

APPENDIX B – PREVIOUS REPORTS

Wynnstay Technology Park
New Housing Development
Geo-Environmental Report
Gratton Oakes Ltd



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1.0 INTRODUCTION

Gratton Oakes Ltd (GOL) propose to develop an area of open land adjacent to Llangollen Road, Wynnstay, Technology Park, Ruabon, with mixed commercial and residential properties.

Outline planning for the development was issued in February 2018, Conditions 7 and 8 relate to the investigation of the site for contaminated land, along with any remediation/validation requirements.

Consequently, GOL have appointed GroundSolve Ltd (GSL) to undertake a Phase I desk study & II site investigation at the site to address the conditions.

This report presents the findings of the desks study and site investigation. It gives firm geotechnical recommendations for the development and presents conceptual ground models and environmental risk assessments.

2.0 THE SITE

2.1 Site Location and Description

The site is located to the south of the A539 Llangollen Road, Ruabon, at National Grid Reference SJ 292, 435, see Figure 1.

It is bounded on all sides by existing roads, with Llangollen Road defining the northern site boundary, with open fields further to the north. An unnamed road defines the western site boundary, with a residential estate on the other side of the road. Access roads to Wynnstay Technology Park lie to the south and west, with industrial unit's present, see Figure 2.

The north, west and southern site boundaries are defined by mature Sycamore and Willow trees, with steel chain-link fencing along the south and east boundaries adjacent to the Technology Park access roads.

The site is currently disused scrubland, previously prepared for development. A topographical survey of the site shows it to fall gently from north to south, from around 125.50mAOD to 123.00mAOD. However, a steep batter leading to an elevation of 130mAOD is present along the northern section of the site leading up towards Llangollen Road. In addition, an embankment defines the western site boundary, although this couldn't be surveyed due to the presence of dense vegetation.

Fly tipping was observed on several sections of the site, but mainly in the dense woodland on the northern and western site boundaries. A stream was observed to the north of Llangollen Road flowing in a southerly direction towards the site, where it was culverted beneath Llangollen Road

Photographs of the site are presented in Appendix A.

2.2 Geology and Hydrogeology

The geology of the site has been studied using the British Geological Survey (BGS) 1:50,000 scale geology plan, Sheet 121, Wrexham, along with the associated memoirs, Reference 1. In addition, geological maps provided with the Envirocheck report have been studied, see Appendix B.

These show the site to be completely underlain by glacial till (clay), described as unstratified stony clays, with sands, gravels and cobbles.

The underlying bedrock is the Pennine Lower Coal Measures Formation and the Pennine Middle Coal measures formation comprising mudstones, siltstones, sandstones and coal seams.

The maps from the Envirocheck report record a fault crossing the site trending northeast to southwest, with a coal shaft on site associated with Wynnstay Colliery. Reference 1 records

this shaft to be located 220yds north-west of the railway line, with the Cefn Rock (Sandstone) outcropping immediately east of this shaft. The Wynnstay Colliery is recorded as having worked to a great distance and depth down the dip of the strata, which varies from east-south-east to south east, at an average of around 16°.

Reference 1 records a section through the No 2 pit at Wynnstay Colliery, which is the shaft on site. The pit bank level was 405.93ft AOD (123.75) with the original surface being at 396.93 ft AOD (121mAOD) after deducting 9ft for the made ground. The shaft sinking was commenced in November 1856. The shaft section is summarised below:

Strata	Thickness (m)	Depth (m)
Made Ground	3	3
Sand and Gravel	11.2	14.2
Cefn Coal	2.82	108.8
Warras Coal	0.76	160.4
John the gate coal	0.56	173.2
Main coal	2.74	280.94
Final Depth		379.3

The underlying superficial aquifer is classified as a Secondary aquifer – undifferentiated, and is of low vulnerability. Whilst the underlying bedrock is a secondary Aquifer – A, also with low vulnerability.

The groundwater table beneath the site would be anticipated to be at significant depth in the sand and gravel.

2.3 Abandoned Mining

A CON29M report was obtained as part of this investigation, it is summarised below, and presented in full in Appendix C. It concluded that:

- The property is in an area that could be affected by underground mining in six seams of coal at 140m to 320m depth, last worked in 1927.
- Within 20 metres of the boundary of the property, there is one mine entry.

The shaft, referenced 329343-194 was recorded to have been filled with colliery shale around 1970 to an unknown specification. In March 1990, Wrexham Maelor Borough Council provided information that they had treated and capped this shaft in accordance with British Coal recommendations. Apparently, 515 tonnes of 9:1 PFA/OPC grout was pressure injected into the shaft fill. The shaft was then capped with a 9.60 x 9.60m x 600mm thick reinforced

concrete cap founded in competent clay some 2.6m below ground level, with the top of the cap being at an elevation of 121.15m.

This mine shaft was conveyed to Tsuda (UK) Co Ltd in 1991.

2.4 History

In order to determine the history of the site, extracts from historical Ordnance Survey (OS) plans dating from 1874 have been examined. Unless otherwise stated all plans are at a scale of 1: 2,500.

The 1874 OS plan shows the site to be within open fields, with roads already constructed to the north and west of the site. Wynnstay Colliery lies to the south of the site, with associated railway lines leading to the colliery. Reference 1 recorded that the shaft on site was sunk in 1856. This shaft located in the southern section of the site is surrounded by a mound of fill, with the shaft shown to be circular and approximately 5m in diameter. There is a small building adjacent to the shaft, with further buildings at the northern edge of the fill mound.

A stream flows southward across the site towards the fill mound, with what appears to be a structure where it enters the fill mound. It then exits the mound to the south flowing in a south westerly direction. A small track leads to the shaft from the road on the southern site boundary, see Figure 3a. A small pond is shown immediately east of the site. A benchmark to the north west of the site records an elevation of 431.6ft AOD (131.58mAOD).

The 1899 OS plan records that the coal shaft is disused and the mound of fill had expanded to the north west. The Wynnstay Colliery was now tipping its waste on the site to the south of the site and an 'old quarry' was recorded some 150m east of the site, see Figure 3b. The stream leading from the mound of fill is no longer shown, however, an air shaft is recorded some 20m to the north of the shaft, along with a building adjacent to the air shaft, suggesting the dis used shaft may be being used for mine ventilation. The benchmark now records an elevation of 428.6ft AOD (130.67mAOD), recording some ground settlement associated with the mining.

By the 1912 OS plan Wynnstay Colliery was tipping its waste on the northern section of the site from a tramway running northwest to southeast from the colliery. The benchmark now records an elevation of 428.5ft AOD, see Figure 3c. The air shaft is no longer recorded, although a chimney is shown at the same location, which is around 5m in diameter. A possible stream is shown on the western side of the original mound of fill, which probably means that the original stream had been diverted and possibly culverted beneath the fill on the northern section of the site.

The 1938 and 1954 OS plan at a scale of 1:10,560 show no changes to the site or its surroundings, see Figure 3d and 3e.

The 1962 OS plan confirms that Wynnstay Colliery was now dis used and tipping on site had ceased. However, the shaft on site was still shown. Several batters are shown on site with the level areas becoming overgrown, see Figure 3f. Several of the railway lines to the west of the site had been dismantled. Since 1954 the pond to the east of the site had been backfilled. The stream to the north is labeled as a “Sink”, confirming it was culverted beneath Llangollen Road.

No changes are shown on the 1968 OS plan, see Figure 3g. However, minor earthworks appear to have been undertaken and the shaft is no longer shown, suggesting it may have been backfilled.

By 1972 the batters are no longer shown, suggesting the site had been leveled as part of a reclamation project and the shaft is no longer shown. Immediately west of the site a large residential estate had been constructed, see Figure 3h.

No significant changes are recorded on the 1974 to 1977 OS plans, see Figure 3i and 3j.

The 1989 OS plan confirms the presence of embankments on the northern and western site boundaries, with the site now part of Wynnstay Technology Park. A large industrial building had been constructed immediately to the east of the site, and the access roads on the southern and eastern boundaries completed. To the north Llangollen Road had been widened and the unnamed access road on the western site boundary rerouted, see Figure 3k. A Civic Amenity Centre had been constructed to the south of the site.

The 1991 OS plan fails to show any changes to the site itself, or immediate surroundings, see Figure 3l.

The 1994 OS plan show no significant changes to the site, however, the industrial building to the south had been constructed, see Figure 3m.

The aerial photograph dated 2001 shows the site to be open land and confirms the layout of the buildings within the Technology Park to the east and south of the site. This photograph also shows the residential estate to the west of the site and the open fields to the north, see Figure 3n.

3.0 ENVIRONMENTAL SEARCHES

An Envirocheck report has been obtained for the site, the main points are summarised below, with the report presented in full in Appendix B.

Agency and Hydrological

- According to the BGS there is potential for groundwater flooding to occur at surface.
- The closest discharge consent is 153m to the south of the site, although this has expired, the closest active one is 558m south west of the site.
- The nearest water feature is 63m north of the site.
- There are no water abstractions within 1km of the site.
- The closest LAPPC is 13m south east of the site and is Rolinx Performance and coatings, with the process air pollution from coating of metal and plastic.
- The closest pollution incident to controlled waters was 249m west of the site and was a Category 3- minor incident.

Waste

- There are no historical landfill sites within 500m of the site.
- The closest Licensed Waste Management facility is 127m south of the site, and is a Household Waste Amenity Site.
- There are no Local Authority landfill sites within 500m of the site.
- The closest potentially infilled land (non-water) is located on site.
- The closest registered waste transfer site is 151m south of the site for Household and commercial waste only.

Geological

The BGS have provided estimated soil chemistry for the site as follows:

- | | |
|------------|----------------|
| • Arsenic | <15 mg/kg, |
| • Cadmium | <1.8 mg/kg, |
| • Chromium | 60 – 90 mg/kg, |
| • Lead | <100 mg/kg, |
| • Nickel | 15 – 30 mg/kg. |

In addition, the following geological information is presented:

- The closest BGS recorded mineral site is located within the site boundary and was a deep underground mine for coal named the Wynnstay Colliery.
- It is in an area affected by coal mining activity, and it recommended a Coal Authority report be obtained.
- It is highly unlikely to be in a non-coal mining area.

- A historic opencast mine for sandstone is 157m east of the site.
- The potential for collapsible ground is very low.
- There is no hazard for compressible ground.
- There is no hazard for ground dissolution.
- There is very low potential for landslides.
- There is very low potential for running sands.
- The potential for shrinking or swelling clay is very low.

The site is within an intermediate probability radon area where 3 to 5% of homes are estimated to be at or above the action level. Therefore, basic radon measures are necessary in the construction of new dwellings or extensions.

Industrial Land Use

- The closest contemporary trade directory was located on site (inactive) and was for use with plastics. (This is considered to have been mis plotted).
- The closest active trade directory is located 63m south of the site and is a cable and wire manufacturer.
- A Power Station is located 130m north west of the site.

Sensitive Land Use

- The closest sensitive land use is 261m south east of the site and is ancient woodland.

4.0 PROPOSED DEVELOPMENT

GOL propose to develop a plot of land within Wynnstey Technology Park, Ruabon, with mixed commercial and residential properties. This will involve forty-three social houses and six Commercial units. The current development proposals are presented in Figure 4.

Foundation loads are not yet known at this stage; however, the houses will be timber framed, and based on experience, foundations loads are anticipated to be between 50 and 75kN/m run for two to three storey residential structures. Floor slab loadings are anticipated to be low, probably not exceeding 5kN/m². In addition, development levels have not yet been set.

The commercial buildings will be steel framed structures, with conventional industrial cladding. Column loads are anticipated to be low, probably around 200 to 300kN. Floor slab loadings are not known.

The area surrounding the mine shaft is set aside as public open space, with an attenuation pond proposed in this area.

The recommendations in this report are based on these assumptions, consequently, they should be reviewed, and if necessary revised during the detailed design.

5.0 SITE INVESTIGATIONS

5.1 Previous Investigation (BGS Website)

Examination of the BGS database confirmed the presence of the Wynnstay No 2 shaft on site, the details of which are summarised in Section 2.2, with the detailed shaft section presented in Appendix D.

In addition, a borehole was drilled on the north eastern corner of the site by Dunelm for a new electricity pylon in 2000. This proved 1.0m of made ground overlying glacial till to a depth of 2.70m. The glacial till was described as firm, becoming stiff, grey mottled red brown, slightly sandy, slightly gravelly clay. Groundwater was encountered at a depth of 2.50m.

5.2 Previous Investigation (GSL)

GSL were first appointed in July 2020 to log four trial pits on the site. Apparently, four soakaway tests had been undertaken previously by other parties, who had not logged the trial pits. Consequently, the Local Authority drainage officer requested that detailed logs be submitted in support of the soakaway test results.

This work involved four machine dug trial pits excavated to a maximum depth of 2m, using a 3T machine provided by the client.

The location of the trial pits is shown on Figure 2, with the logs presented in Appendix E.

5.3 This Investigation

This investigation was carried out on the 8th and 9th September 2020 and comprised:

- Ten machine excavated trial pits to a maximum depth of 3.00m,
- Ten window sample boreholes to a maximum depth of 5.45m, with SPT's carried out at 1m intervals,
- Eighteen CBR tests using a TRL probe up to depths of 0.96m.

The boreholes, trials pits and CBR testing were supervised and logged by an engineer from GSL in general accordance with BS 5930, Reference 2.

The locations of the boreholes, trial pits and CBR testing are shown on Figure 2, with their logs presented in Appendix F, G and H respectively.

5.4 Laboratory Testing

Physical Testing

Samples of the glacial till and made ground were taken for the following physical testing:

- Atterberg limit testing,
- Moisture content,
- Particle Size Distribution (PSD),
- Compaction testing using a 2.5kg rammer,
- pH & sulphate testing (2: 1 water extract).

The testing was carried out in accordance with BS 1377:1991, Reference 3. The results are summarised in Section 6.0, and presented in full in Appendix I.

Chemical Testing

Samples of the made ground and glacial till and were placed in the appropriate containers and a cool box, and taken immediately to the laboratories of DETS in County Durham for the following chemical testing:

Metals & Non-metals - Arsenic (As), Boron (B), Cadmium (Cd), Chromium (hexavalent), Chromium (Trivalent), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni), Phenol, Selenium (Se), and Zinc (Zn).

Petroleum Hydrocarbons - Benzene, Toluene, Ethylbenzene, o-xylene, m-xylene, p-xylene, Aliphatics >C5 – C44, Aromatics >EC5 – EC44.

Polyaromatic Hydrocarbons (PAH) – Acenaphthene, Acenaphthylene, Anthracene, Benz (a) anthracene, Benzo (a) pyrene, Benzo (b) fluoranthene, Benzo (g, h, i) perylene, Benzo (k) fluoranthene, Chrysene, Dibenzo (a, h) anthracene, Fluorene, Fluoranthene, Indeno (1,2,3-cd) pyrene, Naphthalene, Phenanthrene, Pyrene.

Other Contaminants – Sulphide (easily liberated), Water soluble Sulphate (2:1 extract), Cyanide, pH, Soil Organic Matter (SOM).

In addition, asbestos screening was carried out on the samples.

The results are summarised in Section 7.0, with the results presented in full in Appendix J.

6.0 GROUND CONDITIONS

6.1 General Stratigraphy

The following general stratigraphy was encountered in the boreholes and trial pits:

BH/TP No.	Stratigraphy		Glacial Deposits (m)
	Made Ground (m)	Glacial Till (m)	
WS1	0.00 – 2.00	2.00 – 5.42	
WS2	0.00 – 2.50	2.50 – 5.45	
WS3	0.00 – 1.50	1.50 – 5.45	
WS4	0.00 – 1.50	1.50 – 4.37	
WS5	0.00 – 1.00	1.00 – 5.20	
WS6	0.00 – 1.90	1.90 – 3.00	3.00 – 4.41
WS7	0.00 – 1.50	1.50 – 5.36	
WS8	0.00 – 2.00	2.00 – 5.45	
WS9	0.00 – 2.18	n/e	
WS10	0.00 – 1.70	1.70 – 3.72	
TP1	0.00 – 1.30	1.30 – 3.00	
TP2	0.00 – 1.80	1.80 – 2.10	2.10 – 2.50
TP3	0.00 – 1.80	1.80 – 2.50	2.50 – 3.00
TP4	0.00 – 1.70	1.70 – 2.40	2.40 – 3.00
TP5	0.00 – 1.60	1.60 – 2.30	2.30 – 3.00
TP6	0.00 – 1.30	1.30 – 1.80	1.80 – 2.50
TP7	0.00 – 1.90	1.90 – 2.50	2.50 – 3.00
TP8	0.00 – 1.80	1.80 – 2.30	2.30 – 3.00
TP9	0.00 – 2.60	n/e	2.60 – 3.00
TP10	0.00 – 2.10	n/e	n/e
TP 01	0.00 – 1.10	n/e	
TP 02	0.00 – 2.30	n/e	
TP 03	0.00 – 2.00	n/e	
TP 04	0.00 – 1.90	n/e	

Previous GSL investigation in Italics

It should be noted that the findings of the boreholes and trial pits are slightly contradictory, with the boreholes generally proving glacial till beneath the made ground. Whilst the trial pits generally encountered a thin layer of glacial till overlying granular glacial deposits. These are considered to be thin lenses based on the glacial till being proved to around 5m depth in the boreholes.

6.2 Made Ground

The made ground beneath the site comprises colliery spoil, which has been excavated from underground during mining operations. It was variable, with the following general descriptions:

- Loose, reddish brown to black, sandy, angular to subangular, fine to coarse gravel of mudstone, slag, brick and burnt shale.
- Firm, dark grey, silty, slightly gravelly clay.
- Very stiff, orangish brown, slightly sandy, gravelly clay, gravel is fine to coarse sub angular to angular mudstone and coal.
- Very dense, dark grey, slightly sandy, clayey, fine to coarse, sub angular to angular gravel, with a high cobble content.

Several of the trial pits were terminated due to the high density of the materials

Standard Penetration Tests (SPT) recorded SPT “N” values between 8 and greater than 50, confirming the loose to very dense consistency, see Figure 5. However, values were generally between 10 and 26 (medium dense), with the higher values probably influenced by coarse fragments (cobbles) within the colliery spoil.

PSD Testing generally confirmed the made ground to be well graded, with the constituents summarised in the table below. Importantly, the fines content was generally below 15%.

TP No	Silt/clay %	Sand %	Gravel %	Cobbles %	Uniformity co-efficient
TP 01	7	30	63	0	44.71
TP 02	4	14	78	4	29.77
TP 03	11	31	58	0	NA
TP 04	11	26	56	7	NA
TP 05	9	27	64	0	61.07
TP 06	9	24	67	0	102
TP 07	7	41	52	0	38
TP 08	15	31	52	0	NA
TP 09	7	21	72	0	59.8
TP 10	5	20	75	0	36.7

Compaction testing of the colliery spoil is summarized in the table below.

TP No	Depth (m)	OMC %	MDD Mg/m ³	NMC %	Difference ±
TP 03	1.0	9.0	2.02	17.9	+8.9
TP 06	1.0	13.5	1.89	14.1	+0.6
TP 09	0.5	15.5	1.76	18.5	+3.0

pH values between 6.3 to 8.0 were recorded, with sulphate values, when measured as 2:1 water extract, of between 15-110 mg/l (0.015 to 0.11g/l).

Sulphur values in the made ground were between 0.04 and 0.19%.

6.3 Glacial Till

Glacial till was encountered at all locations, except WS 09 and TP10 and was generally described as firm to stiff, black/brown, slightly sandy, slightly gravelly clay. The black till was generally encountered immediately below the made ground and probably includes an amount of organic material, as it was the previous ground surface before the made ground was placed.

However, in WS 01 and WS 07, the clay was very soft becoming firm. These boreholes are on the approximate line of the previous stream that crossed the site, and it is considered highly likely that the stream has caused localised softening of the clay near surface.

Standard Penetration Tests (SPT) undertaken in the till recorded SPT “N” values between 3 and greater than 50 average 25, confirming the very soft to very stiff consistency, see Figure 5. However, values were generally between 10 and 30.

Atterberg limit testing recorded liquid limits between 26 and 36%, plastic limits between 13 and 19%, with plasticity indices between 13 and 20%, indicating clay of low to intermediate plasticity. Natural moisture contents were 14.2 to 31.2%.

pH values were between 5.4 and 7.8, with and sulphate values when measured as 2:1 water extract of between 94 and 1,700 mg/l (0.094 to 1.70g/l).

6.4 Glacial Deposits

Glacial deposits were occasionally encountered beneath the glacial till where they were described as dense, green, clayey, slightly gravelly, fine to coarse sand, gravel being sub angular to sub rounded fine to coarse of sandstone.

SPT “N” Values were greater than 30, confirming the dense consistency.

6.5 Groundwater

Groundwater was encountered across the site as shown in the table below:

TP/BH No	Water Strike (m)	Inflow rate	Strata
TP3	1.80	Slow seepage	Base made ground
TP4	1.70	Slow seepage	Base made ground
TP5	1.60	Slow seepage	Base made ground
TP6	1.30	Fast inflow	Base made ground Glacial Deposits
TP8	1.80	Slow seepage	Base of made ground
TP9	2.60	Slow seepage	
WS 01	1.00		Boundary between granular and cohesive made ground
WS 03	1.50		Base of made ground
WS 04	1.50		Base of made ground
WS 05	1.00		Base of made ground
WS 06	1.80		Base of made ground
WS 07	1.50		Base of made ground
WS 09	1.50		In made ground
WS 10	1.70		Base of made ground

These water strikes are considered to be a perched water table sitting within the base of the made ground, above the low permeability glacial till.

6.6 CBR Testing

CBR testing using a TRL probe has been carried out across the site, see Figure 2.

Examination of the test results revealed high CBR values within the made ground, which is not surprising given the general make-up of the colliery waste material. The range of test results is summarised in the table below:

Test No	Depth (m)	CBR Range %
DCP 1	0.00 – 0.60	19 – 212
DCP 2	0.00 – 0.76	20 – 123
DCP 3	0.00 – 0.92	5 – 21
DCP 4	0.00 – 0.92	14 – 121
DCP 5	0.00 – 0.89	19 – 69
DCP 6	0.00 – 0.93	12 – 78
DCP 7	0.00 – 0.91	9 – 96
DCP 8	0.00 – 0.90	16 – 126
DCP 9	0.00 – 0.94	7 – 54
DCP 10	0.00 – 0.93	11 – 56
DCP 11	0.00 – 0.96	6 – 61
DCP 12	0.00 – 0.93	5 – 18
DCP 13	0.00 – 0.47	12 – 268
DCP 14	0.00 – 0.52	25 – 220
DCP 15	0.00 – 0.94	10 – 71
DCP 16	0.00 – 0.96	25 – 288
DCP 17	0.00 – 0.93	7 – 66
DCP 18	0.00 – 0.71	9 – 76

7.0 RESULTS OF CHEMICAL TESTING

Soil samples were taken from the made ground, with the sample depths are presented in the table below.

TP No	Depth (m)
TP 01	0.50
TP 02	0.50
TP 04	0.50
TP 05	0.50
TP 06	1.00
TP 07	0.50
TP 08	0.50
TP 10	0.50

The results of the soil analyses are presented below, where they have been compared to suitable generic assessment criteria (GACs), in order to allow a generic quantitative risk assessment (GQRA) to be carried out for the site and the proposed development.

The Category 4 Screening Levels (C4SLs) published by DEFRA (2014) have been adopted in the first instance, which have been published for six substances to date. Where a C4SL is unavailable, the “Suitable 4 Use Levels” (S4ULs) published by LQM/CIEH (2015) have been adopted.

These criteria have been derived using the CLEA model for a range of standard end-use scenarios and a range of soil organic matter (SOM) contents. It should be noted that the C4SL values are derived on the basis of a “low level of toxicological concern”, while the S4UL values are based on a “tolerable” or “minimal” level of risk. As such, the S4ULs describe a lower level of risk than the C4SLs, and are equivalent to the former Soil Guideline Values (SGVs, published by the Environment Agency) and the previous editions of the LQM/CIEH GAC values.

A “residential with gardens” end-use has been adopted for this analysis, based on the most-conservative SOM content of 1%.

Note: the S4UL values presented below are Copyright Land Quality Management Limited, reproduced with permission; Publication Number S4UL3668. All rights reserved.

Metals & Non-Metals	Min (mg/kg)	Max (mg/kg)	Average (mg/kg)	Count	Adopted Guideline (mg/kg)	Source	Exceedances
Arsenic	2.8	57	17.98	8	37	C4SL	1
Boron, Water Soluble	0.3	0.8	0.53	8	290	S4UL	0
Cadmium	< 0.1	0.7	0.34	8	22	C4SL	0
Chromium III	10	29	16	8	910	S4UL	0
Chromium, Hexavalent	< 1	<1	<1	8	21	C4SL	0
Copper	24	60	41.5	8	2400	S4UL	0
Lead	15	72	45.38	8	200	C4SL	0
Mercury	< 0.05	0.18	0.08	8	1.2	S4UL	0
Nickel	27	62	38.5	8	130	S4UL	0
Phenol – Monohydric	< 0.3	1.7	0.49	8	120	S4UL	0
Selenium	< 0.5	3.3	1.4	8	250	S4UL	0
Zinc	59	220	98.25	8	3700	S4UL	0

One sample for arsenic from TP 02 exceeded the adopted GAC values for residential land use with gardens. No other exceedances were recorded.

Petroleum Hydrocarbons	Min (mg/kg)	Max (mg/kg)	Average (mg/kg)	Count	Adopted Guideline (mg/kg)	Source	Exceedances
Aliphatic C5-C6	< 0.01	<0.01	<0.01	8	42	S4UL	0
Aliphatic C6-C8	< 0.01	<0.01	<0.01	8	100	S4UL	0
Aliphatic C8-C10	< 0.01	<0.01	<0.01	8	27	S4UL	0
Aliphatic C10-C12	< 1.5	<1.5	<1.5	8	130	S4UL	0
Aliphatic C12-C16	< 1.2	<1.2	<1.2	8	1100	S4UL	0
Aliphatic C16-C21	< 1.5	<1.5	<1.5	8	65000	S4UL	0
Aliphatic C21-C35	< 3.4	<3.4	<3.4	8	65000	S4UL	0
Aliphatic C35-C40	< 3.4	<3.4	<3.4	8	70	S4UL	0
Aromatic C5-C7	< 0.01	<0.01	<0.01	8	130	S4UL	0
Aromatic C7-C8	< 0.01	<0.01	<0.01	8	34	S4UL	0
Aromatic C8-C10	< 0.01	<0.01	<0.01	8	74	S4UL	0
Aromatic C10-C12	< 0.9	<0.9	<0.9	8	140	S4UL	0
Aromatic C12-C16	< 0.5	<0.5	<0.5	8	260	S4UL	0
Aromatic C16-C21	< 0.6	<0.6	<0.6	8	1100	S4UL	0
Aromatic C21-C35	< 1.4	<1.4	<1.4	8	1100	S4UL	0

None of the above values exceeded the adopted GAC values for residential land use with gardens.

Polyaromatic Hydrocarbons (PAH)	Min (mg/kg)	Max (mg/kg)	Average (mg/kg)	Count	Adopted Guideline (mg/kg)	Source	Exceedances
Acenaphthene	< 0.03	<0.03	<0.03	8	210	S4UL	0
Acenaphthylene	< 0.03	<0.03	<0.03	8	170	S4UL	0
Anthracene	< 0.03	0.09	0.04	8	2400	S4UL	0
Benzo(a)anthracene	< 0.03	0.34	0.07	8	7.2	S4UL	0
Benzo(a)pyrene	< 0.03	0.27	0.06	8	5	C4SL	0
Benzo(b)fluoranthene	< 0.03	0.35	0.07	8	2.6	S4UL	0
Benzo(g,h,i)perylene	< 0.03	0.13	0.04	8	320	S4UL	0
Benzo(k)fluoranthene	< 0.03	0.14	0.04	8	77	S4UL	0
Chrysene	< 0.03	0.39	0.08	8	15	S4UL	0
Dibenzo(a,h)anthracene	< 0.03	<0.03	<0.03	8	0.24	S4UL	0
Fluoranthene	< 0.03	1.1	0.16	8	280	S4UL	0
Fluorene	< 0.03	<0.03	<0.03	8	170	S4UL	0
Indeno(1,2,3-c,d)pyrene	< 0.03	0.12	0.04	8	27	S4UL	0
Naphthalene	< 0.03	0.05	0.03	8	2.3	S4UL	0
Phenanthrene	< 0.03	0.44	0.08	8	95	S4UL	0
Pyrene	< 0.03	0.96	0.15	8	620	S4UL	0

None of the above values exceeded the adopted GAC values for residential land use with gardens.

Other Contaminants / Testing	Min (mg/kg)	Max (mg/kg)	Average (mg/kg)	Count	Adopted Guideline (mg/kg)	Source	Exceedances
Organic matter	0.6	7.4	3	8	-	-	-
pH	5.4	8	7.12	12	-	-	-
Sulphide	< 10	60	24	8	-	-	-
Cyanide, Total	< 0.1	<0.1	0.1	8	-	-	-
Sulphur (free)	< 0.75	13	3.53	8	-	-	-
Sulphate Aqueous Extract as SO ₄	15	1700	204	12	-	-	-

None of the above values are of concern for a residential land use with gardens.

In addition, no evidence of asbestos was recorded in any of the samples.

8.0 CONCEPTUAL MODEL AND RISK ASSESSMENT

8.1 General

According to the Contaminated Land Regulations, to determine whether there is a significant possibility of significant harm, the following should be considered:

“The nature and degree of harm, the susceptibility of the receptors and the timescale within which the harm might occur”.

Current good practice therefore requires that the findings from the desk study or site investigation be evaluated for contamination on a site-specific basis using a risk-based approach. Risk assessment involves identification of the hazards and evaluation of the risks associated with these hazards. Risk assessment requires an evaluation of a conceptual “source – pathway – receptor” linkage model and can be qualitative or quantitative.

The basis of an environmental risk assessment involves identifying a ‘source’ of contamination, a ‘pathway’ along which the contamination may migrate and a ‘receptor’ at risk from the contamination.

Current legislation defines the various elements of the pollution linkage as:

- A contaminant ‘source’ is a substance, which is in, or under the ground, and which has the potential to cause harm or to cause pollution of controlled waters.
- A ‘pathway’ is one or more routes through which a receptor is being exposed to, or affected by, a contaminant, or could be so affected.
- A ‘receptor’ is either a living organism, an ecological system, a piece of land or property, or controlled water.

A pollutant linkage indicates that all three elements have been identified. The site can only be defined as ‘Contaminated Land’ if a pollutant linkage exists and the contamination meets the criteria above.

8.2 Hazard Identification

On Site

The desk study has revealed that the site’s historical uses have been as agricultural open fields, and as part of Wynnstay colliery, with a shaft on site. Early historical plans show a mound of spoil around the shaft, which is considered to be the spoil derived from sinking the shaft. Whilst the remainder of the site was later used for tipping colliery spoil from the main colliery to the south.

It is also possible that the site was subject to a land reclamation contract in the 1990’s to produce a level development platform. There were also several old buildings on site,

associated with the shaft, although these would be at depth and probably removed during the land reclamation, or buried as proved by TP 10.

The boreholes and trial pits from this site investigation failed to reveal any visual or olfactory evidence of contamination, with the only material encountered being colliery spoil, with occasional burnt shale and brick fragments. This was confirmed by the chemical testing, although one slightly elevated value of arsenic was identified in one trial pit.

However, it would be prudent to undertake a watching brief during shallow excavations. Any potentially contaminated material encountered should be excavated, stored safely on site, tested and then disposed of at a suitably licensed landfill facility.

Off Site

The desk study has revealed that there were few potential contaminative land uses close to the site.

The basic conceptual ground model is presented in the table below:

Conceptual Ground Model: Source, Pathway, Receptor

Potential Contamination Sources	Potential Contaminants of Concern	Potential Pathways	Receptor Group
Made Ground Mine Gas	Heavy Metals PAH	Inhalation/ingestion of contaminated dust Dermal contact Ingestion of soil	Construction Workers Site end users
		Leaching of contaminated materials Lateral Migration and Infiltration of gas/water	Surface and groundwater Building materials and buried services

8.3 Pathways

In relation to any on site contamination reaching potential site users, the following pathways are generally considered for this type of development:

- Ingestion and skin contact with soils on site,
- Inhalation of contaminated dust,
- Leaching of contaminated materials that may affect controlled waters,
- Direct contact with contaminated material during construction,
- Infiltration and accumulation of ground gas.

8.4 Receptors

The potential impact of a hazard must be assessed with regard to the following target groups:

- Future site users,
- Construction workers,
- Surface and groundwater, both on and off the site,
- Nearby vegetation,
- Building materials and buried services.

8.5 Future Site Users Risk Assessment

The site is to be mainly developed with housing, with commercial units proposed in the southern section of the site, see Figure 4.

The desk study failed to reveal any past contaminated land uses and no visual or olfactory evidence of contamination was encountered in any of the boreholes. This was confirmed by the testing. The only exception being one slightly elevated value of arsenic of 57mg/kg, however, the mean value was 18mg/kg. Analysis of the results showed the remainder of the results to be between 2.8 and 20mg/kg, therefore, this elevated value is considered to be an outlier and not represent any contamination of concern. In addition, examination of the trial pit log identified burnt shale to be present, which probably explains the slightly elevated value.

8.6 Controlled Waters Risk Assessment

When considering the risk to controlled waters both surface waters and underlying aquifers have to be considered.

There is a watercourse immediately north of the site flowing in a southerly direction, whilst the historical plans show it used to flow across the site, it appears from the drainage surveys provided, that it has been diverted around the site in the access road to the west of the site. Therefore, any risk to surface waters has been removed.

There are two aquifers to consider beneath the site, one in the sand and gravel and the underlying bedrock. The low level of contamination in the colliery spoil and the fact that it is

protected from downward percolation by the surface layer of low permeability glacial till ensures that the risk to this aquifer are negligible. In addition, the investigation has proved the surface of the low permeability clay to slope gently to the south following the topography, consequently, any perched water at the base of the colliery spoil will flow southwards off site.

The underlying bedrock aquifer will be contaminated with acidic mine water.

Therefore, the risk to controlled water is considered to be very low, with the risk decreasing once the site is developed, and all current surface run off directed into the site drainage from buildings and hardstandings.

8.7 Construction Workers

The risk to construction workers is considered to be very low; and can be catered for by appropriate PPE and washing facilities in accordance with current good practice.

8.8 Ground Gases

No significant sources of ground gases have been identified during the desk study or site investigation works. Therefore, there is considered to be a negligible risk to the development from ground gas.

Whilst mine gas has been considered, the depth to the workings and the fact that the shaft has been grouted and capped makes the risk from this very low, especially if the shaft is going to be in an area of Public Open Space and covered with granular free venting colliery spoil.

However, the site lies within a basic radon area; therefore, basic radon measures are necessary in the construction of new dwellings or extensions.

8.9 Building Materials

The investigation has not revealed any contamination that could adversely affect building materials or services, although this should be checked with the statutory suppliers, who should be supplied with the laboratory test results.

8.10 Vegetation

The investigation has confirmed that there is no risk to vegetation on site.

9.0 GEOTECHNICAL RECOMMENDATIONS

9.1 General

To assist with the geotechnical recommendations a constraints drawing has been produced, see Figure 6.

The site has a major shaft on site, which given the cap diameter of 9.60m, the shaft may have been up to 4.80m in diameter, which ties in with the historical plans. The shaft has been drilled and grouted, and also capped. The top of the cap is recorded at an elevation of 121.15mAOD, which given the current contours is around 3m depth.

The top of the shaft prior to treatment was recorded as 123.75mAOD, which is at existing ground level.

It would appear that on the historical plans a stream was flowing towards the shaft and beneath the mound of fill. Once the northern area of the site was backfilled the stream would have been culverted.

In addition, on the 1899 historical plan an air shaft is shown some 20m to the north of the main shaft, which on later editions is indicated to be a chimney some 5m in diameter. It is considered that this does not represent a conventional air shaft sunk to the workings. Instead, it is likely that as the air shaft had a building next to it then the No 2 shaft was being used as a ventilation shaft at this time, with the building being a fan house sucking air up the shaft.

Experience of similar features suggest that fan drifts have to be the same size as the shaft, meaning that it could be up to 4.80m in diameter (internal diameter) and be of substantial brick construction. The potential for the presence of the ventilation drift and culvert needs further investigation as the air shaft could impinge on Plots 21 and 22. In addition, the route of the culvert could be beneath several plots as it heads northwards and could be beneath the industrial units.

9.2 Excavations and Site Preparation

Firstly, it will be necessary to strip all surface vegetation and organic matter which should be taken off site to a suitably licensed landfill facility. It will also be necessary to remove several of the trees on site and grub out any root systems, which can be backfilled with well compacted site won material.

Excavations will then be in made ground comprising colliery spoil and possibly glacial till, which should be possible using conventional earthmoving equipment.

The trial pits confirmed that excavations in the colliery spoil could be unstable, therefore, excavations deeper than 1.20m that are to be entered should be shored or battered back for safety reasons.

Shallow excavations for foundations and services are unlikely to encounter water seepages. If encountered they should be easily catered for by pumping from sumps cut within the excavation.

Deeper excavations into the glacial till will encounter slight seepages which can be catered for as described above. The underlying glacial till is of very low permeability and the investigation confirms the surface to be generally following the existing topography. Therefore, it would be prudent to excavate any drainage runs up gradient to ensure excavations are self-draining.

9.3 Foundations and Floor Slabs

Several options have been considered for the foundations, with the following issues relevant when choosing the most appropriate foundation type:

- Depth to founding strata,
- Stability of excavations,
- Volume of materials that needs to be taken off site,
- Can excavated arisings be left on site,
- Final development levels.

The thickness of made ground means that and conventional spread foundations would have to be around 2m deep. The trial pits revealed that the pits were unstable in places, which would increase the volumes of concrete used due to overbreak in the foundation's sides. Whilst this could be limited by leaving excavations until concrete is on its way to site this may not always fit in with the availability of Building Control inspectors. In addition, the underlying glacial till was found to vary considerable in strength across the site ranging from very soft in places to stiff in others. Finally, there is a perched water table at the base of the made ground. For this reason, conventional spread foundation has been discounted as an option.

Therefore, raft foundations are recommended for the residential development founded in the underlying loose to medium dense colliery spoil. Two options are available;

Option 1

Rafts foundations to be designed assuming an allowable bearing pressure of 50kN/m² in the existing colliery spoil. The low bearing pressure being chosen to account for any differences in the density of the colliery spoil beneath individual building plots.

Option 2

To increase the bearing pressure, it would be possible to carry out limited ground improvement. This would involve excavating and recompact the colliery spoil to a depth of 1m beneath the underside of the raft, with the bearing pressure increased to 100kN/m².

Rafts should be designed with edge beams extending a minimum of 0.75m below final external ground levels.

For the commercial buildings the foundations option will ultimately be determined by the floor slab loadings. At present it is assumed that they will be light and around 10 to 15kN/m².

In which case, it is recommended that the column lines for the buildings be founded on reinforced strip footings designed assuming bearing pressures as described above.

However, for the floor slab due to the potential for slight variability in the colliery spoil it is recommended that the colliery spoil be excavated and recompacted to 0.50m below the underside of raft construction. It would be prudent to undertake earthworks trials in advance of the works, which should be tested with plate bearing tests to obtain a modulus of sub grade reaction for the slab design.

Formations should be proof rolled and any loose soft areas identified excavated typically an additional 300mm and replaced with suitable well compacted site won material compacted in accordance with an approved earthworks specification.

9.4 Drainage

It is understood that four soakaway test were carried out on site before GSL were appointed. We have not seen the results of these tests. However, based on the ground conditions encountered in the site investigation, we would not consider the site to be suitable for the use of soakaway drainage.

A drainage strategy report was produced for the site in May 2017 by Tier Consult for N/S Holdings.

This highlighted the presence of a culverted watercourse along the western site boundary, an existing surface water sewer in the existing estate access road, which discharges into the culvert via a manhole located at the estate entrance junction.

This report also concluded that the site was unsuitable for soakaway due to the presence of made ground overlying impermeable clay. However, this was not confirmed by testing.

Therefore, attenuation of water was recommended using Greenfield run off rates for all storm events up to and including a 100-year event and +30% climate change allowance.

At present, it is proposed to provide an attenuation pond in the area of Public Open Space adjacent to the shaft.

TC also produced a letter report regarding the route of a culvert, which passes beneath the site, which was issued in August 2016. This culvert is considered to be the same one as seen exiting from beneath the spoil mound on the 1873 historical plans.

The route of the culvert was based on a GroundSure report, which drew a straight line between the “Sink” and “Issue” either side of the site. Therefore, TC undertook a Sonde survey in July 2016 to confirm the route of the culvert. It recommended that the development be designed so that no buildings are proposed over the confirmed route of the sewer.

However, the survey by TC shows the culvert must have been diverted to run down the side of the estate road probably at the time Llangollen road was widened and the new access road constructed in the early 1990’s.

This therefore means that the old culvert was either diverted at the time of the site’s reclamation, or it is still present beneath the site in its abandoned state.

The original stream flowed beneath the mound with the natural ground at an elevation of 120.83mAOD. Therefore, once culverted it would be anticipated to be at around 3m depth in the location of the shaft. To the north of the shaft the elevation would have decreased, therefore the depth of the culvert in the northern section of the site would increase to around 4m. In which case, it is considered highly unlikely that the reclamation would have excavated to such depths.

There are risks involved with the placement of this pond next to the treated shaft. Water would be able to flow into the shaft despite it being grouted and could potentially lead to shaft instability. Therefore, it is recommended that any such pond be lined to prevent infiltration into the shaft.

9.5 Reuse and Disposal of Materials

The site investigation has confirmed that there is a lack of topsoil on site, which will need to be imported. Prior to import it should be validated by appropriate testing.

The investigation has confirmed that the colliery spoil on site is suitable for re-use on site as a structural fill.

Rather than take the colliery spoil off site to tip, it may be possible to lose it on the existing embankments surrounding the site. Alternatively, the site levels could be chosen to incorporate any arisings, I.e. raising site levels to accommodate foundations and services spoil.

9.6 Roads and Hardstandings

The CBR testing on site seems to confirm that the site has been subject to some form of reclamation to form a level building platform.

Based on the CBR results a minimum CBR value of 6% can be used in the design.

Formations should be proof rolled and treated as described above.

9.7 Protection of Buried Concrete

The chemical testing has confirmed that chemical of buried concrete in the colliery spoil is not an issue. Buried concrete can therefore be designed as the following classes in accordance with Reference 4.

- AC- 1,
- DS – 1.

9.8 Landfill and Radon Gas

The desk study has failed to reveal any nearby landfills consequently, landfill gas is not an issue.

The made ground on site is colliery spoil which is a natural material comprising fragments mainly of mudstone, with minor quantities of sandstone and foreign materials, such as burnt shale and bricks. Consequently, this material would not generate gas.

However, the site is in a low radon risk area and basic radon protection measures are required for the development, which should be designed in accordance with Reference 5. They will also address any residual risk from other gas sources.

Finally, the risk of mine gas can be discounted as the depth to any workings is significant and the shaft, which is the only migration route has been grouted, with 515 tons of grout and subsequently capped.

9.9 Further Site Investigation

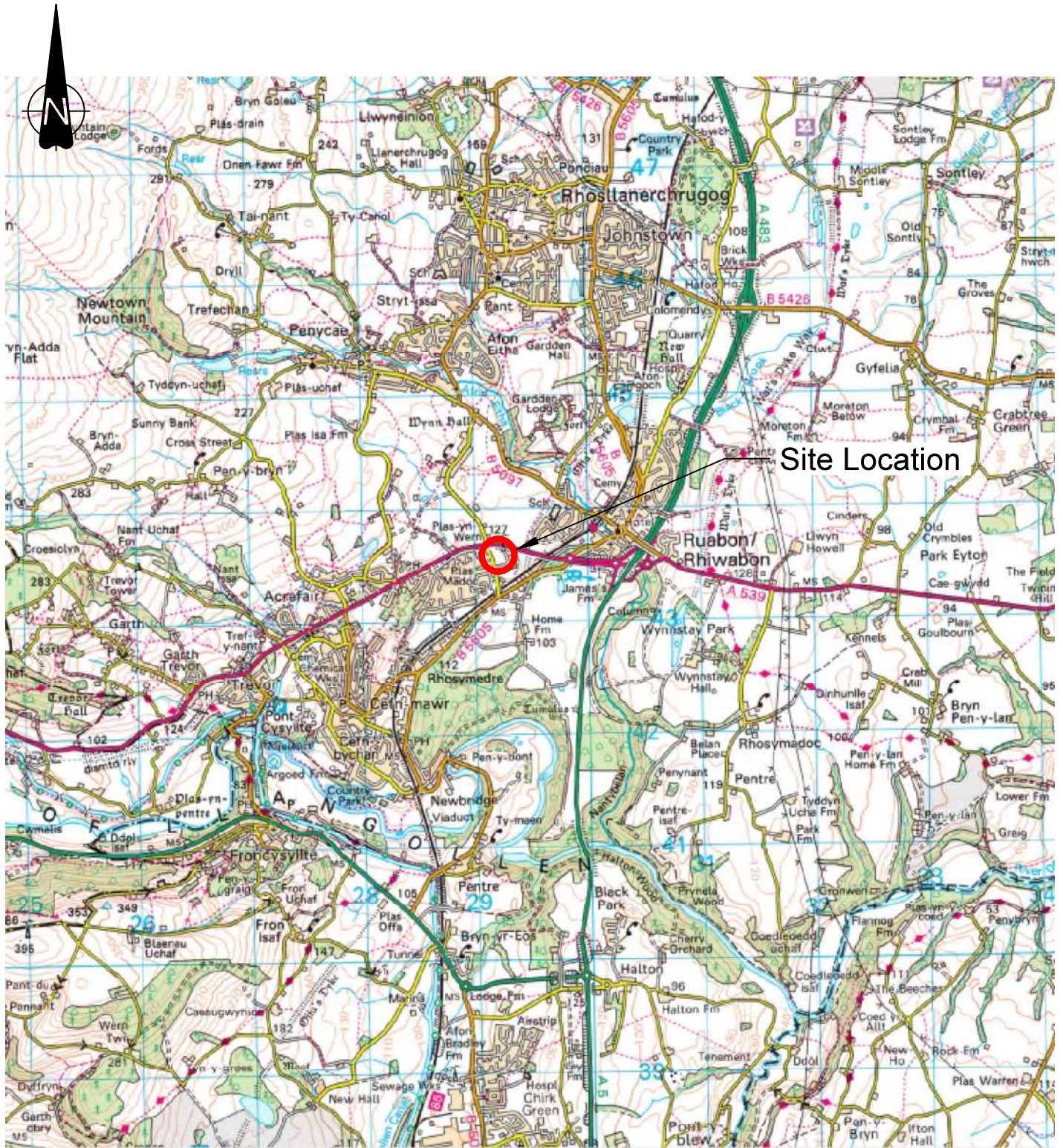
It is recommended that further investigation be undertaken to determine if the ventilation drift and culvert are still present beneath the site, or whether they were removed during the site reclamation.

The easiest way would be to mobilise a tracked machine to site capable of excavating to 5m depth. The excavation should start at the back of the shaft cap, as both the culvert and ventilation drift would have emanated from this starting point. A trial trench across the northern site boundary should also be undertaken, although the presence of trees may preclude this.

REFERENCES

1. The Geology of the Country around Wrexham (Part II), British Geological Survey, 1928.
2. BS 5930:2015, Code of Practice for Site Investigation.
3. BS 1377:1991, British Standard Methods of Tests for Soils for Civil engineering Purposes.
4. BRE Special Digest 1, 2005, Concrete in Aggressive Ground.
5. Radon: Guidance on protective measures for New Buildings, BRE 211, 2007.

FIGURES



OS LICENSE No. 100030802

SCALE 1:50,000 @ A4

Figure Title

SITE LOCATION

FIGURE 1

Site Boundary

Wynnstay Technology Park

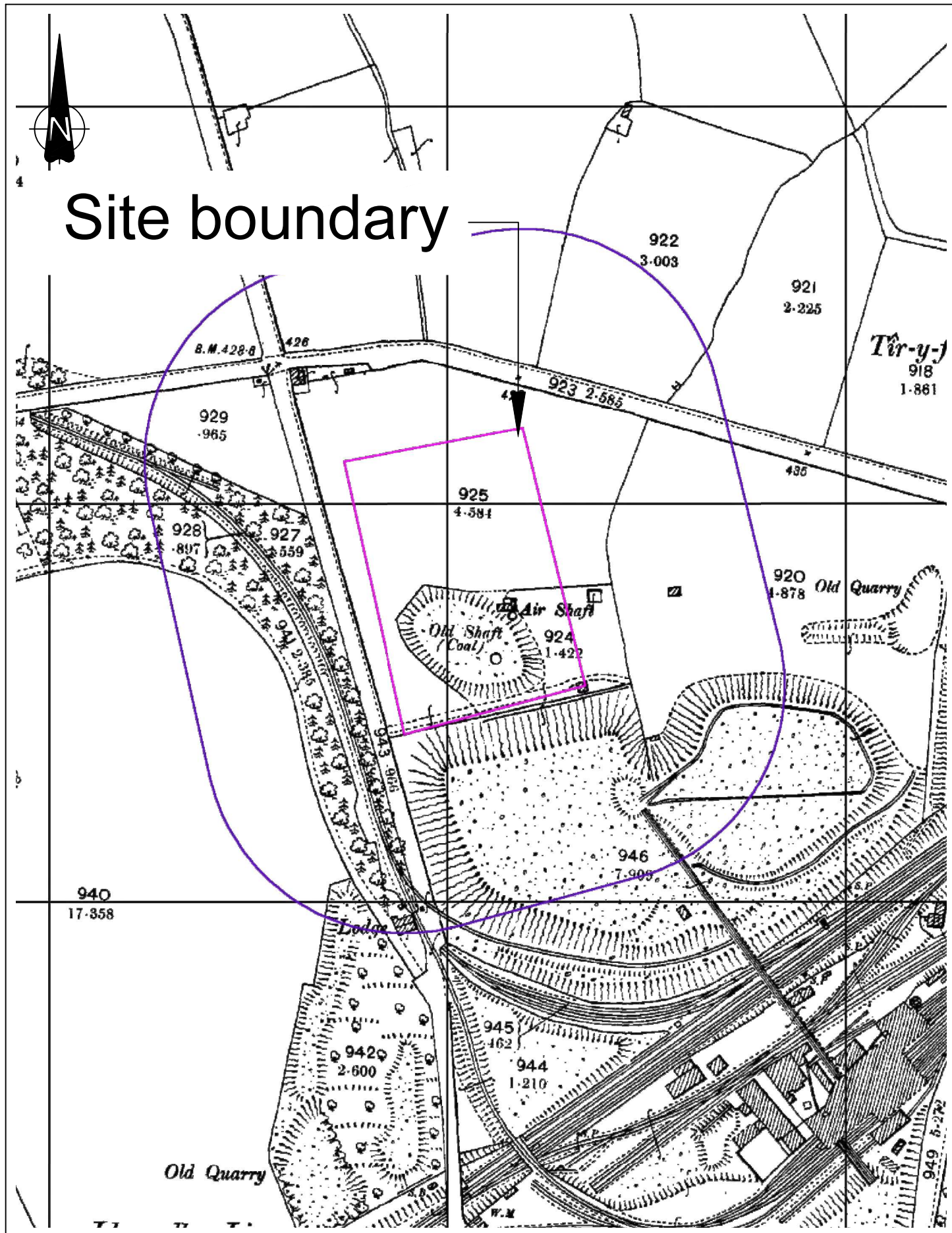
Unnamed Road

Wynnstay Technology Park

LEGEND

- BGS Record
- Previous GSL
- Boreholes- this investigation
- Trial Pits- this investigation
- DCP Test Local



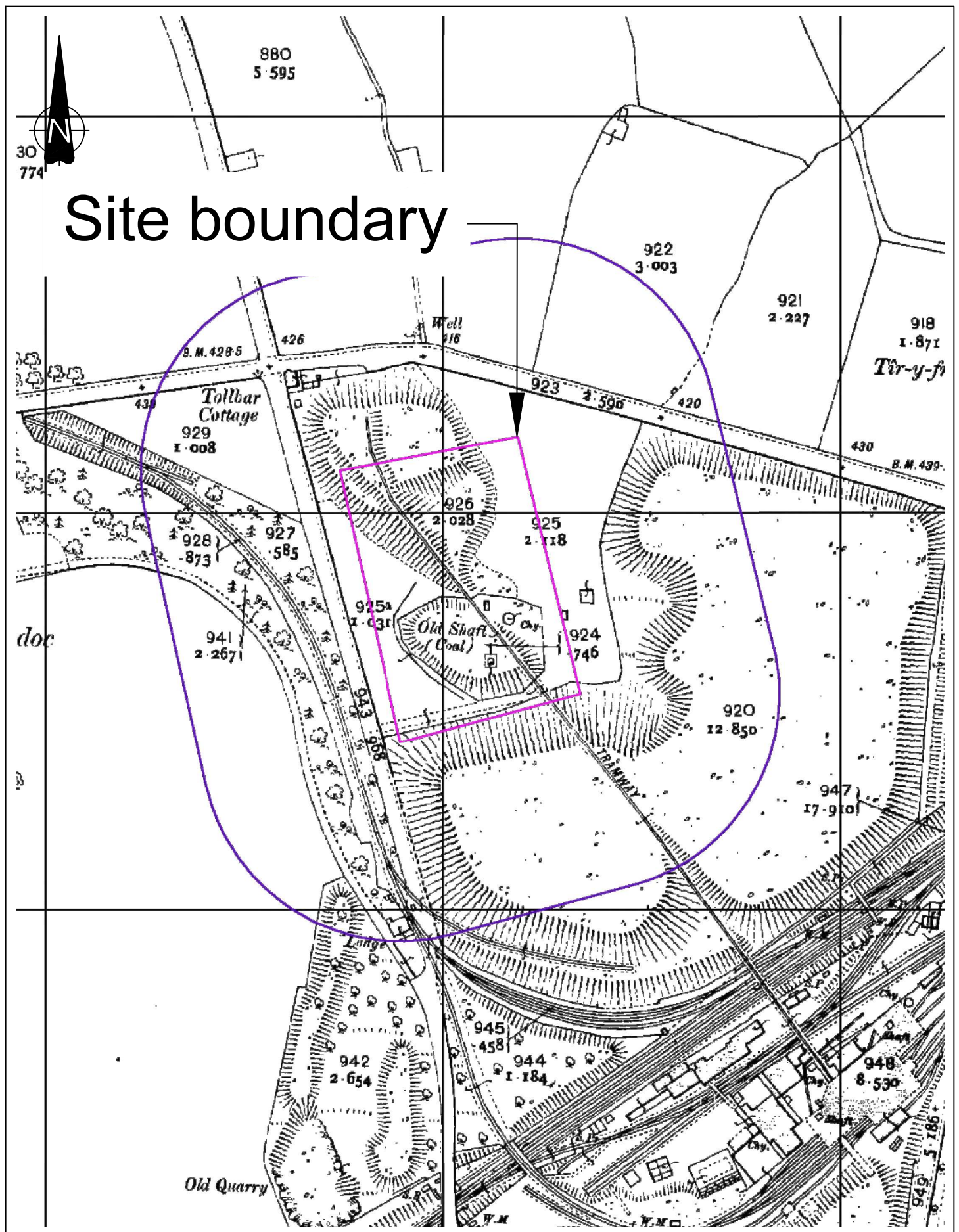


SCALE 1: 2,500 @ A3

Figure Title

Site History
1899

FIGURE 3b

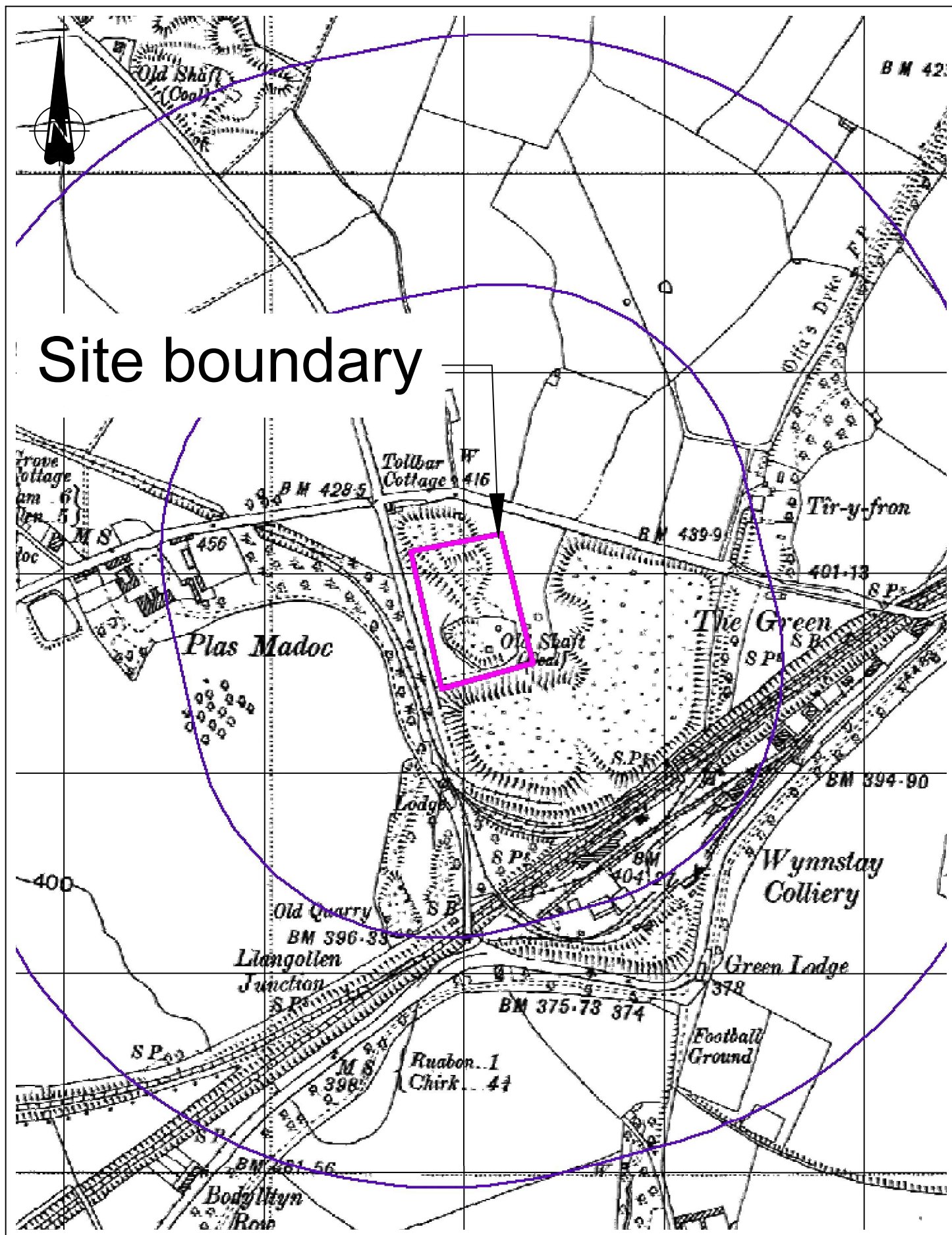


SCALE 1: 2,500 @ A3

Figure Title

Site History
1912

FIGURE 3c

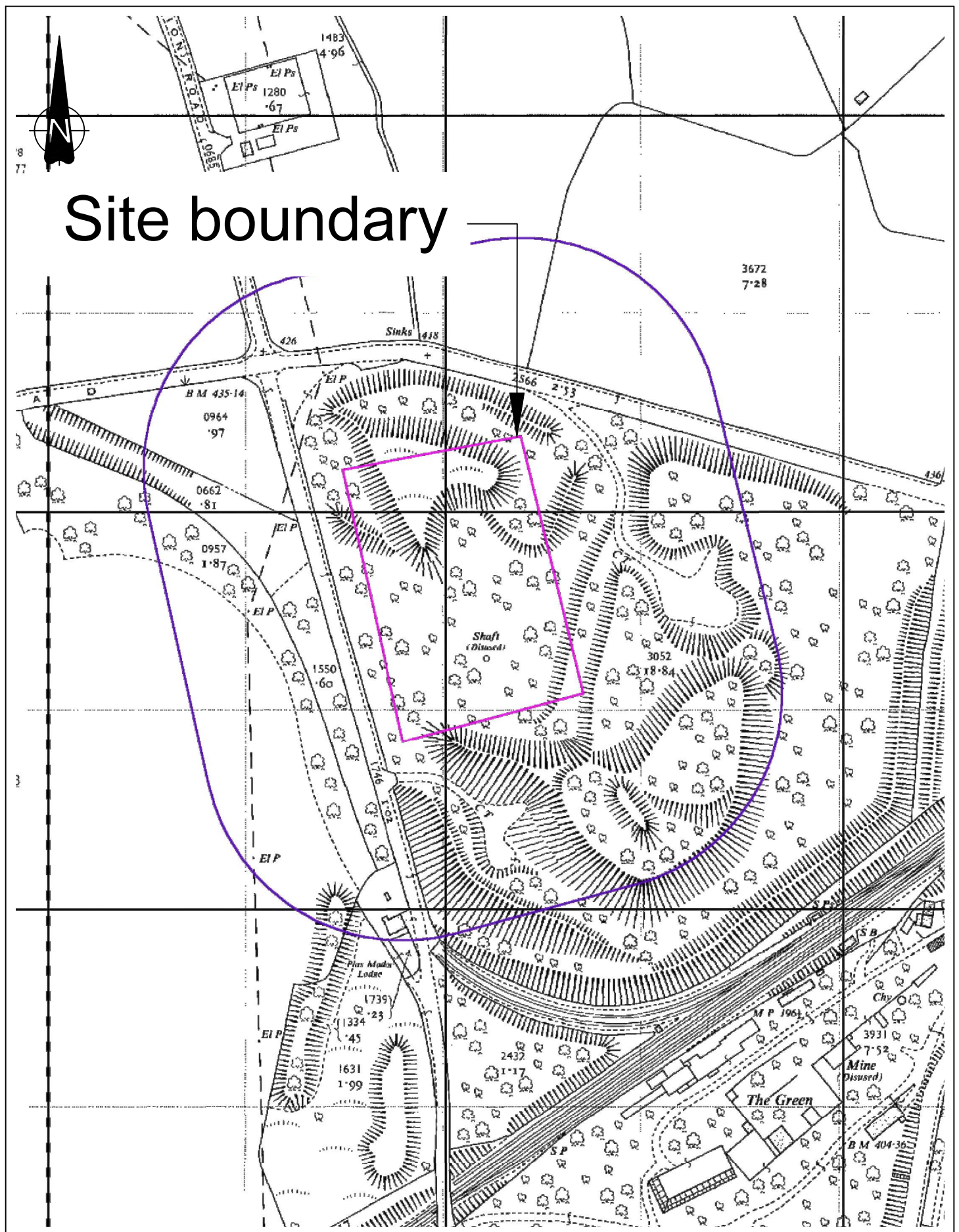


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Figure Title

Site History
1954

FIGURE 3e



SCALE 1: 2,500 @ A3

Figure Title

Site History
1962

FIGURE 3f

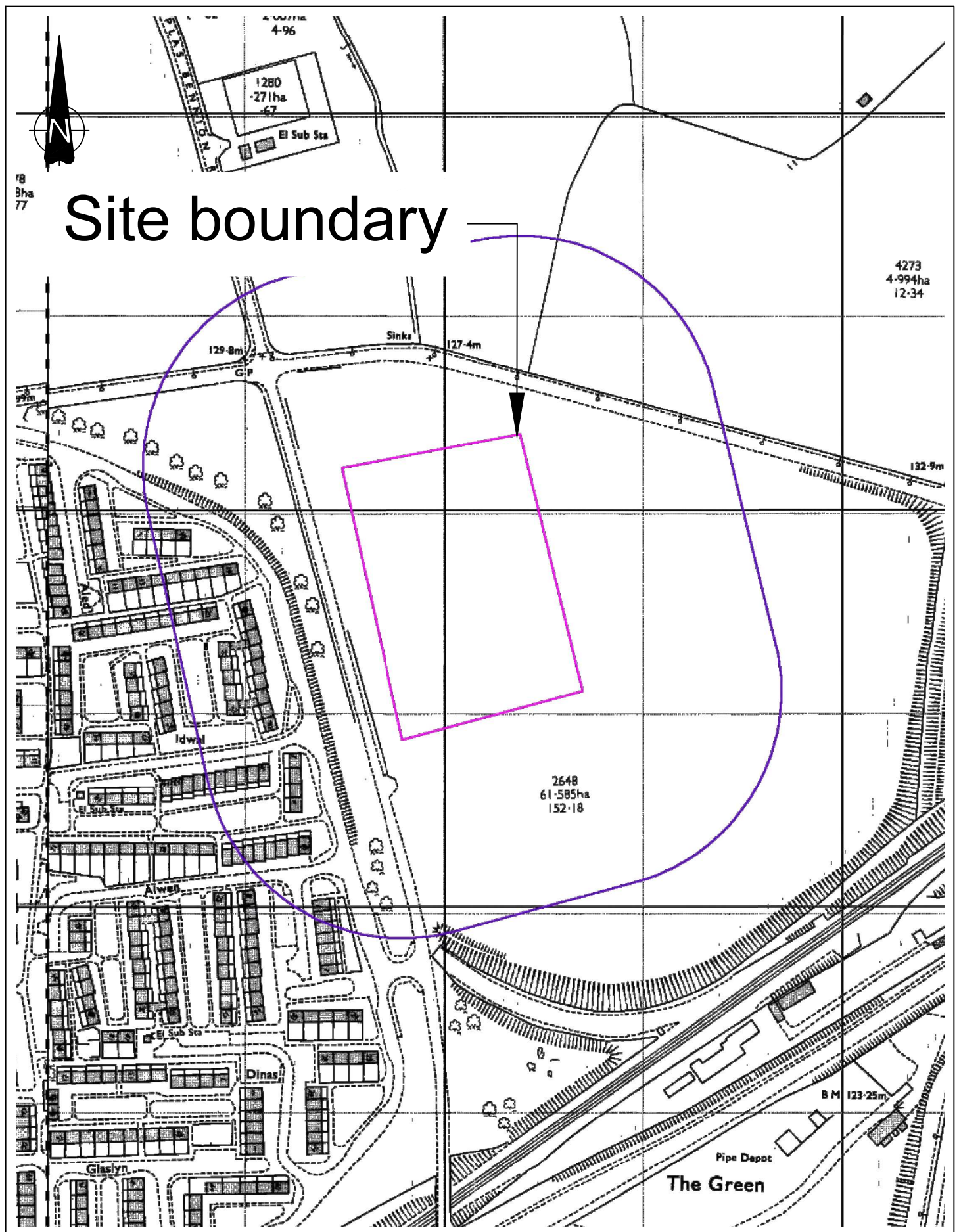


Figure Title

Site History
1972

FIGURE 3h

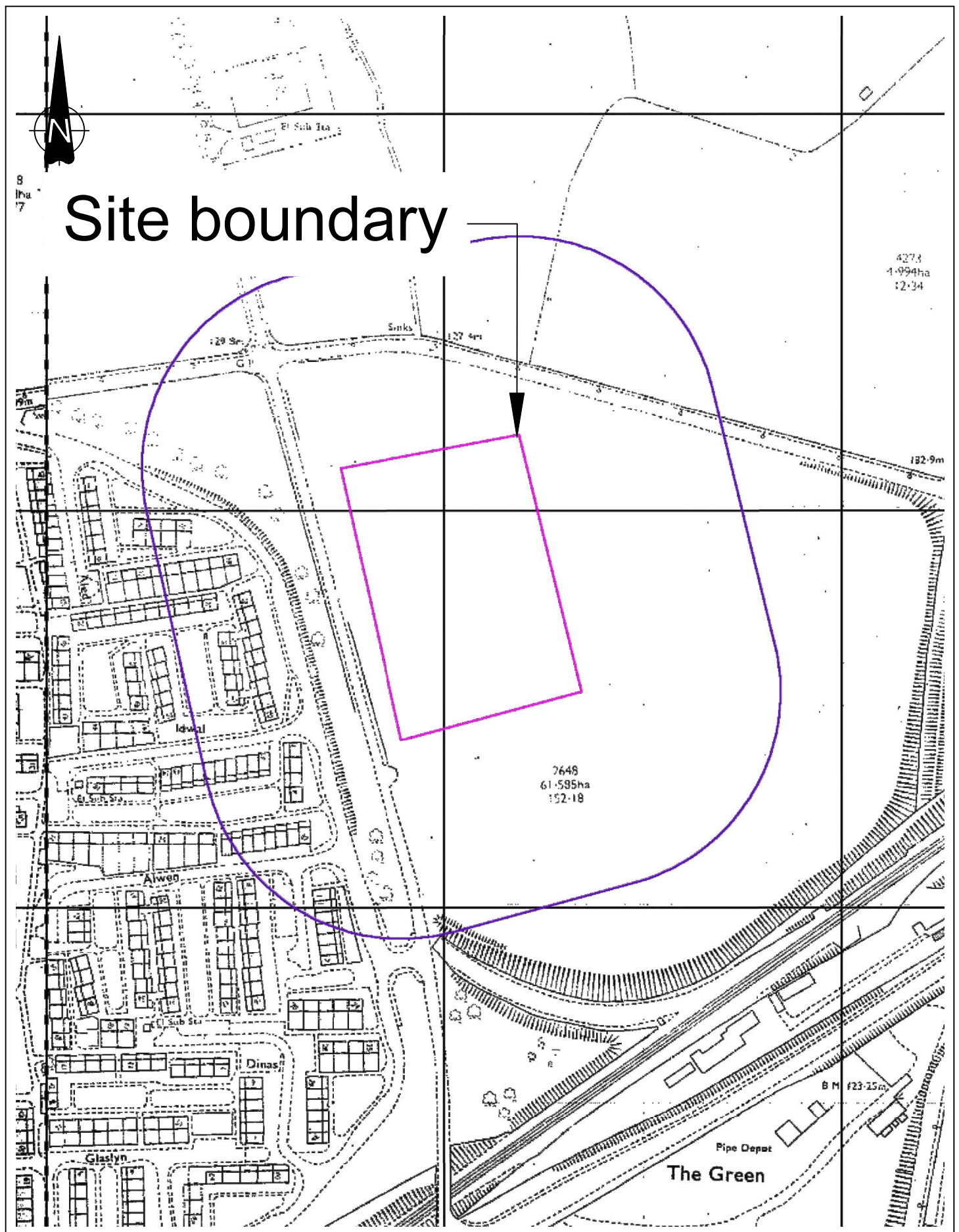
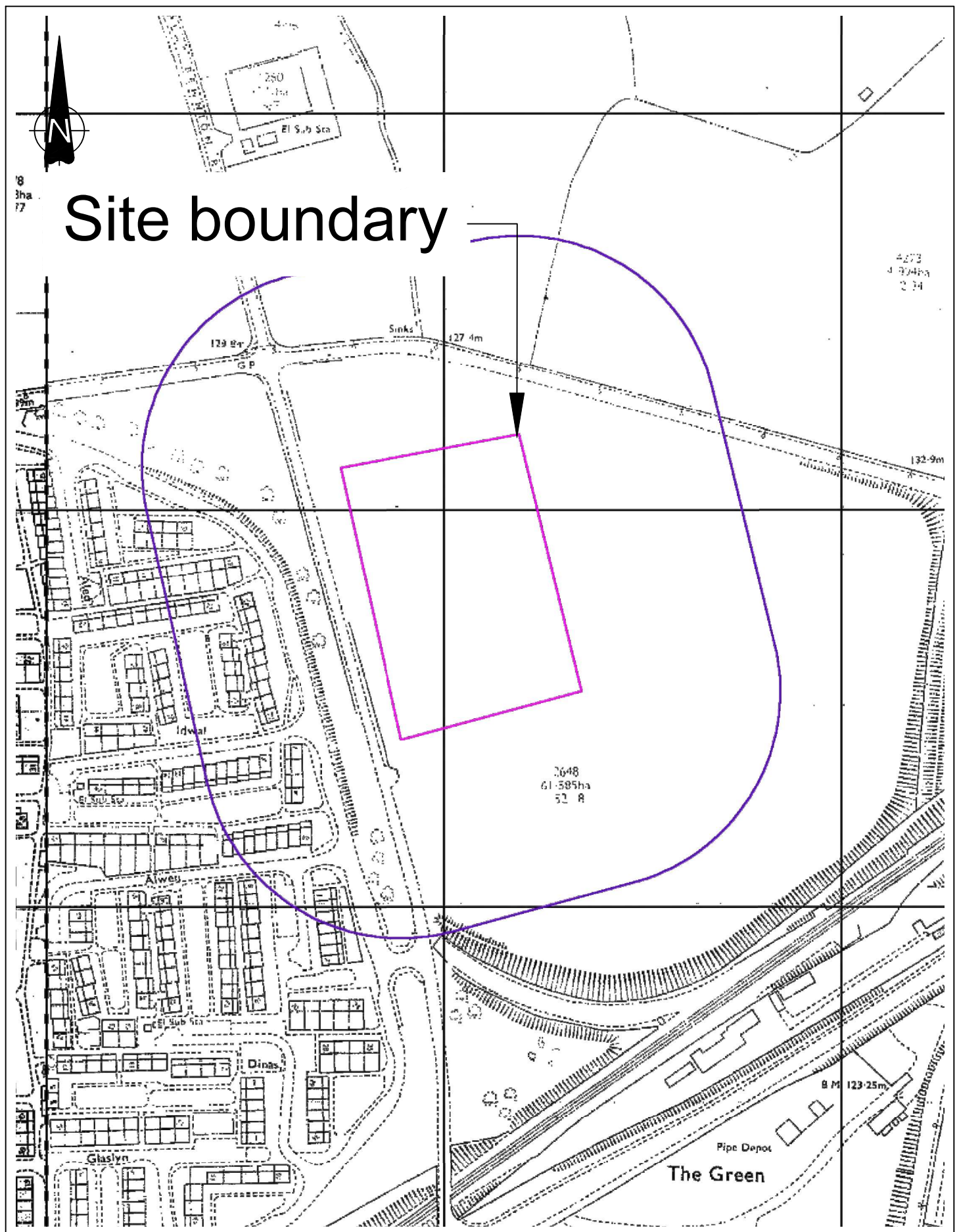


Figure Title

Site History
1974

FIGURE 3i



SCALE 1: 2,500 @ A3

Figure Title

Site History
1977

FIGURE 3j

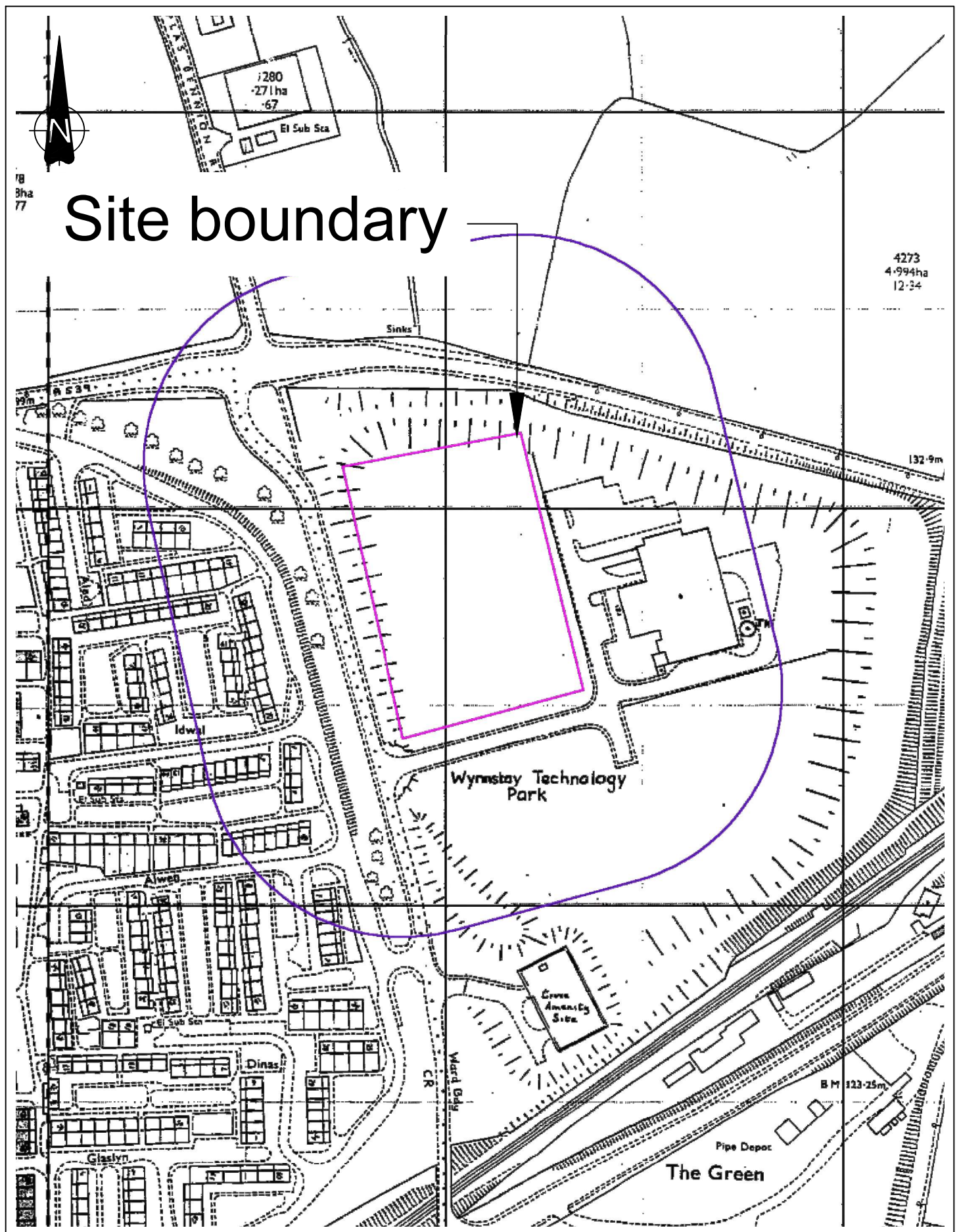
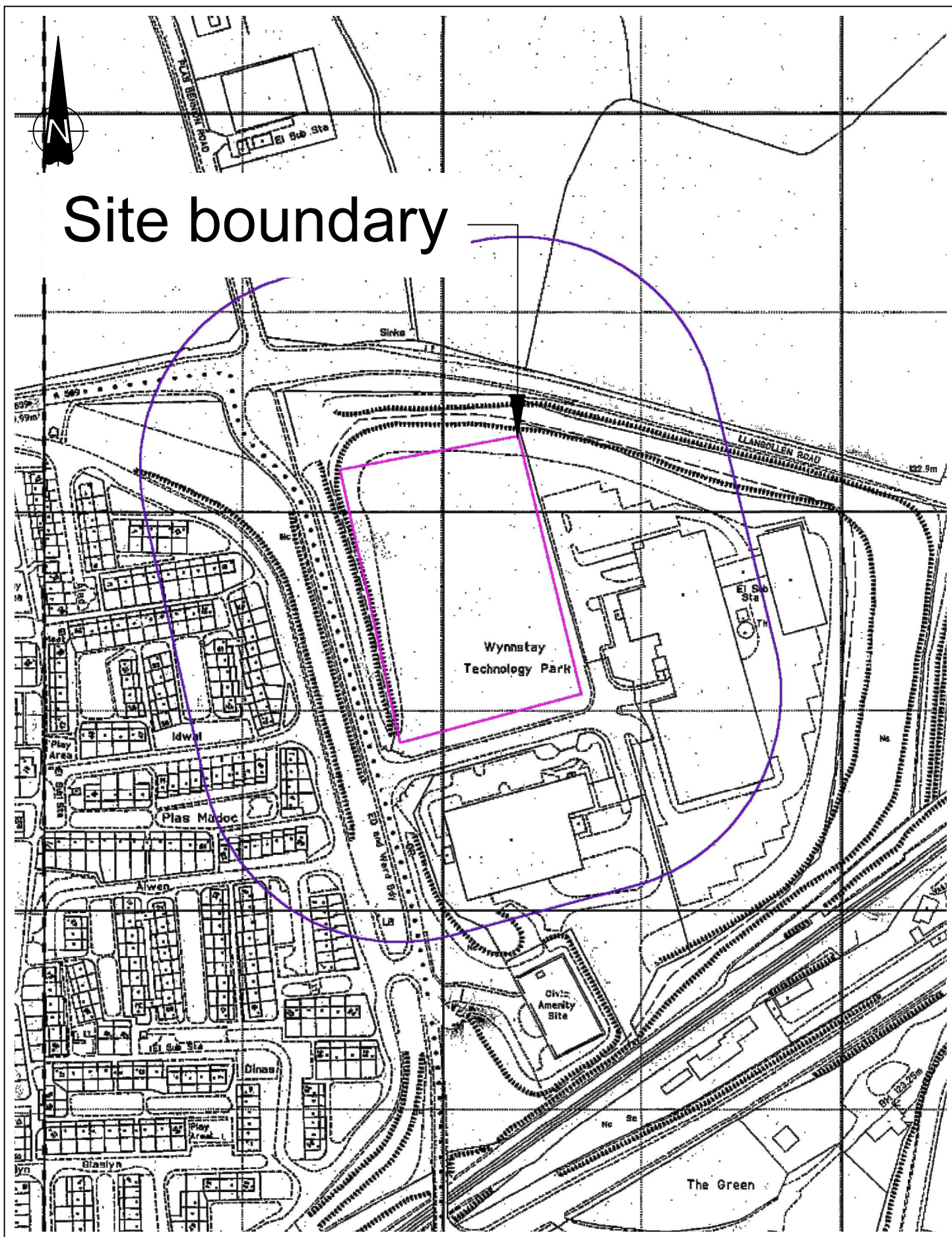


Figure Title

Site History
1989

FIGURE 3k



SCALE 1: 2,500 @ A3

Figure Title

Site History
1994

FIGURE 3m

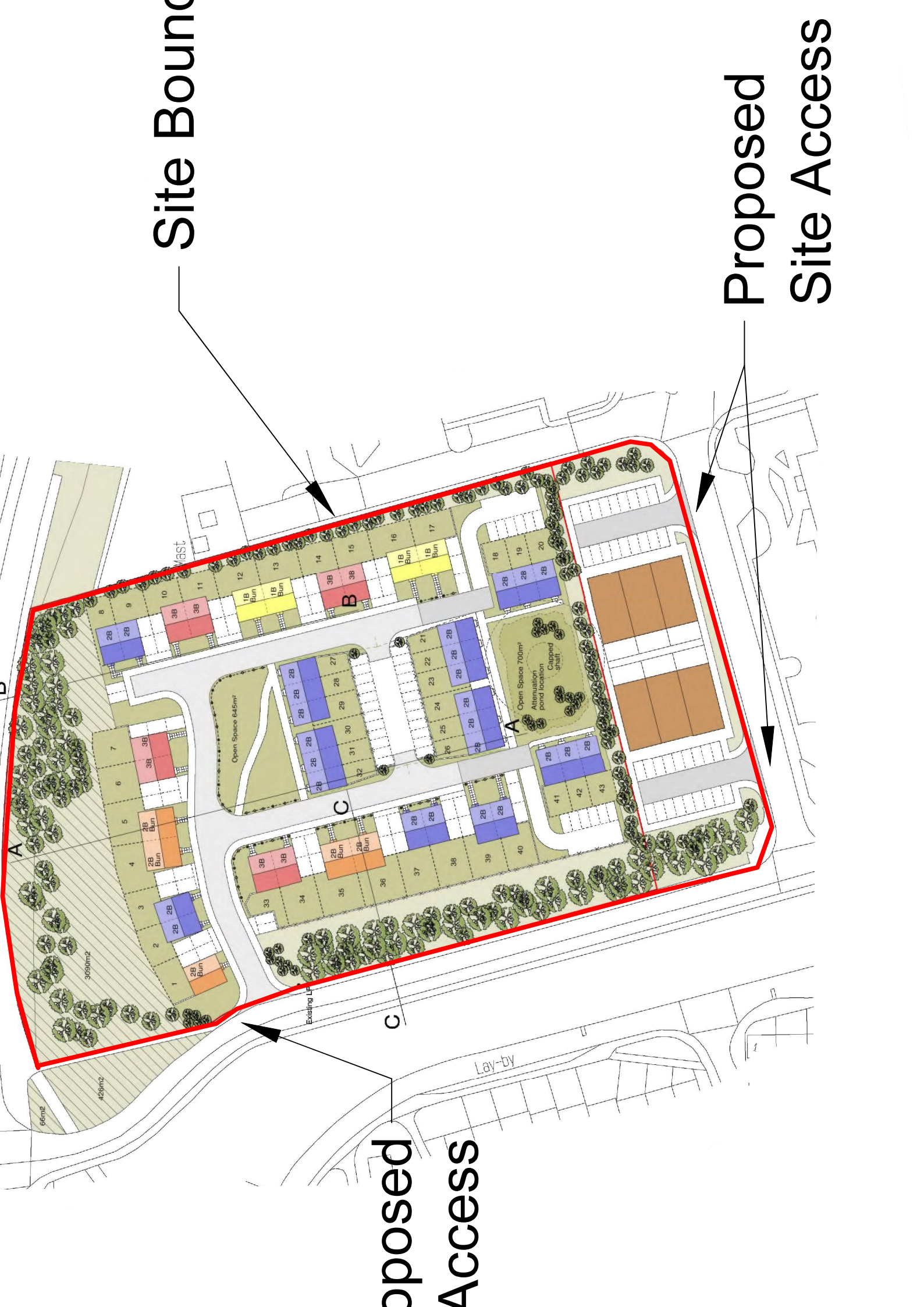


SCALE 1: 2,500 @ A3

Figure Title

Site History
2001

FIGURE 3n



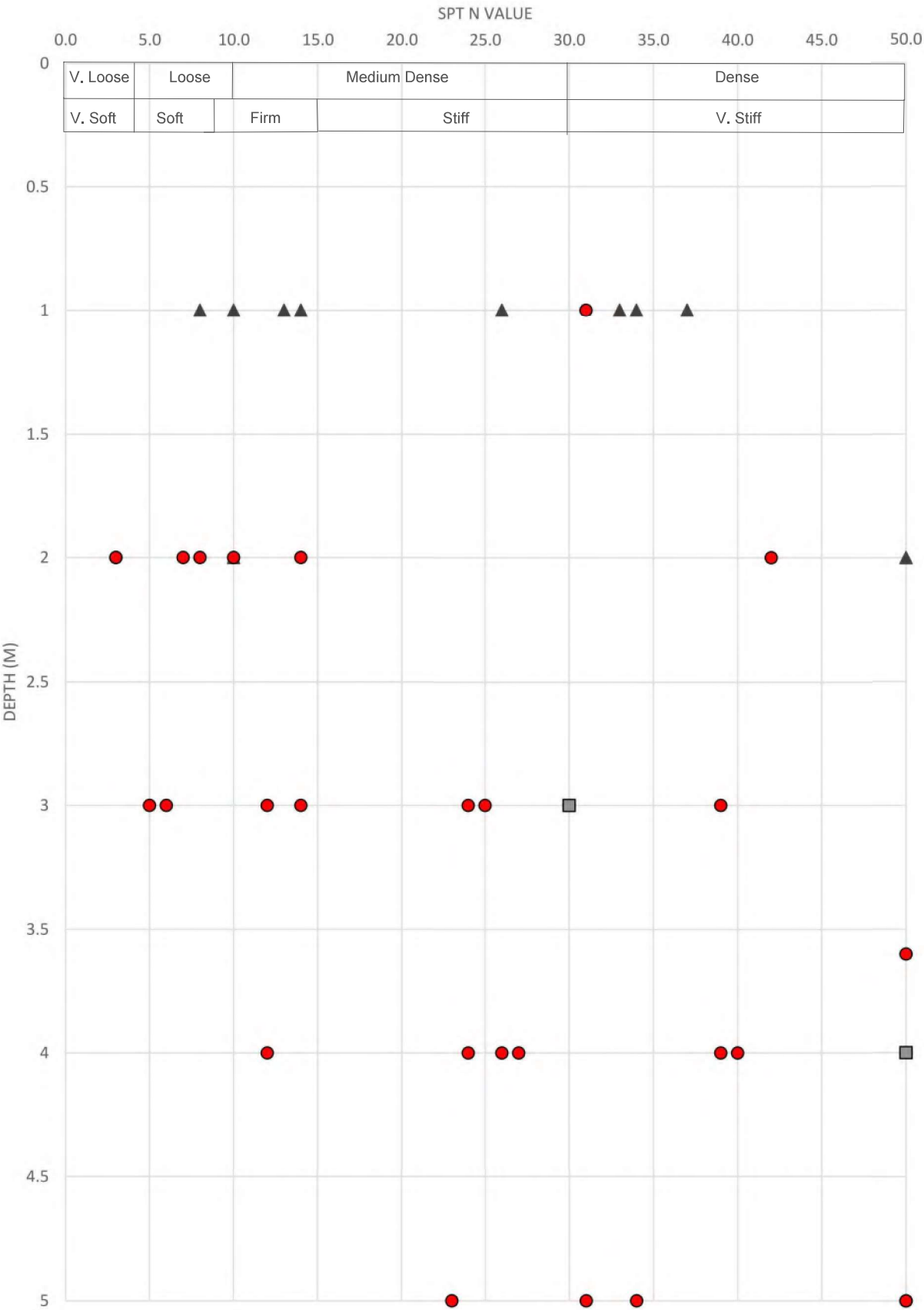
Site Boundary

Proposed
Site Access

Proposed
Access

RECORDED SPT N VS DEPTH

▲ Made Ground ● Glacial Till ■ Glacial Deposits



SCALE Not to Scale

Figure Title
SPT 'N' VALUE VS DEPTH

