has been tested for radon. In radon affected homes, the problem of radon can usually be tackled with simple, effective and relatively inexpensive measures. These measures are comparable in cost to work such as damp-proofing and timber treatment. You can get practical advice about construction work to reduce radon levels from the Building Research Establishment (BRE) **Radon hotline on 01923 664707**.

Advice about radon, its health risks and details of how to order the radon test may be obtained from the NRPB **Radon Freephone** on 0800 614529 or by post from NRPB, Chilton, Didcot, Oxfordshire OX11 0RQ.



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Report issued by: *S. [signature]*
BGS National Geological Records Centre