Eastwood & Partners
CONSULTING ENGINEERS

E P

PHASE 1 & 2 GEOTECHNICAL AND GEO-ENVIRONMENTAL SITE INVESTIGATION

NETHERMILL FARM, BARNSLEY ROAD, PENISTONE

FOR

DUCHY HOMES



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ISSUE 1

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1.0 EXECUTIVE SUMMARY

1. This report presents the findings of a geotechnical and geo-environmental site investigation carried out by Eastwood & Partners (Consulting Engineers) Ltd on behalf of Duchy Homes, on around 0.8 hectares of land to the north west of Barnsley Road in Penistone, centred around Ordnance Survey national grid reference SK 244 038.
2. The site is currently occupied by farm buildings, a derelict cottage and outbuildings, and their associated yards and access roads. The westernmost and easternmost parts of the site are covered by grass or vegetation. The site slopes gently down to the south, towards Barnsley Road.
3. A corn mill, mill dam and mill race were present in the western and northern parts of the site since at least 1851. Most of the mill building was removed, and the mill race and dam were infilled by 1968. Part of the mill building remained as a cottage, which is present today in the western part of the site. The current farm buildings on site were built between 1968 and 1983.
4. The site lies on undifferentiated mudstone, of the Lower Coal Measures, with superficial deposits of river terrace and alluvium. The surrounding area is quite heavily faulted. The strata is generally indicated to dip to the north east between 3 and 6º.
5. The site is not considered to be at risk from shallow mining.
6. A window sample investigation has been undertaken. The ground conditions generally consist of made ground to depths pf between 0.75 m and 2.65 m bgl. This comprises assorted layers of clay and gravel with local inclusions of ash.
7. Natural ground of firm, locally soft gravelly clay alluvium and river terrace deposits were encountered below the made ground, with stiff grey clay and weathered mudstone from depths of between 2.5 and 3.3 m bgl.
8. Shallow groundwater is likely to be encountered within excavations on the site.
9. It is considered that piled foundations will be the most appropriate for plots at this site. Heave precautions will be required for all plots within influencing distance of existing trees.
10. Precast concrete floors with a 200 mm ventilated void below will be required.
11. Due to the depth of made ground beneath the proposed houses, and due to the localised inclusion of organic matter within the made ground within the infilled mill dam sediment, it is recommended that a fully lapped and sealed 2000g polythene membrane is included below the floor slab of all plots to protect against the ingress of any low concentrations of ground gases.

12. It is very unlikely that soakaways will be a viable method of surface water drainage.
13. Significantly elevated concentrations of PAHs have been recorded in the made ground. A locally elevated concentration of arsenic, and chrysotile (white asbestos) fibres have also been recorded in the shallow made ground.
14. To mitigate against risk to human and plant health from the contaminants in the made ground, a minimum of 600 mm clean capping layer, including a minimum 150 mm clean topsoil and a geotextile marker layer at the base, should be placed across all gardens and landscaped areas.
15. Sulphate precautions comprising DS-3 and AC-3 classification should be allowed for in below ground concrete in contact with the made ground on the site. Concrete in contact with the natural ground may be assigned DS-1 AC-1.
16. This report should be forwarded to the water supplier to confirm its requirements for the water supply pipes.
17. The conclusions made in this report are subject to agreement by the approving bodies such as the Local Authority and NHBC.

2.0 INTRODUCTION

2.1 Terms of Reference

This report presents the findings of a geotechnical and geo-environmental site investigation carried out by Eastwood & Partners (Consulting Engineers) Ltd for, and on the instructions of, Duchy Homes. Any other parties using the information in this report do so at their own risk and any duty of care is excluded.

2.2 Context

Eastwood and Partners completed a Phase 1 investigation of the site as a larger parcel of land on behalf of Chris Carr Architects in October 2012. The report is referenced MJY/AJK/DES/35223-001. The site under consideration in this Phase 2 investigation is contained within “Area A” in the Phase 1 report, with the easternmost part of the site comprising the garden of Nether Mill House, but not the house itself. This previous report has been reviewed during this investigation, and relevant information extracted.

2.3 Aims and Objectives

The aims and objectives of this additional investigation were as follows:

- Review and assimilate Phase 1 data to derive an outline conceptual model identifying potential contaminants, pathways and receptors, as well as possible linkages between these;
- Obtain additional information and incorporate with previous data enabling refinement and subsequent further testing of the conceptual model;
- Detail the ground conditions and their geotechnical properties enabling outline foundation proposals to be made for the proposed residential properties;
- Carry out tiered risk assessment to establish the likely risks to future receptors, involving the use of generic assessment criteria and where unacceptable risks are identified, site specific assessment criteria within a detailed quantitative risk assessment;
- Identify feasible remediation options if unacceptable risks are highlighted;
- Develop an appropriate remediation strategy where remediation is required.

2.4 Scope of Investigation

This document is split into two sections. These constitute the findings of the Phase 1 and Phase 2 investigations, consecutively.

2.4.1 Phase 1

The Phase 1 investigation involved a review of the previous report, which included information extracted from published documentation as well as that obtained from a site reconnaissance. Information regarding the current and former land uses both on and surrounding the site, as well as the environmental sensitivity of the site location as determined by factors including geology, hydrogeology and hydrology were examined.

Information analysed in this section of the report has been obtained from a variety of sources and included the following:

- A Landmark Envirocheck Report. This includes historical Ordnance Survey maps, as well as information regarding environmental issues such as abstraction licenses, pollution incidences and waste facilities;
- Coal Authority Report;
- The British Geological Survey map.

The results of the Phase 1 investigation were used to derive an outline conceptual model from which a preliminary risk assessment was made.

2.4.2 Phase 2

This part of the investigation consisted of intrusive works and laboratory analysis. The findings were used to test the conceptual model and produce a final risk assessment.

The findings of the intrusive investigation were used to test the conceptual model and produce a final risk assessment.

The intrusive works comprised the drilling of window samples to enable:

- Examination of the upper few metres of ground;
- Assessment of any contamination identified using visual and olfactory methods; and
- Collection of samples for chemical testing.

2.5 Limitations of Investigation

This report is based on the assumption that the site will be developed with residential properties of conventional construction. It is assumed that existing ground levels will not alter significantly. If this is not the case, then the advice given in this report may not be appropriate.

Where assessments of site areas affected in particular ways are given, these are approximate. All information, comments and opinions given in this report are based on the ground conditions encountered during the site work, on the results of laboratory testing carried out as part of the investigation and information gained from a geological and historical desk study. However, there may be conditions at the site that have not been taken into account, such as unpredictable soil strata and water conditions between or below investigation points. It should be noted that groundwater and gas levels vary due to seasonal or other effects, and may at times differ from those measured during the investigation.

This report considers the ground and groundwater and does not cover any buildings or their fabric. Generally, testing has only been carried out for contaminants identified as potentially present with no assessment made of biological contamination. Risks to ecological receptors, such as bats, have not been considered.

3.0 THE SITE

3.1 Description

The site is located to the north west of Barnsley Road, Penistone. The site has an area of around 0.8 hectares and is centred around Ordnance Survey national grid reference SK 244 038 (424474, 403828). The site is irregular in shape, and slopes gently down to the south, towards Barnsley Road.

The easternmost part of the site comprises the garden to Nethermill House. The garden is most laid to lawn, with some mature trees, including chestnuts.

Two large barns are present in the centre of the site. The largest of these is around three storeys in height and consists of cement bound asbestos panels fixed around a steel frame. The barn is currently used for storing hay and a number of tractors and other equipment. The rear section of the building is divided into pens for animals. The smaller barn, to the west, is also a steel framed building but with timber cladding to the walls, and a cement bound asbestos panel roof. Further hay bales and farm machinery were stored within this barn. Additional animal pens are also located between the two barns. A concrete covered yard is present to the north of the barns, with a small blockwork retaining wall along the northern side. Various building materials were stored in this yard, along with a number of vehicles. To the front of the barn, a cobbled track runs, with a gated entrance from Barnsley Road at the western end of the barns.

To the south of the barns, derelict buildings are present. These appear to be old brick built barns or garage type buildings, currently used for storing timber, bricks and other materials. A raised area, supported on stone walls is present, although no evidence of a tank having been present on this feature in the past was noted. Clay land drain sections are currently stockpiled on this area. A two storey stone built barn with attached cottage is present to the south of the derelict buildings, facing onto Barnsley Road. The western end of the site comprises a gravel surface yard. The gravel included lumps of concrete as well as bricks. At the time of the visit, the yard was empty. The yard is raised around 500 mm to 1 m above the road.

The site is surrounded by a new housing development to the north west and west, open fields to the north, by Nethermill House to the east, and bounded by Barnsley Road to the south. A college is present further to the north. A garage and fuel filling station is located around 50 m to the west.

The ‘Exploratory Hole Location Plan’, drawing 38208/002 A, in Appendix 1, shows the main features described.

3.2 History

Historical Ordnance Survey maps have been reviewed in the Envirocheck Report to assess the previous use of the site and surrounding area. The Envirocheck from the existing Phase 1 report has been used, which covered the site currently under consideration as well as surrounding land to the north west and south east, with the information checked against current guidance from the Environment Agency website. The site history has been written for the site currently under consideration only. A copy of the historical maps and Envirocheck report are included in Appendix 2.

3.2.1 The Site

The earliest map viewed, dated 1851, shows the site to comprise two fields, with a mill race running from the south west corner to the north east. The 1893 map shows a mill dam in the south west corner of the site, next to a small building named as Nether Mill, which was a corn mill. The mill race is shown to run from the north western gable of Nether Mill, and towards the north east. The easternmost part of the site is shown to be the land surrounding Nether Mill House.

A sluice was present next to Nether Mill by 1905, as part of the mill dam, and the southern part of the mill race is labelled as 'overflow'. Outbuildings associated with the mill have been built just to the north of Nether Mill.

By 1931, in the northern part of the site, a rectangular building was developed.

Between 1960 and 1968, the mill dam, mill race and most of Nether Mill were removed, and a much larger building was constructed in the north, in the place of the 1931 building. The northernmost part of the Nether Mill building, and its outbuildings, were left. By 1983, with the construction of another building connected to the 1960s building in the centre of the site, the farm buildings had reached their current layout.

Little change is shown on any of the subsequent maps up to the present day.

3.2.2 The Surrounding Area

The earliest existing Ordnance Survey map, from 1851, showed the area surrounding the site to predominantly be agricultural land, with a few quarries and farmhouses in the surrounding area. A well is shown around 100 m north east of the site and Water Hall is present around 100 m to the south of the site. Scout Dam is present between 250 and 500 m to the north of the site. Broad Hill Quarry, a sandstone quarry, was present approximately 250 m to the north east of the site in 1851. More sandstone quarries were present between 250 and 500 m to the south of the site. Railways

were present around 250 m to the south and east. Springs were also present in the surrounding area.

By 1893, escarpments can be seen around 100 m to the east and 200 m to the north east of the site. The Penistone Union Workhouse and an associated pump was built around 100 m to the north of the site. A gas works was present around 250 m south west of the site. By 1894 the sandstone quarries are no longer labelled, and the ones to the south of the site are replaced by a school and its grounds.

Another escarpment was labelled by 1907, around 100 m south of the site, and a sewage farm was present around 450 m to the west of the site. Residential development around the site increased between the 1900s to the 1930s, including the development of two houses adjacent to the western boundary of the site. The escarpment around 100 m to the south of the site became a recreation ground, although the slope was still present. The Union Workhouse was changed to the Poor Law Institution.

By 1960 the Poor Law Institution had changed its use to Netherfield Home for the Aged. An electricity substation and Bridge Mill Joinery Works are shown around 20 m to the south west of the site by 1968, and a garage around 50 m to the south west of the site. During the 1970s and 1980s residential development in the area intensified, particularly to the south of the site. The gas works appear to have been removed by 1978.

The surrounding area then stays much the same to the present day. Netherfield Home for the Aged was converted into Penistone Grammar School Sixth Form Annex.

3.3 Geology

The Geological Map of the area, sheet 273 SE (1:10,560 scale) indicates the solid geology beneath the site to predominantly be undifferentiated mudstone of the Lower Coal Measures. A band of Penistone Flags sandstone is indicated to run along the northern boundary. The site and surrounding area is covered by deposits of alluvium and river terrace associated with the River Don which flows from west to east on the southern side of Barnsley Road.

No faults or other lines of weakness are indicated to cross the site, although the surrounding area is quite heavily faulted. The dip of the strata is generally indicated to be to the north east at angles of between 3° and 6°.

3.4 Hydrogeology

3.4.1 Groundwater Vulnerability

The Environment Agency groundwater vulnerability maps identify the site to overlie a Secondary A aquifer. Both the drift deposits and the bedrock are given this classification. Secondary A aquifers are defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.

The site does not lie within a Groundwater Source Protection Zone.

3.4.2 Groundwater Abstractions

The Envirocheck Report indicates that there are no groundwater abstraction licenses within 250 m of the site.

3.5 Hydrology

The nearest surface water feature is the River Don on the southern side of Barnsley Road, approximately 15 m away from the southern boundary of the site The Scout Dike is also present around 100 m from the eastern boundary, joining the Don around 115 m away from the site. Both of these watercourses are potential receptors if contaminated materials were to be found on the site.

3.6 Mining

3.6.1 Coal

The geological maps indicate several seams of coal to outcrop in the area surrounding the site. The named coal seams outcropping nearest to the site are the Grenoside Sandstone Coal, which outcrops approximately 750 m to the south west, the Lower Penistone Coal, which outcrops approximately 540 m to the south, and the Penistone Green Coal, which outcrops approximately 750 m to the south. The Lower Penistone Coal and the Penistone Green Coal outcrop approximately 150 feet (45.7 m) higher than the site, on the southern side of the large valley in which Penistone sits. The area is heavily faulted, but several seams of coal are indicated to outcrop in corresponding positions in the northern side of the valley. It is therefore considered that these seams of coal are stratigraphically ‘above’ the site, and are therefore not expected to be present below the site.

Therefore the shallowest coal expected beneath the site is the Grenoside Sandstone Coal, although its outcrop thins and discontinues towards the north. Because of this, it is doubtful if this seam

continues beneath the site. If it is present, it is estimated to be around 35 m beneath the south westernmost corner of the site and around 50 m beneath the north easternmost corner of the site, based on the strata dipping at 3° towards the north east.

The seam is recorded as being around 4 inches (0.1 m) thick in the local area. The geological memoir states that the coals in the area have locally been worked where thick enough, but only usually at outcrop or occasionally from shallow shafts.

A Coal Authority mining report has been obtained for the site and is enclosed in Appendix 2. This states that the site is not within the likely zone of influence from past underground workings. There are no recorded mine entries within the site or within 20 m of the site boundary.

The site is not within the likely zone of influence from any present or currently proposed future underground coal workings. However, reserves of coal exist in the locality which could be worked at some time in the future subject to feasibility, licences and planning consents. Future workings of the coal reserves below the site are considered unlikely due to the demise of the coal mining industry in this area.

There are no records of any mine gas emission which required action by The Coal Authority having taken place on the site, and no claims for mining related subsidence have been made on the site.

Given the thin nature of the shallowest seam of coal expected below the site, if it is present at all, it is not expected that the site is at risk from the effects of shallow mine workings.

3.6.2 Quarrying

Broad Hill Quarry, a sandstone quarry, was present approximately 300 m to the north east of the site in 1851. More sandstone quarries were present between around 250 and 500 m to the south of the site. By 1894 these quarries are no longer labelled, and the ones to the south of the site are replaced by a school and its grounds.

Quarrying activities are not expected to have taken place on the site in the past due to the presence of alluvium and river terrace deposits associated with the River Don. The expected shallow water table will also have deterred any potential surface workings.

3.7 Ground Gas

3.7.1 Landfill Gas

A mill race, mill dam and overflow were present in the west and north of the site, and were infilled between 1967 and 1968. It is possible that organic materials remain in the bed of the former race or dam. It is also possible that biodegradable materials were used to infill these features, although neither are expected to be of significant depth due to the level of the adjacent river.

The Envirocheck Report lists one historical landfill site within 250 m of the site. This was named "T.A. Centre" and was situated 230 m to the west of the site. It operated between 1982 and 1994 and accepted commercial and inert wastes, demolition waste, excavation waste, subsoil and topsoil. Reference to historical maps suggests that the landfill may have operated to allow the redevelopment of an old TA centre into a new sports centre including sports pitches. It is therefore likely that limited amounts of waste were imported to level the site as part of the redevelopment. As such, a significant risk of ground gas generation is not anticipated, and the risk of migration to the current development site is not expected to be a significant risk.

Potentially infilled sandstone quarries have been identified around 250 m to the north east and south of the site. However, at this distance, a significant risk of gas migration towards the site, should any of these quarries have been infilled, is not anticipated.

Generally, based on the review of the available desktop information, there is considered to be a low risk of gas generation and migration which could affect the proposed development. The risk is presented from the former mill race and mill dam on the site, rather than from any former feature in the surrounding area. The level of risk will be dependent on what materials are present within the infilled mill race. If biodegradable or putrescible wastes are included, some gas monitoring may be required, or gas resisting measures incorporated into the proposed dwellings. The contents of the former mill race and mill dam will need to be confirmed by way of intrusive investigation.

3.7.2 Radon

According to information included within the Envirocheck Report, which has been provided by the BRE, no radon protective measures are required in new dwellings at this site.

3.8 Pollution Incidents to Controlled Waters

Out of the pollution incidents listed in the Envirocheck, there have been six pollution incidents to controlled waters within 250 m of the current site under consideration. These include the discharge

of an unknown pollutant in 1995 to the River Don, mud, clay or soil to a freshwater stream or river in 1994, diesel oil to a freshwater stream or river in 1993, treated sewage to a Don tributary in 1998, unknown oils to the River Don in 1997, and treated sewage effluent to the River Don in 1998. These were all minor incidents except for the unknown pollutant in 1995.

None of these incidents are expected to still be affecting the site, and are not expected to significantly affect the proposed development.

3.9 Discharge Consents

The Envirocheck lists two active discharge consents within 250 m of the site. The closest appears to be around 22 m south west of the site, is operated by Yorkshire Water, and involves the discharge of storm overflow to the River Don. The second discharge consent is around 162 m to the west of the site, is also operated by Yorkshire Water, and involves the discharge of final treated effluent to the River Don and Ingbirchworth Dyke. These are not expected to affect the site.

3.10 Flooding

According to the Environment Agency flood maps, the most southerly part of the site lies within an area at risk of flooding from river waters.

4.0 OUTLINE CONCEPTUAL MODEL

The Phase 1 report contained an Outline Conceptual Model which detailed the sources, pathways and receptors potentially present from information gained from the desktop study. The possible pollutant linkages identified are thus documented in the table below.

Possible Pollutant Linkages

Source	Potential Contaminants	Potential Pathways	Potential Receptors
• Made ground (from infilled mill dam, mill race, historical construction and demolition of buildings on site)	• Commonly encountered contaminants including metals/metalloids, sulphates and polycyclic aromatic hydrocarbons (PAHs). • Asbestos fibres	• Ingestion, inhalation, direct contact	• Future residents and visitors to the site • Site construction workers
		• Direct contact	• Water supply pipes
		• Migration through ground	• Secondary A aquifer
• Contamination from fuel leaks or spills from vehicles on site	• Petroleum hydrocarbons.	• Ingestion, inhalation, direct contact	• Future staff and visitors to the site • Site construction workers
		• Direct contact	• Water supply pipes
		• Migration through ground	• Culvert beneath site • Secondary A aquifer
• Naturally elevated concentrations of contaminants	• Naturally occurring contaminants such as arsenic and pyrite (resulting in elevated levels of sulphate), as well as anthropogenically influenced contamination such as PAHs.	• Ingestion, inhalation, direct contact	• Future residents and visitors to the site • Site construction workers
		• Direct contact	• Water supply pipes
		• Migration through ground	• Secondary A aquifer
• Made ground or natural ground	• Sulphates.	• Direct contact	• Sub-surface concrete structures.
• Landfill gas from 50 year old infilled mill dam and mill race on site • Made ground on site ≥ 2.5 m deep.	• Methane and carbon dioxide.	• Asphyxiation and explosion	• Future residents and visitors to the site • Buildings

5.0 GROUND INVESTIGATION

5.1 Site Works

We visited site on 9 September 2015 and again on 21 September, and drilled a total of six window sample holes, referenced WS1 to WS6, in order to determine the underlying ground conditions. These reached depths of between 3.0 and 3.8 m bgl.

The exploratory holes were positioned to give good coverage around the current buildings, as well as to investigate the areas of potential contamination identified by the Phase 1 report. The window samples were generally terminated upon reaching competent natural ground, though which further progression was difficult.

Copies of the exploratory hole logs are presented in Appendix 3, and their locations are plotted on the 'Exploratory Hole Location Plan', Drawing number 38208/002 revision A, in Appendix 1.

5.2 Laboratory Testing

One sample of topsoil, nine samples of made ground, and two samples of natural ground, were dispatched for chemical testing. Two samples of natural ground were also sent for geotechnical testing. Soil samples were taken in 500 g plastic tubs and 60 ml amber glass jars. All samples were analysed at Chemtest Laboratories, Newmarket using MCERTs accredited methodologies where available.

The laboratory test results are presented in Appendices 4 and 5, and discussed further in Sections 7.0 and 8.0.

6.0 GROUND CONDITIONS

6.1 Hardstanding

Hardstanding is present to the north of the buildings in the north west of the site. This comprises a concrete slab which was 100 mm thick. No reinforcement was encountered in WS5, which was drilled through this slab.

6.2 Topsoil

The westernmost part of the site comprises rough vegetation over made ground/topsoil, which was between around 100 and 350 mm thick. This material comprises a sandy clay with inclusions of concrete, brick, coal and other gravels.

The easternmost part of the site is currently a private garden, which has a surface covering of 300 mm of brown clay topsoil.

6.3 Made Ground

Made ground is present from surface across most of the site. This predominantly comprises assorted granular materials placed along tracks and across the various storage areas.

Below the surface covering, assorted fill materials were encountered in five of the six exploratory holes to depths of between 0.75 m and 2.65 m bgl. These included a mixture of firm to stiff occasionally gravelly clay which was typically present to between around 1.0 and 2.0 m bgl. In WS2 and WS4, this was interspersed with layers/pockets containing coal and clinker. In WS4, the made ground continued to a depth of 2.65 m bgl.

Below the clay in WS3, a soft black clay with fragments of vegetation was encountered between 1.3 and 2.5 m bgl. A slight hydrocarbon/organic odour was also noted from within this material, and the wet soils displayed a slight organic sheen. This exploratory hole was drilled within the footprint of the former mill dam and this material is likely to be the sediment from within the former dam.

Materials which were possibly or probably made ground were encountered in several of the window sample holes. These materials tended to comprise soft brown sandy clay and gravel, where the gravel was entirely sandstone. This is likely to represent the deposits of alluvium and river terrace which are recorded to cover the site.

Standard penetration tests (SPT's) were undertaken within the window sample holes. These recorded N-values of between 6 and 92 within the made ground/probable made ground.

6.4 Natural Ground

The natural ground was encountered in all six exploratory holes from depths of between 0.3 m and 2.65 m bgl. The upper layers of the natural ground comprised mainly sandy gravelly clay, where the gravel was sandstone, which will represent the superficial alluvial/river terrace deposits. These extended to depths of between 2.45 m and 3.3 m bgl. SPT N-values of between 13 and 34 were recorded within the superficial deposits, indicating that they can be generally recorded as medium dense to dense in compaction where granular, and should be regarded as being generally firm, but locally soft, where cohesive.

Below the alluvial deposits, stiff grey clay and weak mudstone was encountered in all six of the window sample holes from between 2.45 and 3.30 m bgl. This continued to the base of all of the holes. The window samples refused at depths of between 3.0 m and 3.6 m bgl within this material in 5 out of the 6 holes. SPT N-values of at least 50 were recorded within the mudstone strata.

6.5 Obstructions

Sandstone cobbles were encountered within the made ground and alluvial deposits at around 1.55 m bgl in WS1, at 0.35 and 1.60 m bgl in WS2, and at 0.30 m bgl in WS3 although these were easily broken through by the window sampler. No other significant obstructions were encountered.

6.6 Groundwater

Wet soils were encountered in all of the window sample holes within the made ground and alluvial layers. It is likely that shallow groundwater will be present in excavations given the site's position within the valley bottom and being adjacent to the River Don.

6.7 Evidence of Contamination

Layers of made ground containing ash, coal or clinker were found in WS2 and WS4 in the upper 2.00 m. The soils in WS3 between 1.30 m and 2.50 m bgl was black, had a hydrocarbon/organic odour and a slight sheen.

7.0 GEOTECHNICAL APPRAISAL

7.1 General

Beneath the current surfacing, layers of cohesive and granular made ground are present to depths of between 0.75 m and 2.65 m bgl. Below the made ground, superficial layers of clay and gravel alluvium and river terrace deposits are present, with weathered mudstone from between 2.3 m and 3.3 m bgl. Groundwater is expected to be encountered within excavations at shallow depth.

Two samples of the weathered mudstone were sent for geotechnical testing at Soil Property Testing Ltd (subcontracted by Chemtest Laboratories). The samples were taken from WS1 at 3.4 m bgl and WS4 at 2.95 m bgl. The samples were calculated to have modified plasticity indexes of 14 and 18%. This corresponds to a low volume change potential classification in accordance with the NHBC Chapter 4.2 standards. A copy of the geotechnical test results is included in Appendix 4.

7.2 Foundations

It is proposed to redevelop the site with low rise housing of traditional construction. The made ground across the site is not considered to be a suitable founding material, and the superficial deposits vary in strength between soft, firm and stiff, and are therefore also unsuitable as a founding stratum. It is therefore likely that foundations will need to be constructed on the weathered mudstone below the alluvium/river terrace deposits at likely depths of between 2.5 m and 3.4 m bgl.

Due to this depth, and also due to the likelihood of encountering groundwater within excavations which may lead to instability of trenches, it is considered that piled foundations may be the most appropriate/economical foundation solution. These would need to be driven through the made ground and upper layers of the natural ground into the mudstone bedrock to likely depths of between about 5 m and 8 m bgl. Reinforced concrete ground beams will be required to span between pile caps to carry the masonry walls.

Where within the influence of existing trees, heave precautions will be required below and inside ground beams.

7.3 Superstructure Precautions

Additional superstructure precautions are not expected to be required.

7.4 Ground Slabs

Due to the depth of made ground across most of the site, precast concrete floors with a 200 mm high ventilated void below will be required for all plots.

7.5 Problems Due to Past Development

Relic foundations from the current and other previous buildings may need to be removed where they conflict with new structures.

Groundwater is likely to be encountered within excavations at relatively shallow depth.

7.6 Excavation Problems

Excavations on site are likely to experience instability and collapse, especially where groundwater is present.

The stability of any trenches is likely to be variable in the made ground and alluvial deposits. Where excavations which workers are required to enter are over 1.2 m deep, or less where there is a risk of harm from collapse of the sides of the excavation, the sides should be supported or battered back to make them safe.

7.7 Surface Water Drainage

The soils beneath the site are generally clayey in nature, and there is shallow groundwater. Therefore soakaways are not expected to be a viable method of surface water dispersal. There are existing drains serving the site, and it should be possible to retain these for use within the proposed development, subject to agreement with the water company and the Local Authority. On site attenuation may be required.

8.0 REFINEMENT OF OUTLINE CONCEPTUAL MODEL

8.1 Source Characterisation

An outline conceptual model, detailing the possible sources and associated contaminants of concern, potential pathways and receptors identified in the Phase 1 study, is set out in section 4.0 above.

This section of the report documents the works undertaken to obtain information to test and refine this model enabling a risk assessment to be produced and, where significant risks are expected, remediation recommendations.

8.2 Ground Conditions

The ground conditions on the site comprise made ground to depths of between 0.75 m and 2.65 m bgl. Some ashy materials were noted locally within the made ground, and a hydrocarbon/organic odour and accompanying sheen was noted in WS3 between 1.30 and 2.50 m bgl.

Below the made ground, natural ground of alluvium/river terrace was encountered with weathered mudstone bedrock below this. No reasons to suspect that these materials would be contaminated were noted.

8.3 Gas Precautions

The site is in an area where no radon protections are required for new buildings.

A recorded landfill is present around 230 m to the west of the site, and potentially infilled sandstone quarries around 250 m to the north east and south of the site. However, none of these sites are expected to pose a potential significant risk to the proposed development.

Made ground in excess of 2.0 m deep has been encountered on the site, although significant amounts of biodegradable or organic materials were not present in most locations. However, a slight risk of ground gas generation may be presented from within this deep fill. The infilled mill dam in the west of the site was found to contain some organic materials within the sediment at its base, with an accompanying hydrocarbon/organic odour and sheen on the soil's surface between 1.30 and 2.50 m bgl. A slight risk of gas generation may be presented by ongoing degradation of these materials, which could subsequently migrate through the near surface deposits across the site.

8.4 Unexpected Contamination

Layers of made ground containing ash, coal or clinker were found in WS2 and WS4 in the upper 2.00 m. As described above, odorous materials were encountered within the infilled mill dam in WS3 in the west of the site.

No other visual or olfactory evidence of unexpected contamination was identified during the window sampling.

8.5 Chemical Testing

Two samples of topsoil, seven samples of made ground, and three samples of the natural ground were despatched for chemical testing. Each of the samples was analysed for the suite of contaminants listed below:

Contaminant Type	Actual Contaminants
Metals/Metalloids	Arsenic, cadmium, chromium (hexavalent and trivalent), lead, mercury, nickel, selenium, copper and zinc
pH	pH
PAHs	Speciated PAH
TPHs*	Fractionated TPH
Sulphates**	Water soluble sulphate, acid soluble sulphate and sulphur
Asbestos	Asbestos fibres

* Samples with hydrocarbon odour only

** All except samples of topsoil.

8.6 Assessment Criteria

The proposed development of the site is for a residential end use, with private gardens and landscaping. Therefore, the most conservative assessment criteria relating to a residential end use with home-grown produce have been used.

Tables detailing the relevant assessment concentrations used are included in Appendix 5.

8.7 Chemical Test Results

Some preliminary risk assessment is undertaken in this section of the report where determinants can be readily discounted.

8.7.1 Topsoil

The sample of topsoil from WS2 at 0.1 m bgl recorded seven PAH compounds which were significantly elevated above their residential assessment values. These particular PAHs are listed in the table below, along with their respective assessment values:

Contaminant	Residential Assessment Value (mg/kg)	Concentration (mg/kg)
Phenanthrene	95	**140**
Benzo(a)anthracene	7.2	**110**
Chrysene	15	**100**
Benzo(b)fluoranthene	2.6	**120**
Benzo(a)pyrene	2.2	**110**
Indeno(1,2,3-cd)pyrene	27	**79**
Dibenz(a,h)anthracene	0.24	**18**

The material in this location was found to have inclusions of made ground materials.

In the only other sample of topsoil, taken from WS6 at 0.1 m bgl, no contaminants were found to be elevated above their residential assessment values.

8.7.2 Made Ground

Metals and Metalloids

The sample of made ground from WS2 at 0.5 m bgl recorded an elevated concentration of arsenic, of 96 mg/kg compared to the residential assessment value of 37 mg/kg. The material in this location included ash and clinker, and the elevated concentration is likely to be a result of these materials.

No other metals or metalloids were found to be elevated above their respective residential assessment values in any of the samples of made ground tested.

Polycyclic Aromatic Hydrocarbons (PAHs)

Four of the seven made ground samples recorded between six and ten elevated PAHs compared to their residential assessment values. The samples and their elevated concentrations are summarised in the table below:

Contaminant	Residential Assessment Value (mg/kg)	WS1 @ 0.3 m	WS4 @ 0.2 m	WS3 @ 0.2 m	WS3 @ 1.6 m
		Concentration (mg/kg) – bold indicates elevated concentration			
Naphthalene	2.3	0.52	**14**	1.9	**3.9**
Phenanthrene	95	43	**150**	53	**490**
Fluoranthene	280	79	180	86	**440**
Benzo(a)anthracene	7.2	**41**	**82**	**44**	**200**
Chrysene	15	**40**	**73**	**40**	**190**
Benzo(b)fluoranthene	2.6	**52**	**81**	**53**	**210**
Benzo(k)fluoranthene	77	22	37	22	**98**
Benzo(a)pyrene	2.2	**50**	**75**	**51**	**180**
Indeno(1,2,3-cd)pyrene	27	**34**	**52**	**37**	**120**
Dibenz(a,h)anthracene	0.24	**7.5**	**12**	**8.4**	**36**

No other polycyclic aromatic hydrocarbons were found to be elevated above their respective residential assessment values in any of the samples of made ground tested.

Total Petroleum Hydrocarbons (Fractionated TPH)

One sample, from WS3 at 1.6 m bgl, was tested for fractionated TPH. This was a black wet clay with a slight sheen and hydrocarbon/organic odour.

None of the hydrocarbon fractions exceeded their respective residential assessment values.

8.7.3 Natural Ground

None of the three samples of natural ground tested contained any elevated concentrations of contaminants, compared to their respective residential assessment values.

8.7.4 Asbestos

One sample of made ground, from WS4 at 0.2 m bgl, recorded the presence of chrysotile (white asbestos) fibres/clumps. This poses a potential risk to human health.

8.7.5 Sulphates

The site has been taken as a Brownfield location in relation to the Aggressive Chemical Environment and water is expected to be mobile through the near surface soils.

Tests for total sulphur indicate that the total potential sulphates for the made ground are between 0.01 and 0.88%, compared with the Design Sulphate Class limits of 0.24% for DS-1, 0.6% for DS-2 and 1.2% for DS-3. The concentrations of water soluble sulphate within the made ground are between 10 mg/l and 650 mg/l compared with the Design Sulphate Class 2 limits of between 500 and 1500 mg/l.

The pH varied between 7.3 and 9.7.

The concentration of total potential sulphate within the samples of natural ground are calculated to be below 0.02%, compared with the Design Sulphate Class 1 upper limit of 0.24%. The concentration of water soluble sulphate within the natural ground samples was <10 mg/l, compared with the Design Sulphate Class 1 upper limit of 500 mg/l.

The pH was between 6.5 and 7.3.

8.8 Significant Pollutant Linkages

The significant pollutant linkages identified are documented in the table below:

Significant Pollutant Linkages

Source	Pathway	Receptor
• Significantly elevated concentrations of PAHs in the made ground, • Elevated concentration of arsenic in one sample of made ground from WS2. • Elevated concentrations of PAHs within the topsoil with inclusions of made ground in the west of the site.	• Ingestion, inhalation, direct contact	• Future residents and visitors to the site, • Construction workers
	• Leaching through soils	• Secondary A aquifer, controlled waters
• Locally elevated concentration of arsenic within the made ground.	• Direct uptake through root systems.	• Plants
• Asbestos containing materials close to the surface in made ground in WS4	• Ingestion or inhalation of fibres.	• Future residents and visitors to the site, • Construction workers
• Ground gases from within made ground in excess of 2 m deep.	• Generation and upward migration into buildings • Inhalation	• Future residents and visitors to the site
• Elevated sulphates within made ground	• Direct contact	• Below ground concrete.

9.0 RISK ASSESSMENT

9.1 Human Health: Future Site End Users

The results of the testing carried out during this site investigation indicate that significantly elevated concentrations of PAHs are present within the made ground and topsoil. One elevated concentration of arsenic was also present within the shallow made ground in WS2. Asbestos containing materials were also identified in one location. The end use of the site is proposed to be residential with landscaping and private gardens. This means that a pathway will exist between the contaminated soils and future site users. This poses a potential risk to the health of future site users.

There is a large volume of material affected, and therefore excavating the made ground and removing it from site is unlikely to be viable. It will therefore be necessary to construct a capping layer of inert material above the made ground where ever it is present within gardens and soft landscaping areas. This should be at least 600 mm thick, and should have a geotextile marker layer at the base to delineate between the capping materials and the contaminated made ground and to deter any further excavation.

9.2 Human Health: Construction Workers

Groundworkers employed during the construction phase of the development are potentially at risk of harm if in direct contact with the soils. However, the contact is generally of short duration, and all competent ground workers should be aware of the potential risks associated with soils of this nature. Therefore the overall risk to the health of construction workers is considered to be relatively low.

All ground workers employed on the site should be made aware that normal site procedures such as the wearing of gloves when handling soils, and the washing of hands prior to eating should be implemented. Suitable overalls, face masks and gloves should be worn when handling any soils which are suspected of containing asbestos fibres.

Any unusual, brightly coloured, ashy or odorous material encountered during construction should be brought to the attention of the site staff and investigated.

9.3 Plants

An elevated concentration of the phytotoxic contaminant arsenic has been recorded locally within the made ground, and therefore a potential risk to plant growth may be presented. However, this risk is considered to be very low. The made ground is unlikely to prove suitable as a growing

medium due to the lack of organic matter, and it has been recommended to place a 600 mm capping layer over the made ground. Therefore any planting which may be proposed would not come into contact with the made ground. No significant risks from the arsenic concentration recorded in the made ground are therefore expected.

The capping layer should include a minimum thickness of 150 mm of topsoil to act as a growing medium for plants.

9.4 Building Products

The results of the laboratory testing indicate that the made ground should be assigned a Design Sulphate Class of DS-3 and Aggressive Chemical Environment for Concrete (ACEC) class of AC-3.

The natural ground should be assigned a Design Sulphate Class of DS-1 and Aggressive Chemical Environment for Concrete (ACEC) class of AC-1.

It is likely that protective pipes will be required for fresh water supplies. The laboratory test results will need to be forwarded to the water supplier to confirm its requirements.

9.5 Controlled Waters

Elevated concentrations of PAHs have been identified within the made ground, which appears to have the remnants of the historical mill race running through it between around 1.00 and 2.00 m bgl.

The contaminants recorded are generally of low solubility, and are not expected to pose any more significant risk to controlled waters than is already being posed. The concentrations do not appear to be leaching into the underlying natural ground. The provision of additional hard surfacing and the capping layer will also limit the volume of surface water potentially draining through the affected soils, and therefore the level of risk presented to the River Don is likely to reduce after redevelopment.

9.6 Ground Gas

Made ground in excess of 2 m deep is present beneath the site. Therefore a potential risk of gas generation and migration may be presented. Significant amounts of biodegradable and organic materials were not included in the made ground, and a significant risk of methane generation is not anticipated, although some carbon dioxide could still be generated. However, the volume of this is not expected to be significant, and the potential flow rate is expected to be negligible. The level of risk anticipated to be presented to the proposed development is unlikely to exceed ‘Amber 1’ (NHBC traffic light system) or CS-2 (Card and Wilson Method) as detailed in CIRIA C665 guidance.

It is therefore proposed to install basic gas protective measures in lieu of carrying out gas monitoring.

A 2000 gauge polythene damp proof membrane should therefore be installed below the floor slab in all plots. The membrane should be fully lapped and sealed, and should extend through the external walls of the proposed building to the external leaf of brickwork. All service penetrations through the floor slab should be sealed.

This approach is subject to the approval of the local authority and any warranty provider.

9.7 Remedial Strategy

Significantly elevated concentrations of PAHs were recorded in the made ground on site, along with locally elevated concentrations of arsenic and the presence of asbestos containing materials in one location. It is recommended that a 600 mm clean capping layer, inclusive of a minimum of 150 mm topsoil at the surface, with geotextile marker layer at the base of the capping, should be placed in all gardens and landscaped areas, to mitigate the potential risks to human health. The placement of the capping layer and geotextile layer will need to be independently verified.

As with most brownfield sites, there may be isolated hotspots of contamination which have not been identified and a strategy for dealing with unexpected contamination should be prepared.

9.8 Disposal of Material

If material needs to be removed, it should to be taken to a suitably licensed landfill or waste treatment facility. The costs of disposal and landfill tax can be substantial. The disposal of material should therefore be seen as a last resort with options such as treatment and reuse either on-site or off-site considered at the earliest opportunity.

The category of landfill which can accept the waste (inert, non-hazardous or hazardous) would need to be determined and will also have a significant effect on the costs. Additional testing may be required by the landfill operator and the acceptance of material is generally at their discretion.

10.0 CONTAMINATION - RECOMMENDATIONS AND APPROVALS

1. A 600 mm clean capping layer, inclusive of a minimum 150 mm clean topsoil, and a geotextile marker layer at the base, is proposed in all gardens and landscaped areas. This will mitigate against the risk to human and plant health from the locally elevated arsenic concentration, significantly elevated PAH concentrations, and isolated presence of asbestos containing materials.

2. A fully lapped and sealed 2000 gauge polythene membrane should be incorporated into the floor slabs of all plots to mitigate against the risk of ground gas generation from within the made ground on site.

3. Sulphate precautions comprising DS-3 and AC-3 should be provided for subsurface concrete in contact with any made ground at the site. For the natural ground, DS-1 AC-1 precautions can be used.

4. This report should be forwarded to the water supplier to confirm its requirements for the water supply pipes.

5. The conclusions made in this report in relation to contamination are subject to agreement by the approving bodies such as the Local Authority and any warranty provider.

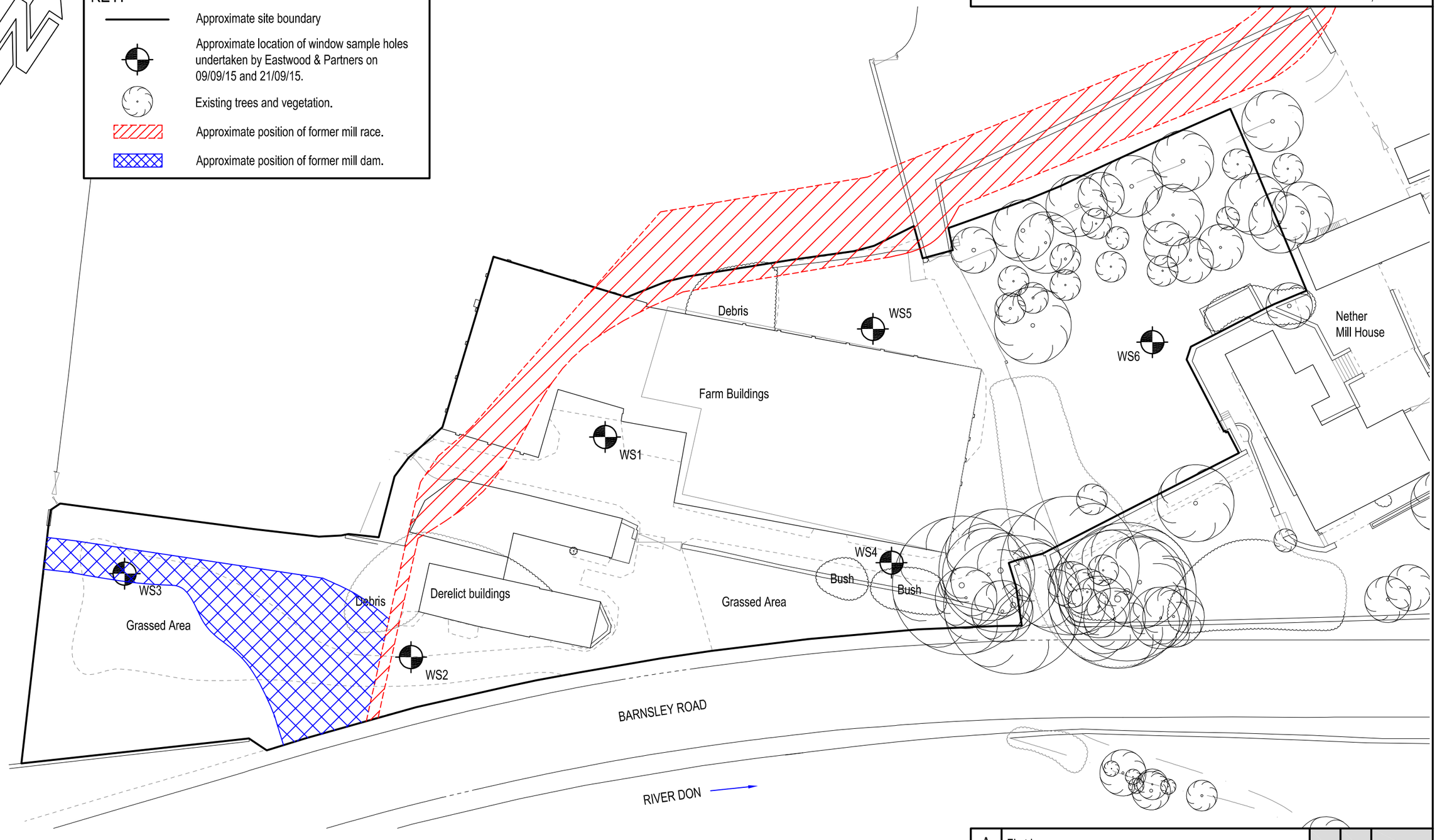
Appendix 1

‘Exploratory Hole Location Plan’, Drawing Reference 38208/002 Revision A

INFORMATION WITHIN THIS DRAWING IS NOT NECESSARILY PRODUCED TO SCALE.
ALWAYS USE FIGURED DIMENSIONS AND CO-ORDINATES - IF IN DOUBT, ASK.

KEY:

- Approximate site boundary
- Approximate location of window sample holes undertaken by Eastwood & Partners on 09/09/15 and 21/09/15.
- Existing trees and vegetation.
- Approximate position of former mill race.
- Approximate position of former mill dam.



REV	DESCRIPTION	SIG	CHK	DATE
A	First Issue.			

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DUCHY HOMES

NETHERMILL FARM, BARNSLEY ROAD, PENISTONE

EXPLORATORY HOLE LOCATION PLAN

SCALE WHEN PLOTTED AT A3	DRAWING STATUS
1:500	INFORMATION

DRAWN	CHECKED	DATE	DRAWING NUMBER	REV
RH	AJK	03.11.15	38208/002	A

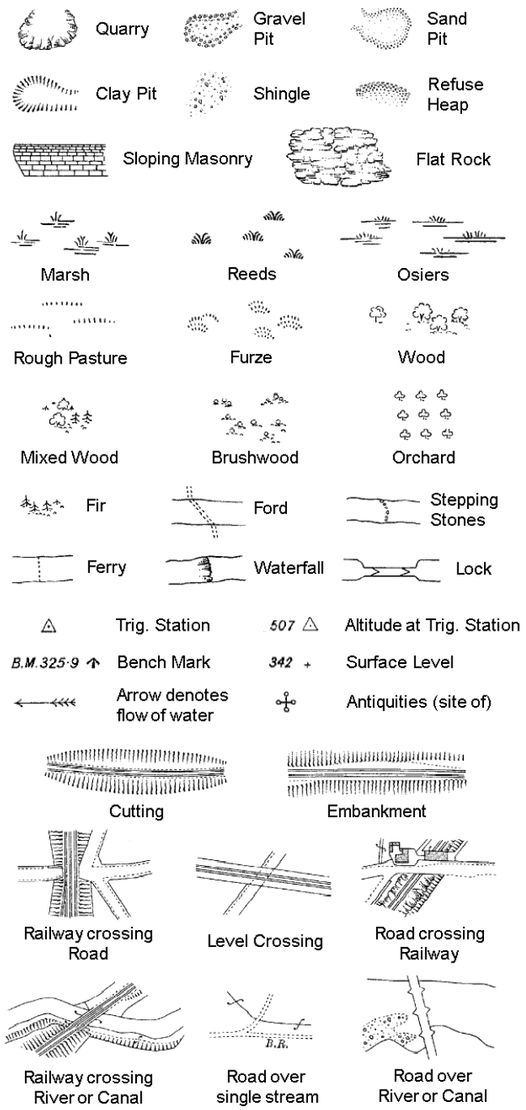
Appendix 2

Envirocheck Report

Coal Authority Report

Historical Mapping Legends

Ordnance Survey County Series and Ordnance Survey Plan 1:2,500



County Boundary (Geographical)

County & Civil Parish Boundary

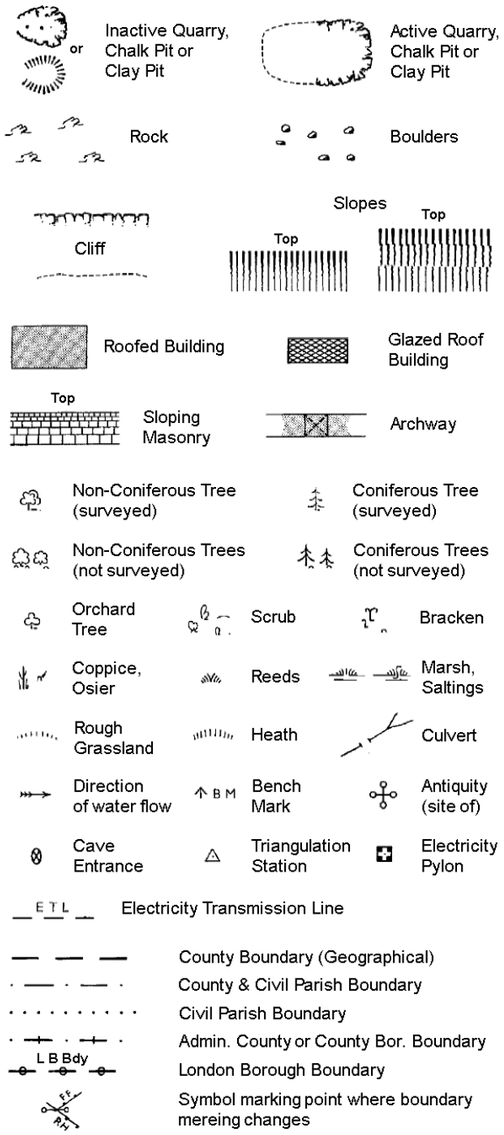
Administrative County & Civil Parish Boundary

Co. Boro. Bdy. County Borough Boundary (England)

Co. Burgh Bdy. County Burgh Boundary (Scotland)

B P B S	Boundary Post or Stone	P.C.B	Police Call Box
B.R.	Bridle Road	P	Pump
E.P	Electricity Pylon	S.P	Signal Post
F.B.	Foot Bridge	St.	Sluice
F.P.	Foot Path	Sp.	Spring
G.P	Guide Post or Board	T.C.B	Telephone Call Box
M.S	Mile Stone	Tr.	Trough
M.P M.R	Mooring Post or Ring	W	Well

Ordnance Survey Plan, Additional SIMs and Supply of Unpublished Survey Information 1:2,500 and 1:1,250



County Boundary (Geographical)

County & Civil Parish Boundary

Civil Parish Boundary

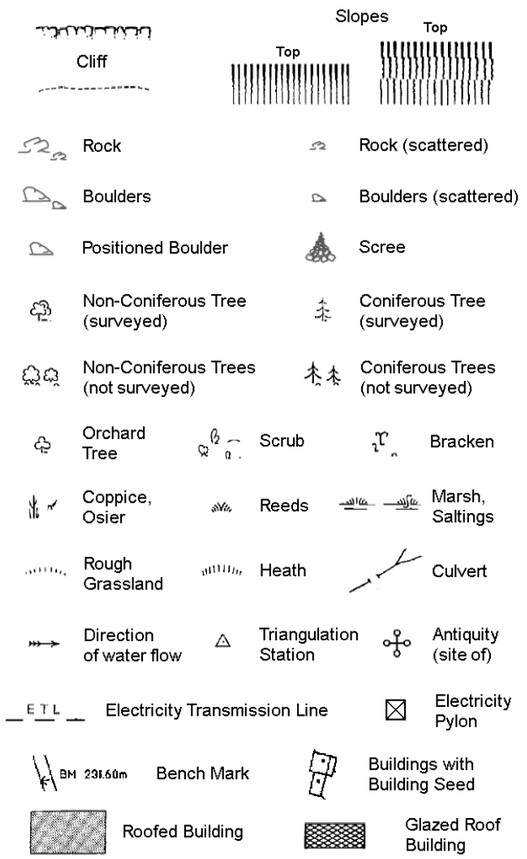
Admin. County or County Bor. Boundary

L B Bdy London Borough Boundary

Symbol marking point where boundary mereing changes

BH	Beer House	P	Pillar, Pole or Post
BP, BS	Boundary Post or Stone	PO	Post Office
Cn, C	Capstan, Crane	PC	Public Convenience
Chy	Chimney	PH	Public House
D Fn	Drinking Fountain	Pp	Pump
El P	Electricity Pillar or Post	SB, S Br	Signal Box or Bridge
FAP	Fire Alarm Pillar	SP, SL	Signal Post or Light
FB	Foot Bridge	Spr	Spring
GP	Guide Post	Tk	Tank or Track
H	Hydrant or Hydraulic	TCB	Telephone Call Box
LC	Level Crossing	TCP	Telephone Call Post
MH	Manhole	Tr	Trough
MP	Mile Post or Mooring Post	Wr Pt, Wr T	Water Point, Water Tap
MS	Mile Stone	W	Well
NTL	Normal Tidal Limit	Wd Pp	Wind Pump

Large-Scale National Grid Data 1:2,500 and 1:1,250



Civil parish/community boundary

District boundary

County boundary

Boundary post/stone

Boundary mereing symbol (note: these always appear in opposed pairs or groups of three)

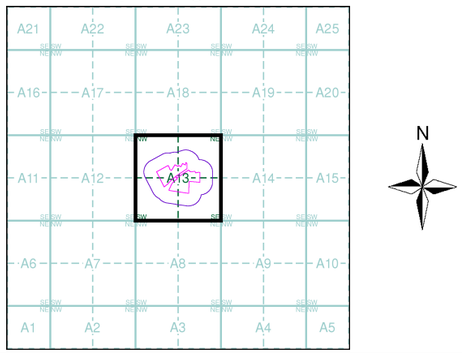
Bks	Barracks	P	Pillar, Pole or Post
Bty	Battery	PO	Post Office
Cemy	Cemetery	PC	Public Convenience
Chy	Chimney	Pp	Pump
Cis	Cistern	Ppg Sta	Pumping Station
Dismtd Rly	Dismantled Railway	PW	Place of Worship
El Gen Sta	Electricity Generating Station	Sewage Ppg Sta	Sewage Pumping Station
El P	Electricity Pole, Pillar	SB, S Br	Signal Box or Bridge
El Sub Sta	Electricity Sub Station	SP, SL	Signal Post or Light
FB	Filter Bed	Spr	Spring
Fn / D Fn	Fountain / Drinking Ftn.	Tk	Tank or Track
Gas Gov	Gas Valve Compound	Tr	Trough
GVC	Gas Governer	Wd Pp	Wind Pump
GP	Guide Post	Wr Pt, Wr T	Water Point, Water Tap
MH	Manhole	Wks	Works (building or area)
MP, MS	Mile Post or Mile Stone	W	Well

Envirocheck®

Historical Mapping & Photography included:

Mapping Type	Scale	Date	Pg
Yorkshire	1:2,500	1893	2
Yorkshire	1:2,500	1906	3
Yorkshire	1:2,500	1931	4
Ordnance Survey Plan	1:2,500	1960	5
Ordnance Survey Plan	1:2,500	1968	6
Additional SIMs	1:2,500	1978	7
Additional SIMs	1:2,500	1980 - 1989	8
Additional SIMs	1:2,500	1981	9
Additional SIMs	1:2,500	1983	10
Ordnance Survey Plan	1:2,500	1985	11
Large-Scale National Grid Data	1:2,500	1992	12
Large-Scale National Grid Data	1:2,500	1993	13
Large-Scale National Grid Data	1:2,500	1998	14

Historical Map - Segment A13



Order Details

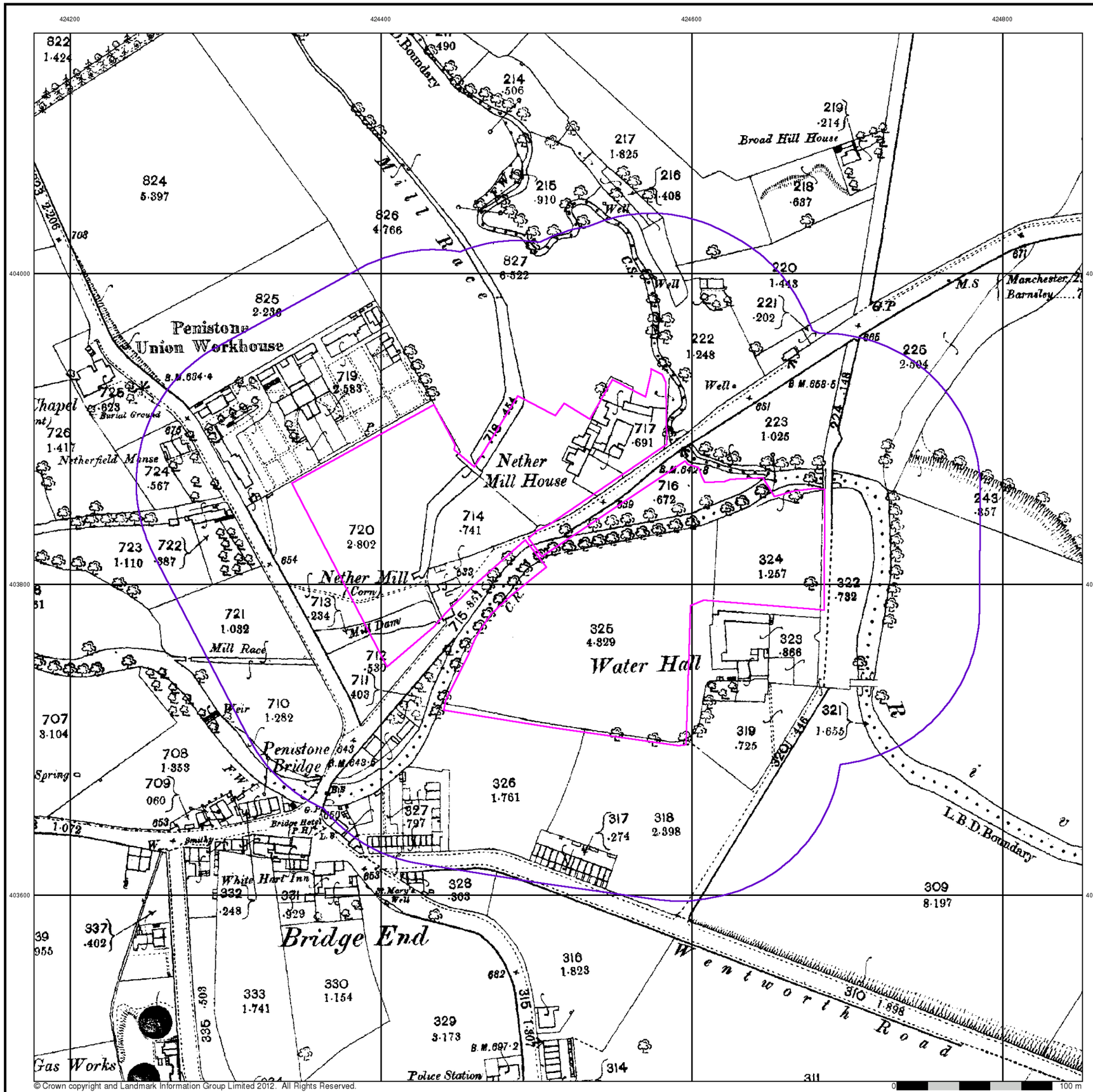
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Slice:	A
Site Area (Ha):	4.49
Search Buffer (m):	100

Site Details

Nether Mill House, Barnsley Road, Penistone, SHEFFIELD, S36 8AD

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Web: www.envirocheck.co.uk



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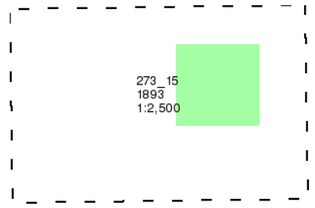
Yorkshire

Published 1893

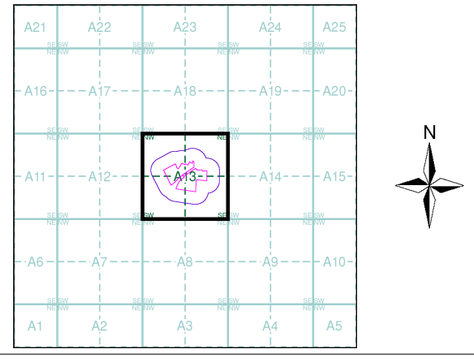
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



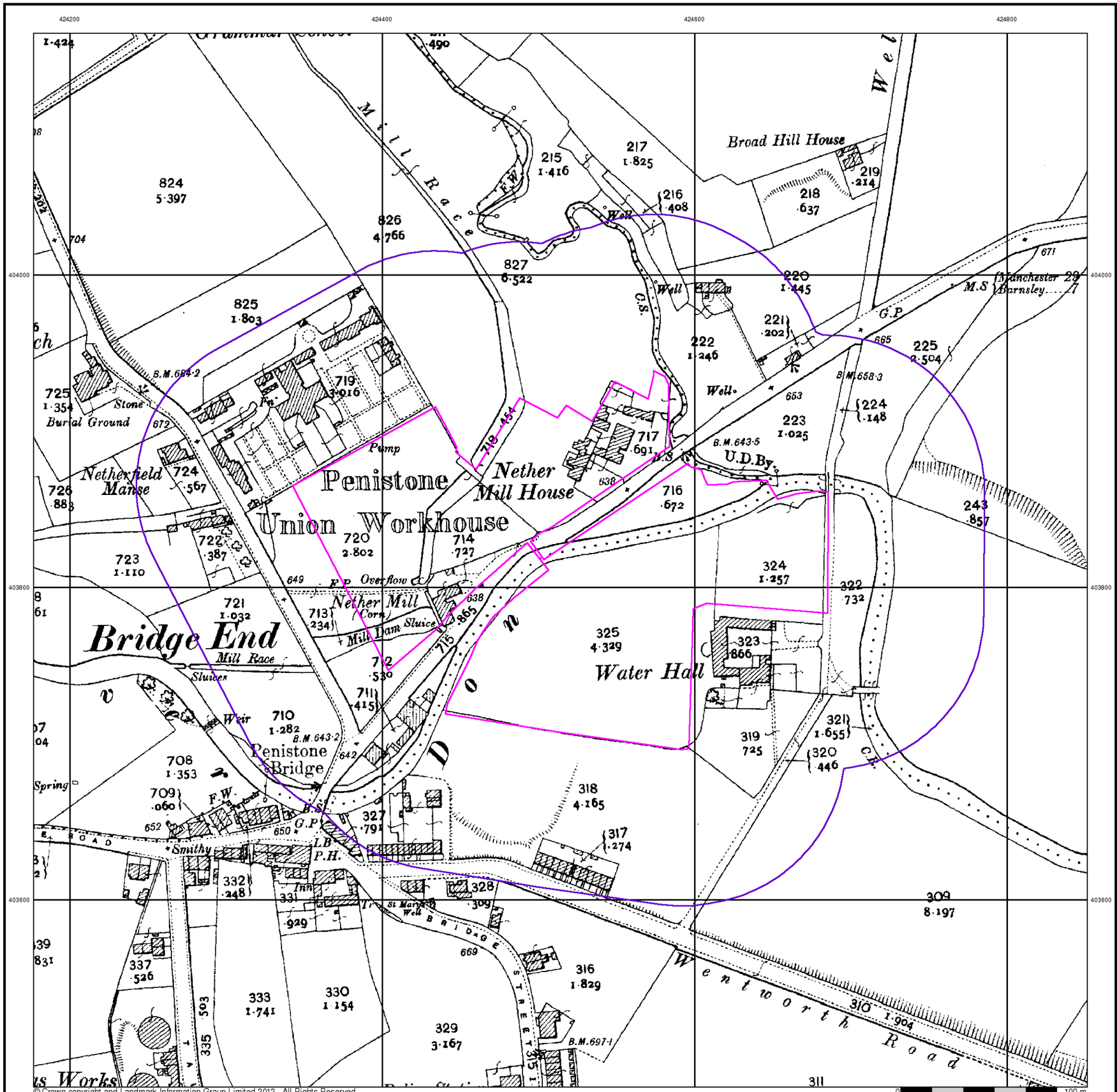
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Slice:	A
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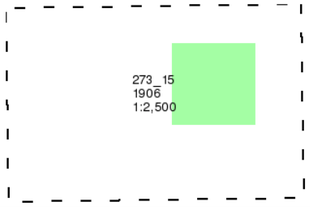
Yorkshire

Published 1906

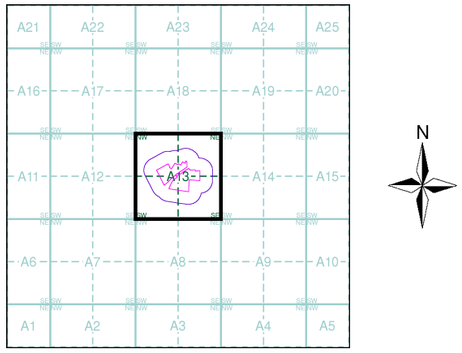
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



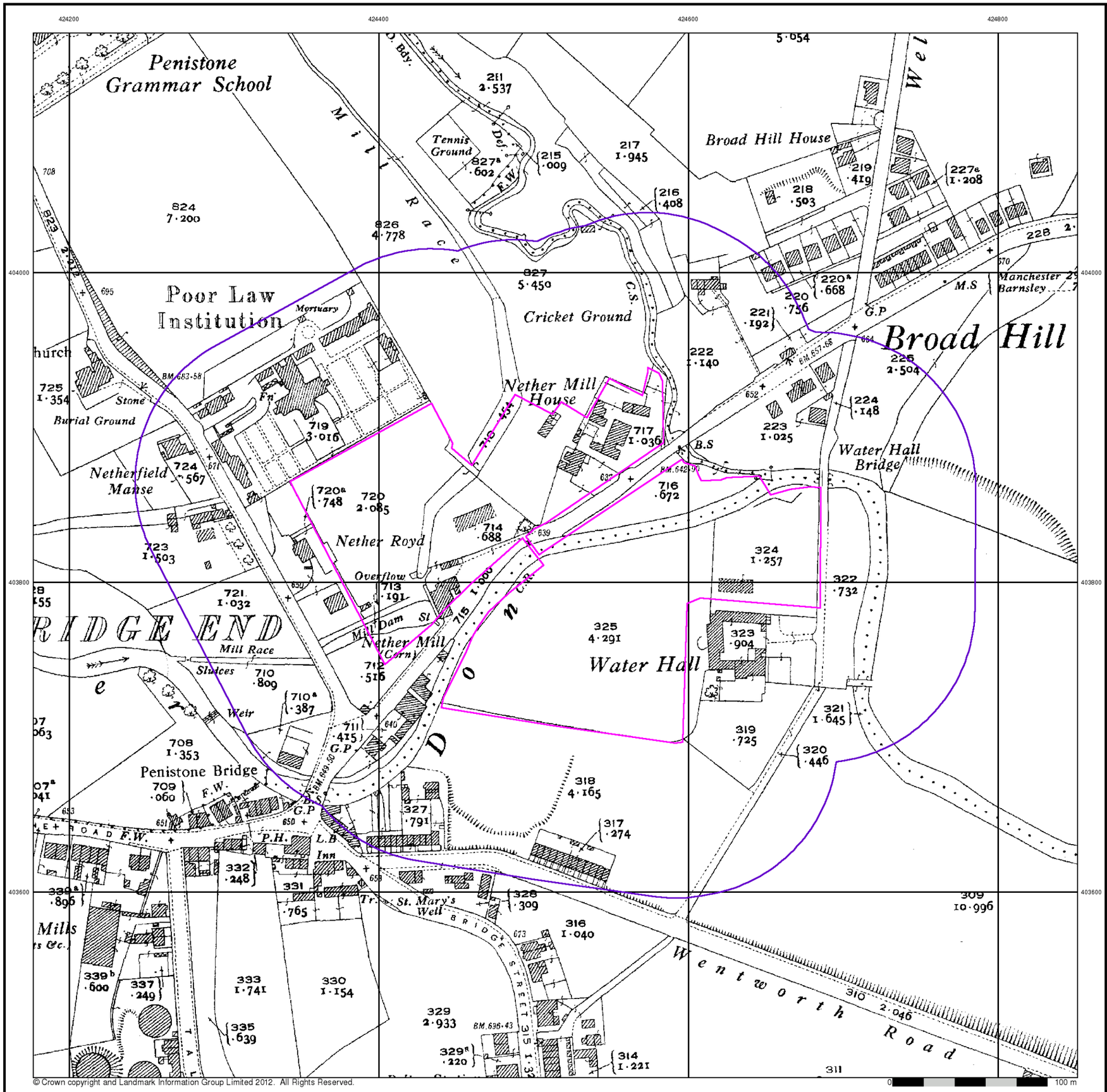
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Customer Ref:	35223/MJY/AJK
National Grid Reference:	424520, 403820
Slice:	A
Site Area (Ha):	4.49
Search Buffer (m):	100

Site Details

Nether Mill House, Barnsley Road, Penistone, SHEFFIELD, S36 8AD

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



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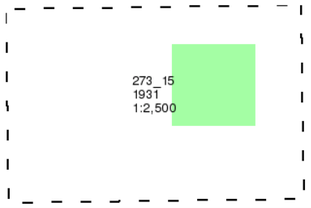
Yorkshire

Published 1931

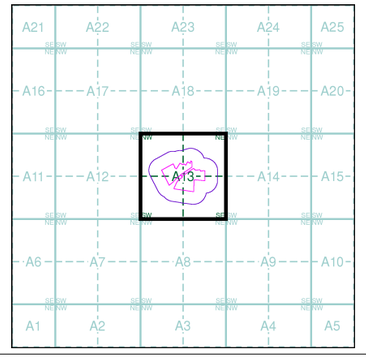
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Map Name(s) and Date(s)



Historical Map - Segment A13



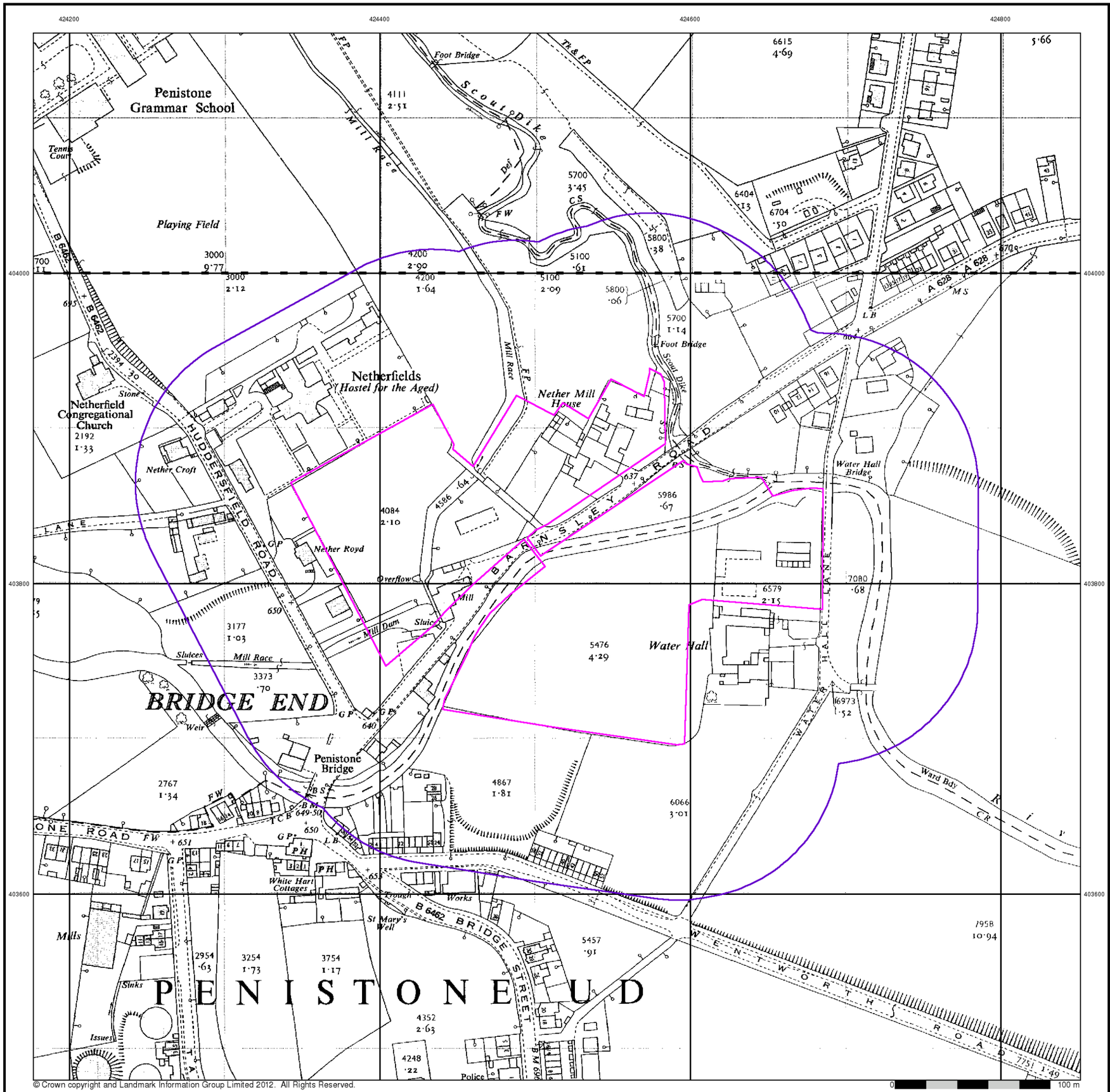
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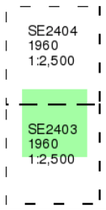
Ordnance Survey Plan

Published 1960

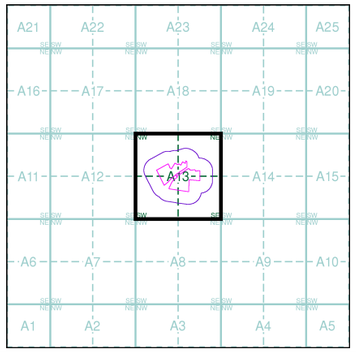
Source map scale - 1:2,500

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Map Name(s) and Date(s)



Historical Map - Segment A13



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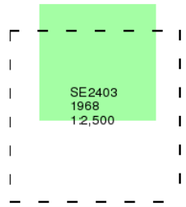
Ordnance Survey Plan

Published 1968

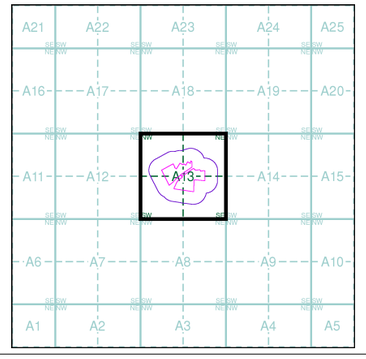
Source map scale - 1:2,500

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Historical Map - Segment A13



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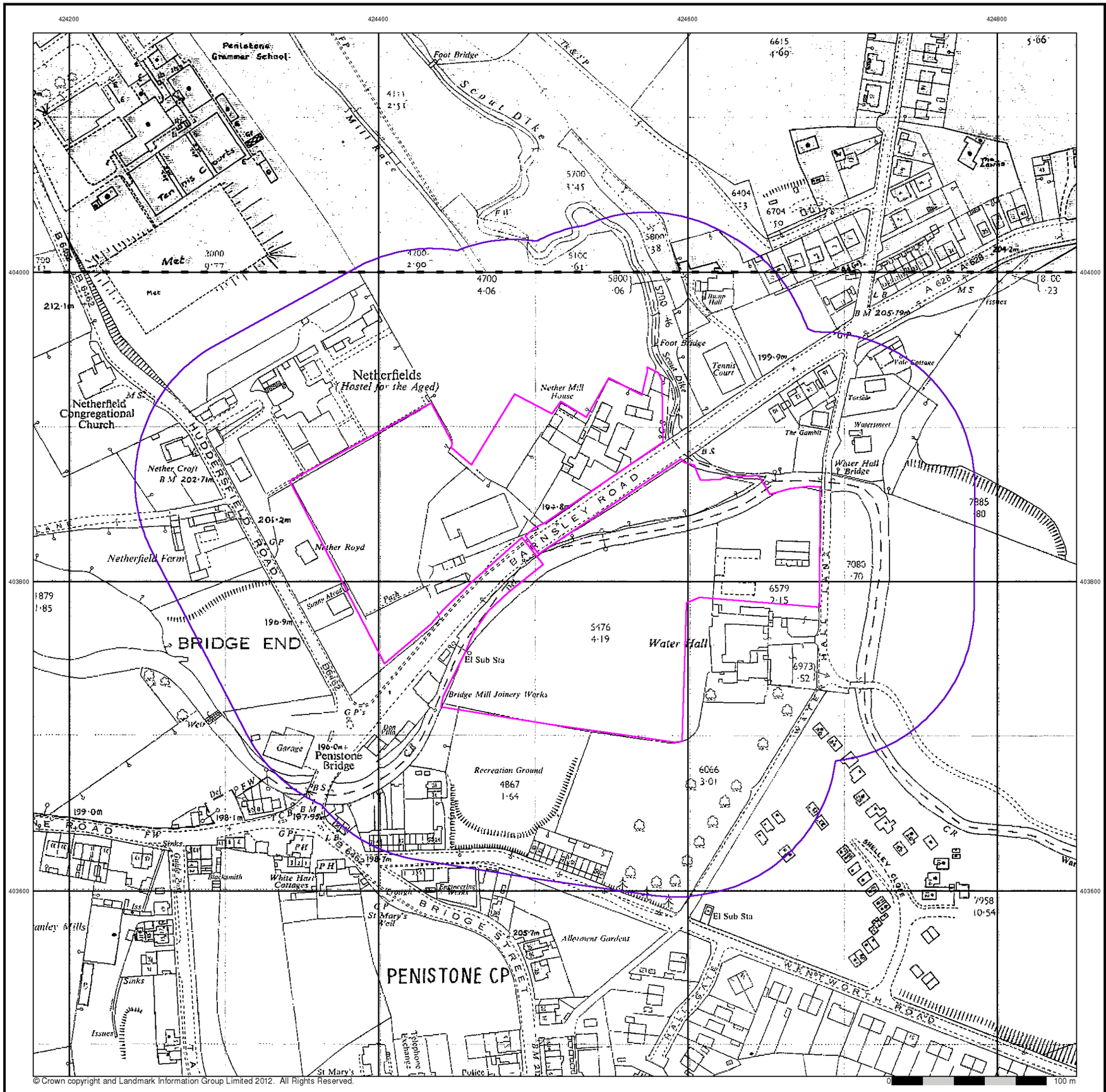
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Additional SIMs

Published 1978

Source map scale - 1:2,500

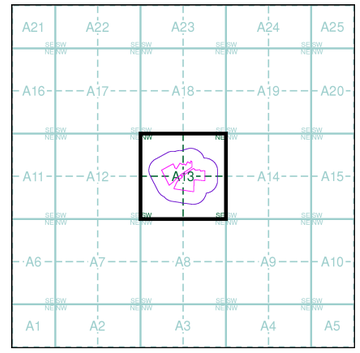
The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)

SE2404
1978
1:2,500

SE2403
1978
1:2,500

Historical Map - Segment A13



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