The SPT 'N' values for the granular Clay-with-Flints indicate it to be medium dense to dense with estimated Ø values between 32 and 37°.

Chalk

Chalk was encountered at depth across the site in all locations where the full thickness of Clay-with-Flint was confirmed. The depth to the surface of the chalk ranged from 1.50 mbgl to 6.40 mbgl in almost all excavations. However, it should be noted that one exploratory hole, WS9, extended to a depth of 10.00 mbgl without encountering the top of the chalk.
The chalk occurs as an upper weathered layer overlying a more competent material. The upper, weathered, chalk is described as a soft structureless putty chalk with occasional flint nodules and chalk lithorelicts, locally becoming stiff with depth. These values are likely to correlate to CIRIA chalk grade Dm. The competent chalk is described as hard to very hard chalk with flints, which may correlate to CIRIA chalk grades A-C, although the precise grading cannot be confirmed without in-situ observation of discontinuities.

The engineering properties of the Chalk, obtained from the available geotechnical testing, are presented in Table 7 below.

Table 7: Summary of Engineering Properties, Chalk

		No of Results	Range	Average (mean)	Suggested Characteristic Value
SPT 'N' value	Weathered	49	2-48	14	4[(a)]
	Competent	21	24-50/119	47[(b)]	22
Modulus of Volume Compressibility Mv (cohesive material)(m^2/MN))[(c)]		49	0.04-1	0.14	0.6[(a)]

[(a)] within zone of influence from shallow footings

[(b)] calculated assuming maximum SPT value of 50 for failed tests

[(c)] estimated from a correlation by Stroud and Butler (1975) using plasticity index of 23 and 1/mv.N = 0.5.

The results of the geotechnical testing indicate the Chalk at the site to be variable in strength. Figure 7 presents the variation in SPT 'N' values for the weathered and competent chalk with depth. This shows a general increase in strength in the material with depth. It should be noted that at shallow depths, within the zone of influence of shallow foundations, the weathered chalk is very weak, and consequently a low Suggested Characteristic Value has been adopted. It can be seen that below around 6.00 mbgl there is a general trend of

increasing strength with depth for the weathered material, which appears to grade into to profile for the competent chalk.

Estimates of the modulus of compressibility indicate the weathered chalk to be of low to high compressibility, generally medium to high compressibility near the proposed founding depth.

The competent chalk below 18.50 mbgl is indicated to have an SPT 'N' value of greater than 50.

12.2 Geotechnical Assessment

The Proposed Development

It is understood that the proposed development will residential in nature with the construction of 26 dwellings and associated gardens and infrastructure. The layout of the proposed development is shown in Figure 4 of this report. Final loadings for these structures have not been confirmed. Consequently typical loadings for similar developments have been assumed. For this assessment it is anticipated that potential structures and connecting infrastructure are settlement sensitive.

Preliminary Geotechnical Parameters

Based on the parameters derived in Section 12.1, the following characteristic properties are suggested (* indicates assumed).

Table 8: Suggested Characteristic Properties

Stratum	Topsoil	Clay with Flints (cohesive)	Clay with Flints (granular)	Weathered Chalk	Competent Chalk
Undrained shear strength c_u (kN/m^3)	-	60	-	17	-
Angle of shearing resistance $\varphi°$ (degrees)	-	-	22	-	-
Unit weight (kN/m^3)	16*	19*	16*	14	14
Modulus of Volume Compressibility Mv (m^2/MN)	-	0.16	-	0.6	-

Groundwater was not observed during the ground investigation and during the monitoring period of approximately six weeks, a period of mainly dry weather, during the late summer; consequently ground water is not anticipated to be encountered during the works.

Trees and Vegetation

The current site usage is agricultural with the site comprising a field surrounded by mature hedgerows, locally with trees.
Seasonal water uptake by vegetation can have a detrimental impact on foundations situated on clay soils due to cyclical desiccation and rehydration of the clay soils resulting shrinkage and heave of the material respectively. As this site is surrounded by existing vegetation, an assessment of the required foundation depth has been made for each housing plot based on the method set out in *NHBC* Part 4, Chapter 4.2, *Building near Trees*.

At the time of the preparation of this report limited information was available regarding the extent, location, height and type of vegetation present surrounding the site. As a result a highly conservative approach has been adopted, based on the following assumptions:

- Clay soils assumed to have high volume change potential based on PI of 44%;
- High water demand trees up to 24.00 m high assumed as worst case;
- Trees located within field boundary at closest point to proposed foundation assumed as worst case.

Table 10 on pages 29 to 31 indicates that the majority of the dwellings around the boundary of the site require deep foundations, with lower depths required in the central area.

Normal desiccation assessments to estimate the influence of the trees is difficult, as the soils in the field have been subject to desiccation due the corn crops grown on this field.

It should be noted that a highly conservative approach has been adopted due to lack of supporting information, and it is possible that the required foundation depths could be reduced by a revised assessment utilising site-specific tree survey information including tree heights, species and location.

The proposed development plan shows a number of additional trees/shrubs to be planted within the new development. It is not clear if these are for illustrative purposes only, or indicate an intended planting regime. Should new trees or shrubs be intended then attention should be paid to section 4.2 part (e) of *NHBC* Part 4, Chapter 4.2, *Building near Trees*, which provides guidance regarding vegetation type and height, foundation depths and required separation. If significant numbers of trees are to be installed in the central area of the site it may be necessary to increase foundation depths in this region.

12.3 Foundations

The Topsoil and weathered chalk are not considered to be suitable founding strata. The Clay-with-Flint is considered to be a suitable founding stratum for shallow footings where it is of sufficient thickness beneath the proposed foundation level. However across most of the Site it is of insufficient thickness and consideration shall have to be given to deep foundations.

The competent Chalk is considered to be a suitable founding stratum for deep foundations in the form of piles.
Table 10 on pages 29 to 31 presents the potential foundation options across the site on a plot by plot basis. It outlines proposed foundation depths based on the impact of vegetation (see page 27); anticipated depth to the base of the Clay-with-Flints; and suggested foundation type with additional pertinent information included as a comment.

Strip Footings

As can be seen in Table 10, only a limited number of plots are considered suitable for shallow trench foundations, being situated in areas where significant thicknesses of Clay-with-Flints are anticipated. At the time of this assessment final loadings and settlement requirements were not available; hence loadings of 60 - 70 kN per metre run were assumed, with a settlement tolerance of less than 25 mm.
Generally speaking foundation widths in the order of 0.30 m to 0.40 m where found to be suitable at selected locations, with foundation width limited by settlement rather than bearing considerations.

Due to the high and localised variability in thickness of the Clay-with-Flints at the site is essential that the ground conditions at each plot are confirmed before foundation construction commences. Where weathered chalk (putty chalk) is found at a shallower than anticipated depth it may be necessary to revise the required foundation to a piled option.

Piled Foundations

As Table 10 shows, the majority of plots at the site require piled foundations due to the presence of weathered chalk within the zone of influence of shallow footings.
At the time of the preparation of this report final loadings for the structures and final pile loadings were not available. In the absence of this information is has not been able to perform a detailed piling analysis for the site. Provisional single pile analyses have been made for CFA piles with a range of diameters founded within the competent chalk at a depth of 18.5mbgl. The results of this provisional analysis are presented in Table 9 below. The lowest allowable pile capacity for each diameter was selected. It is recommended that final pile design analysis is performed by a competent piling contractor when final pile loadings have been confirmed.

Table 9: Results of Provisional Piling Analysis

Pile Diameter (mm)	Allowable single pile capacity (kN)
150	213
250	434
350	651
450	872
600	1234

Table 10: Proposed Foundation Types For Each Plot

Plot No	Approximate Depth to Weathered Chalk (mbgl)	Provisional Foundation Depth due to Vegetation (mbgl)	Recommended Foundation Type	Comments
1	5+	2.5	Piled	Full thickness of Clay-with-Flints not confirmed (>5.00 m)
2	10+	2.5	Strip foundation 0.30 m wide	Full thickness of Clay-with-Flints not confirmed (>10.0 m)
3	2.9	2.5	Piled	Potential for significant variation in depth to putty chalk
4	5	2.5	Strip foundation 0.40 m wide	Potential for significant variation in depth to putty chalk
5	5	2.5	Strip foundation 0.40 m wide	
6	4.5	2.5	Piled	May be suitable for strip footings if line loadings reduced.
7	1.5	2.5	Piled	Potential for significant variation in depth to putty chalk
8	1.5	2.3	Piled	Potential for significant variation in depth to putty chalk
9	6.4	2.5	Strip foundation 0.30 m wide	
10	2.3	2.5	Piled	Potential for significant variation in depth to putty chalk across footprint
11	2.3	2.5	Piled	
12	2.1	2.3	Piled	
13	2.6	2.5	Piled	
14	3.7	2.5	Piled	May be suitable for strip footing if line loadings reduced. Depth to putty chalk approximated from nearest exploratory holes on adjacent plots.
15	3.7	2.5	Piled	May be suitable for strip footing if line loadings reduced.
16	2.8	2.5	Piled	

Plot No	Approximate Depth to Weathered Chalk (mbgl)	Provisional Foundation Depth due to Vegetation (mbgl)	Recommended Foundation Type	Comments
17	5	1.5	Piled	May be suitable for strip footing if line loadings reduced. Foundation depth may require revision depending on proposed tree planting. Depth to putty chalk approximated from nearest exploratory holes on adjacent plots.
18	5	1	Piled	May be suitable for strip footing if line loadings reduced. Foundation depth may require revision depending on proposed tree planting.
19	5	1	Piled	May be suitable for strip footing if line loadings reduced. Foundation depth may require revision depending on proposed tree planting. Depth to putty chalk approximated from nearest exploratory holes on adjacent plots.
20	4.8	1	Piled	May be suitable for strip footing if line loadings reduced. Foundation depth may require revision depending on proposed tree planting. Depth to putty chalk approximated from nearest exploratory holes on adjacent plots.
21	2.1	1	Piled	May be suitable for strip footing if line loadings reduced. Foundation depth may require revision depending on proposed tree planting.
22	2	1	Piled	May be suitable for strip footing if line loadings reduced. Foundation depth may require revision depending on proposed tree planting. Depth to putty chalk approximated from nearest exploratory holes on adjacent plots.

Plot No	Approximate Depth to Weathered Chalk (mbgl)	Provisional Foundation Depth due to Vegetation (mbgl)	Recommended Foundation Type	Comments
23	2	1	Piled	May be suitable for strip footing if line loadings reduced. Foundation depth may require revision depending on proposed tree planting. Depth to putty chalk approximated from nearest exploratory holes on adjacent plots.
24	3	1	Piled	May be suitable for strip footing if line loadings reduced. Foundation depth may require revision depending on proposed tree planting. Depth to putty chalk approximated from nearest exploratory holes on adjacent plots.
25	2.9	1	Piled	Foundation depth may require revision depending on proposed tree planting. The Clay in this area is soft, hence piled foundation required. Depth to putty chalk approximated from nearest exploratory holes on adjacent plots.
26	2.9	2.5	Piled	

13.0 COMMENTS AND RECOMMENDATIONS

In our opinion, the findings of our recent site investigation establish that this site will be suitable for the proposed residential development without any remedial action. The elevated arsenic concentrations identified represent a natural phenomenon, appear to be present in an insoluble form and are unlikely to pose a significant risk of significant harm to either human health or the groundwater.

However, we recommend the emplacement of 400 mm of low arsenic Topsoil in the future gardens, certainly in the areas around WS5 and WS6, where elevated arsenic was proven in shallow soils, to break the potential pathways to the low risk potentially posed by the arsenic in a few locations. It may be prudent to extend this measure to all private gardens.

Any topsoil imported for landscaped amenity areas should conform to the requirements of *BS 3882: 2015, Specification for Topsoil.* Topsoil selected for use on this site should be sampled at source and tested for compliance using a NAMAS- and UKAS- accredited laboratory. The test results should be submitted to the local authority for approval before emplacement on site. We caution against the purchase of any topsoil on the strength of suppliers' certificates only, which may be out of date or unrepresentative of the material purchased.

Due to the complex and variable geotechnical ground conditions encountered, it may be necessary to design the foundations on a plot by plot basis. Where strip foundations are being considered, probing to confirm the thickness of the Clay-with-Flints Formation should be considered.

No direct evidence of solution voids has been found on this site. However, the site is underlain by a significant layer of softened chalk. The use of soakaways is under consideration. This will need careful assessment, as erosion by water may form voids in this softened chalk layer. Catt et al advised that "sites for soakaways should be chosen where the chalk surface is even and without cavities, as indicated by trial pitting or shallow boring. Where such areas are not available, bored soakaways to carry water into the chalk to a depth below any solution pipes should be considered, though these are subject to approval by the Environment Agency because contamination of the aquifer is likely" (John Catt [editor], *Hertfordshire Geology and Landscape*, 2010, page 293).

Figures

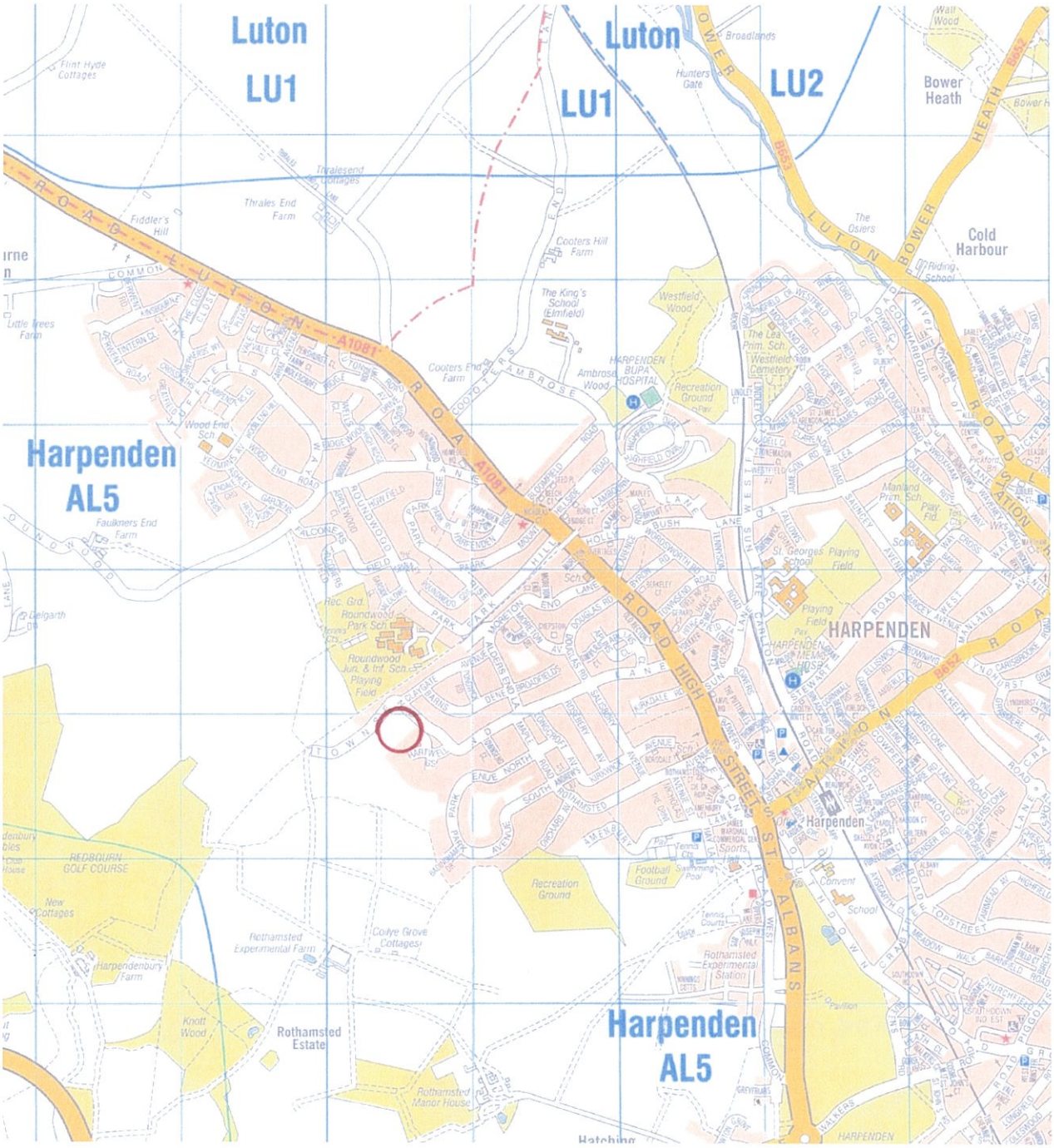
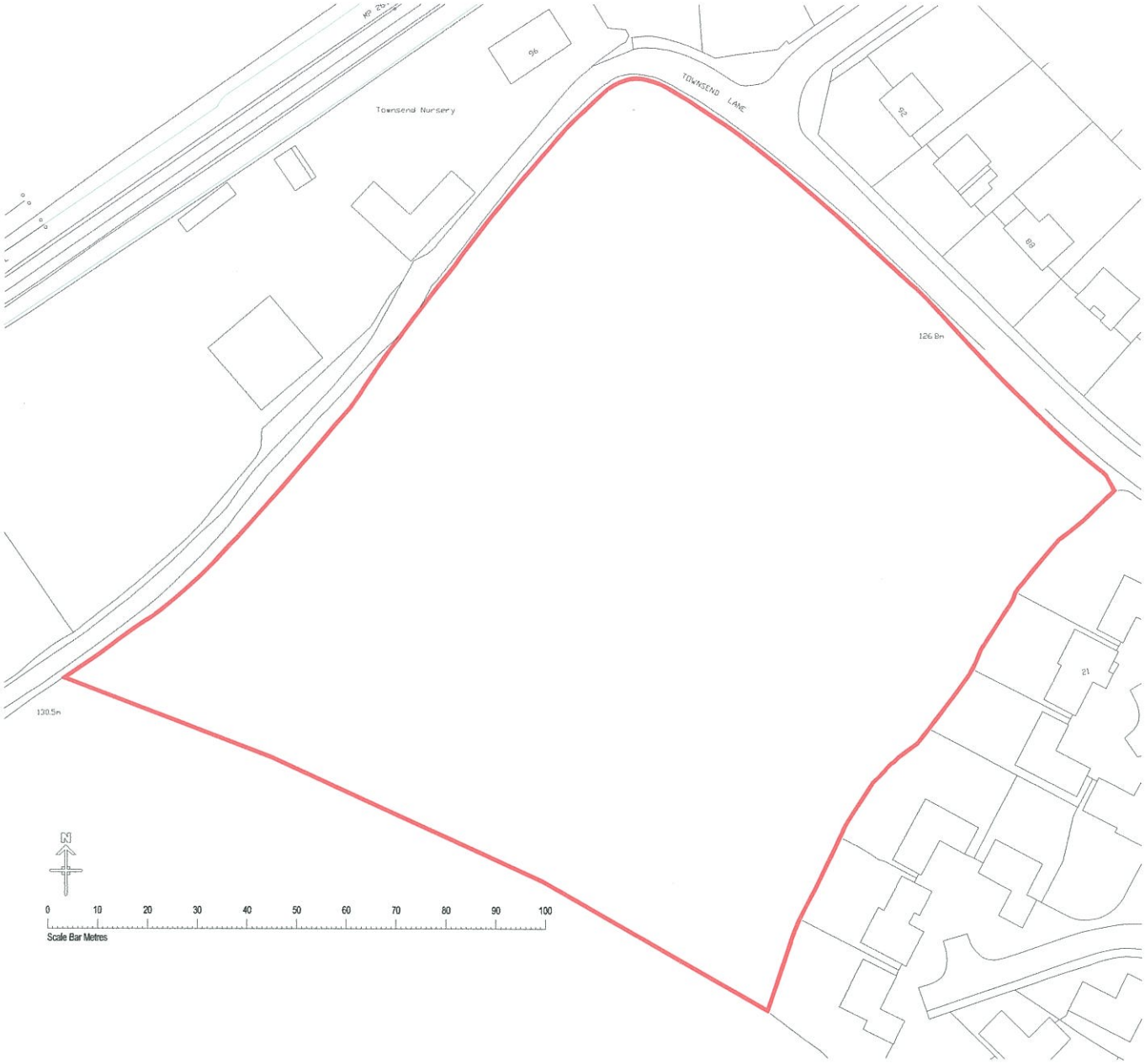


Figure 1: Site Location Plan

Figure 2

Site Plan showing the Boundaries of the Development Site

Rev. No.	Date.	Amendment.	Initial.



Hill

Client:
Hill Residential Limited
The Courtyard, Abbey Barns,
Ickleton, CB101SX

Project:
Townsend Lane
Harpenden
Hertfordshire

Drawing:
Site Location Plan

Scale:		Date:	
1:1250@A4		March 2015	
Drawn By:	Checked By:	Drawing No:	Rev. No:
MC	JET	Preliminary	
CAD Ref:			

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All dimensions to be checked on site or in the workshop before work commences.
Only figured dimensions to be worked to. Any discrepancies to be reported to the Architect.

Figure 3

2015 Aerial Photograph of the Site


Harpenden, Hertfordshire AL5 2RH
Townsend Ln
Barns Den
Hartwell Gar
© 2015 Google
Image © 2015 Getmapping plc
2000
Imagery Date: 1/1/2006 51°49'02.81" N 0°22'22.87" W elev 131 m

Figure 4

Layout of the Proposed Development


Townsend Nursery
Townsend Lane
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N

Figure 5

Location Plan of Excavations

Rev. No.	Date.	Amendment.	Initial.
—	—	—	—

Hill

Client:
Hill Residential Limited
The Courtyard, Abbey Barns,
Ickleton, CB10 1SX

Project:
Townsend Lane
Harpenden
Hertfordshire

Drawing:
Proposed Site Layout

PRELIMINARY

Scale:	Date:	
1:500@A1	September 2014	
Drawn By:	Checked By:	Drawing No: / Rev. No:
MC	NP	Preliminary / -
CAD Ref:		

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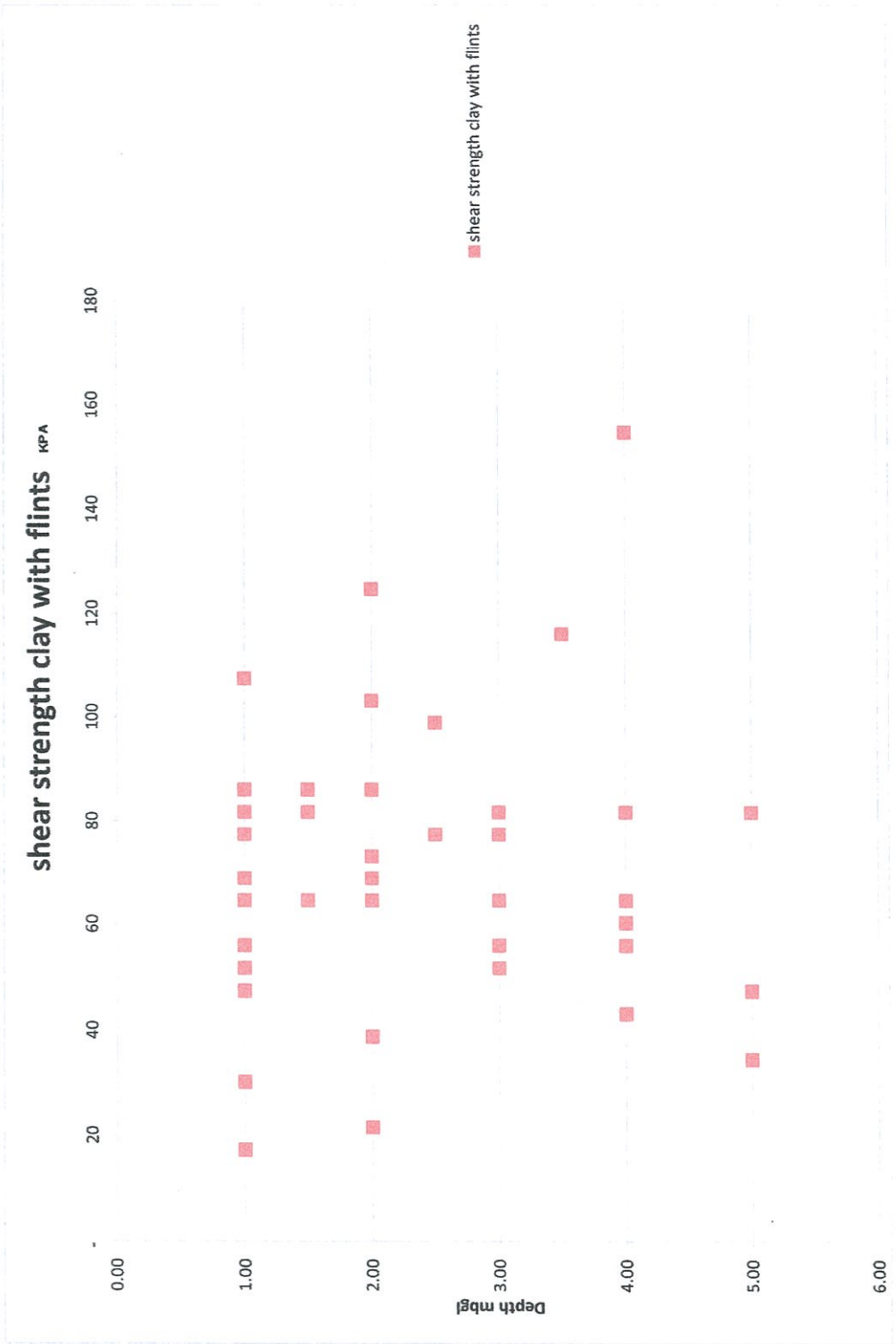


Figure 6: Shear Strength of Clay-with-Flints vs Depth

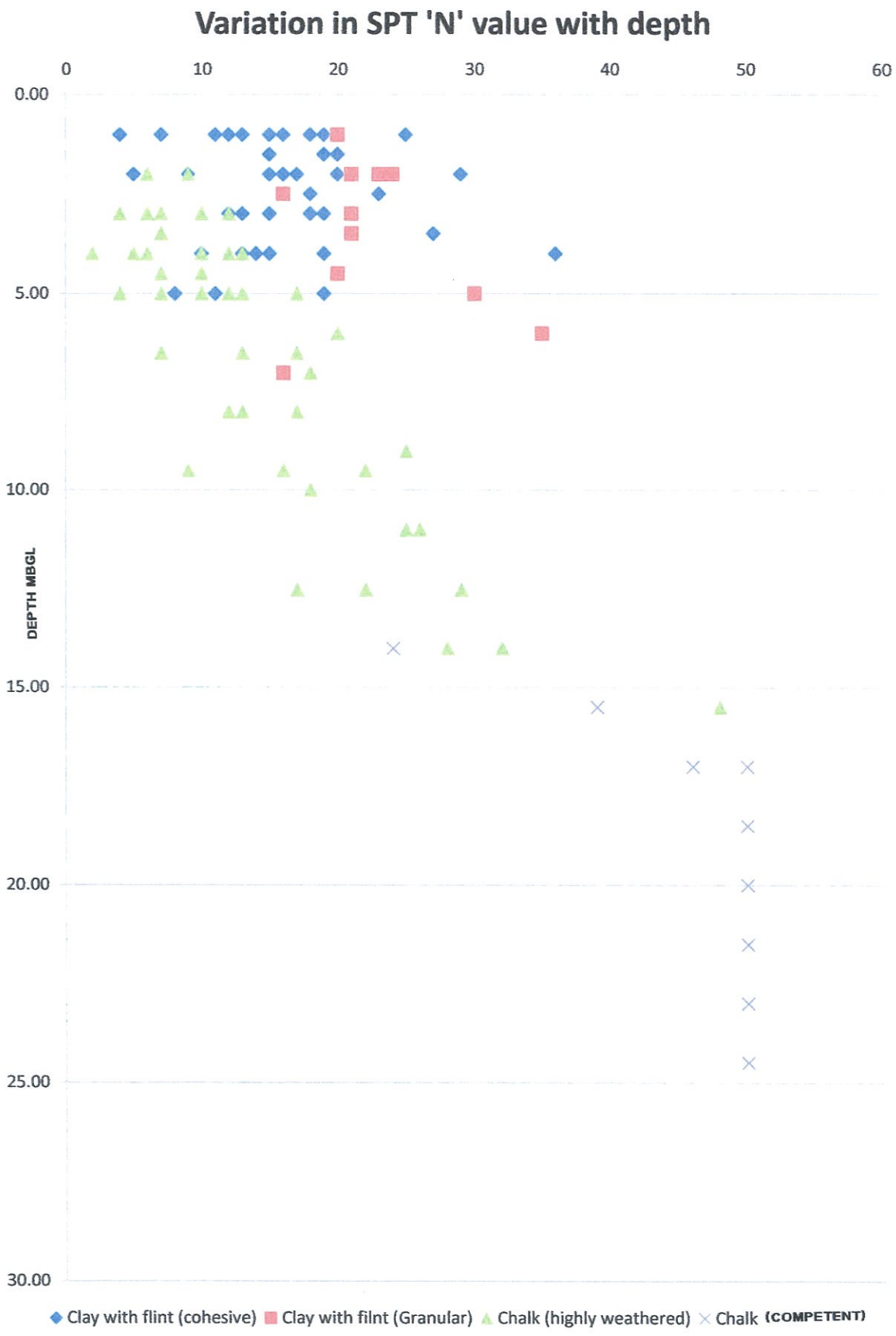
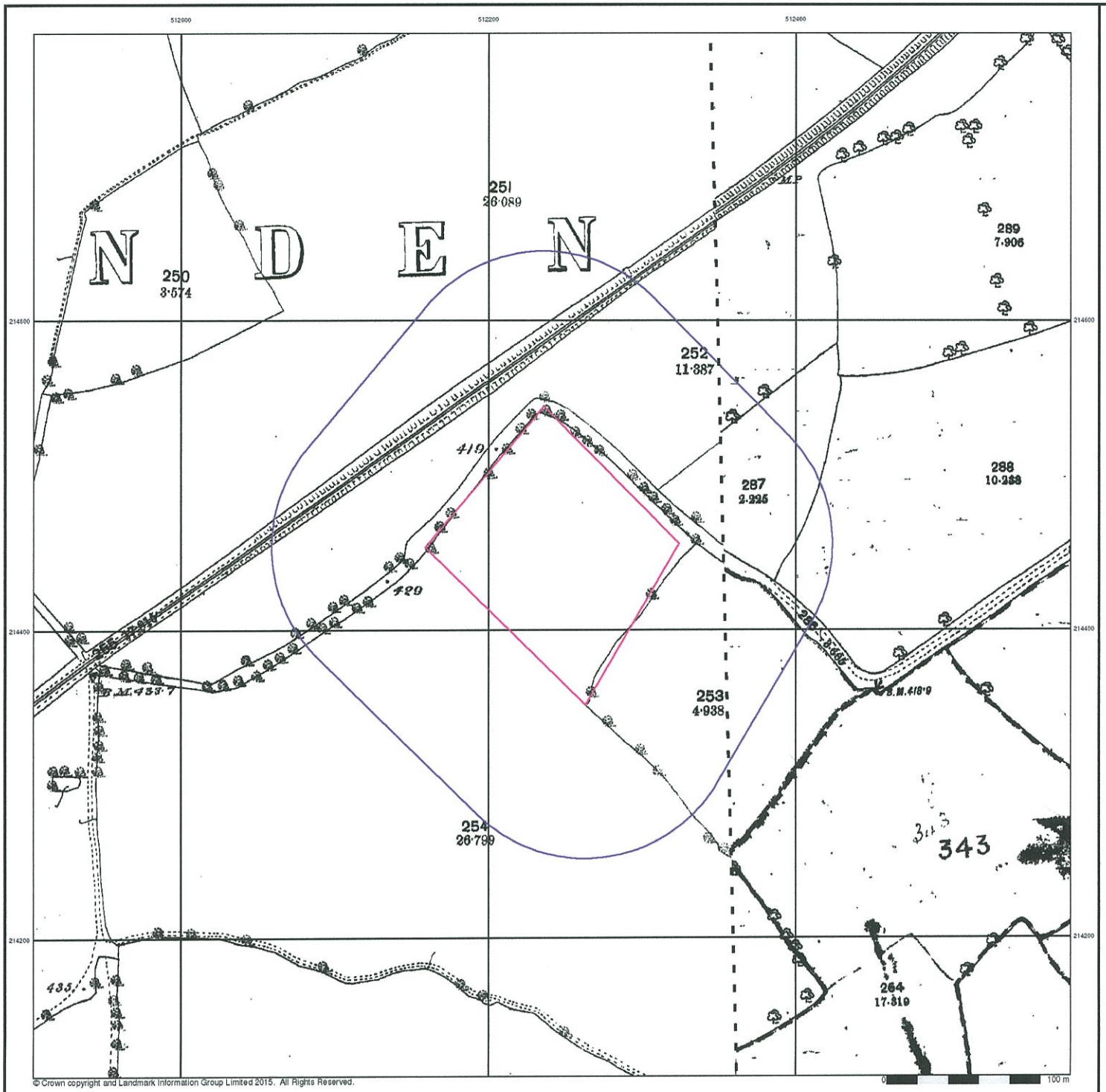


Figure 7: Variation of SPT "N" Value with Depth

Appendices

Appendix A

Historical Maps



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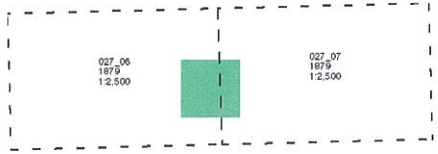
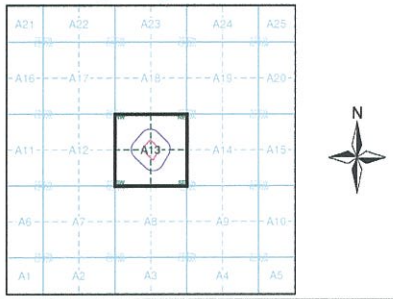


Historical Map - Segment A13



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National Grid Reference:	512240, 214450
Slice:	A
Site Area (Ha):	1.6
Search Buffer (m):	100

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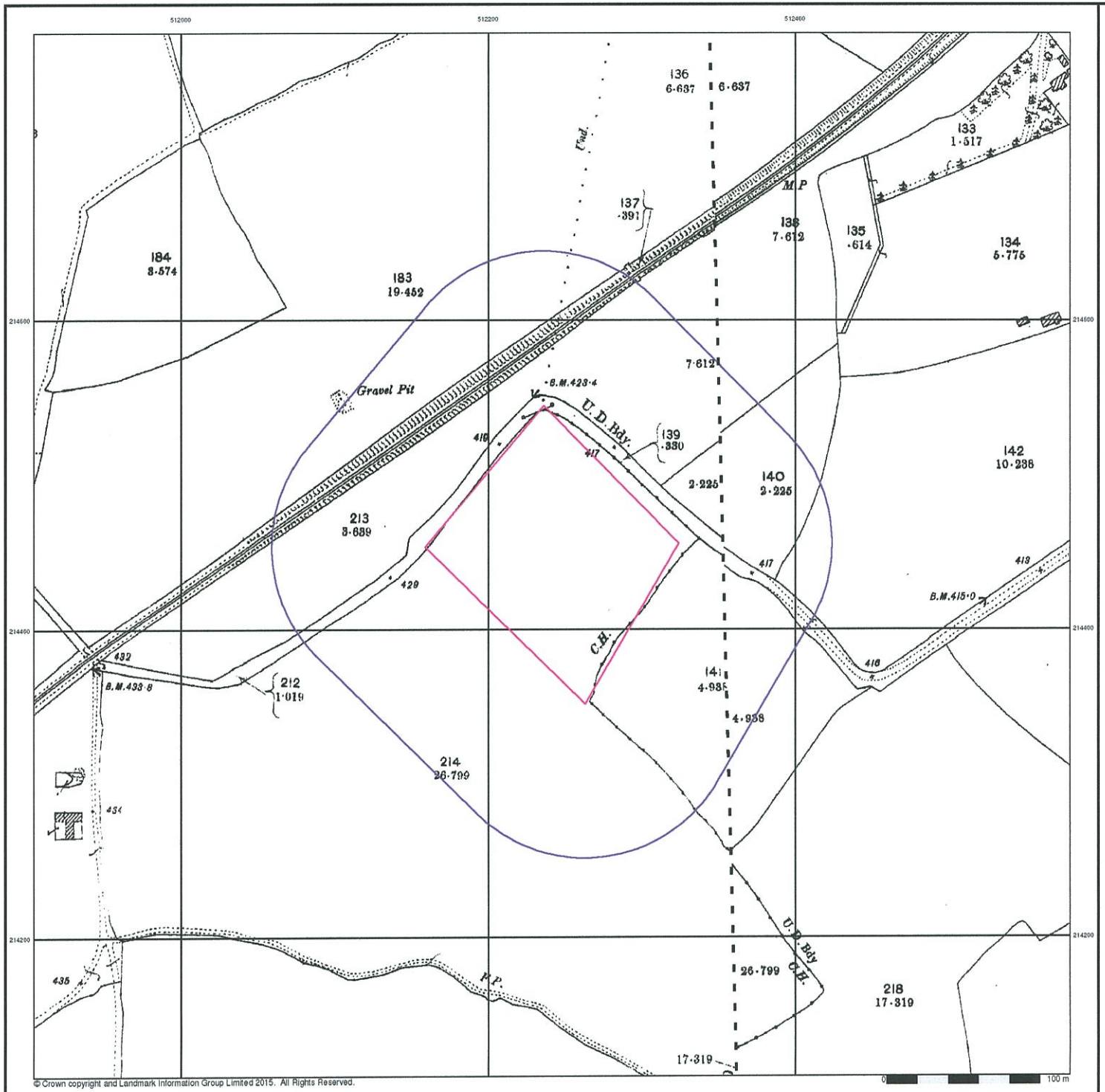

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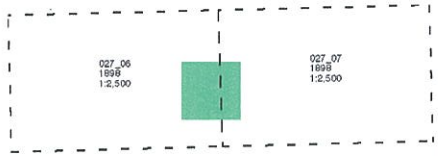

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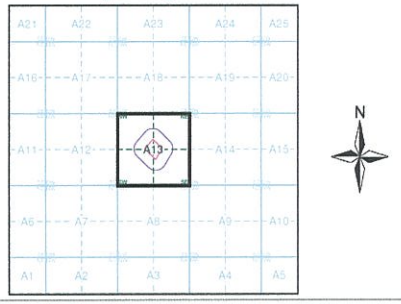

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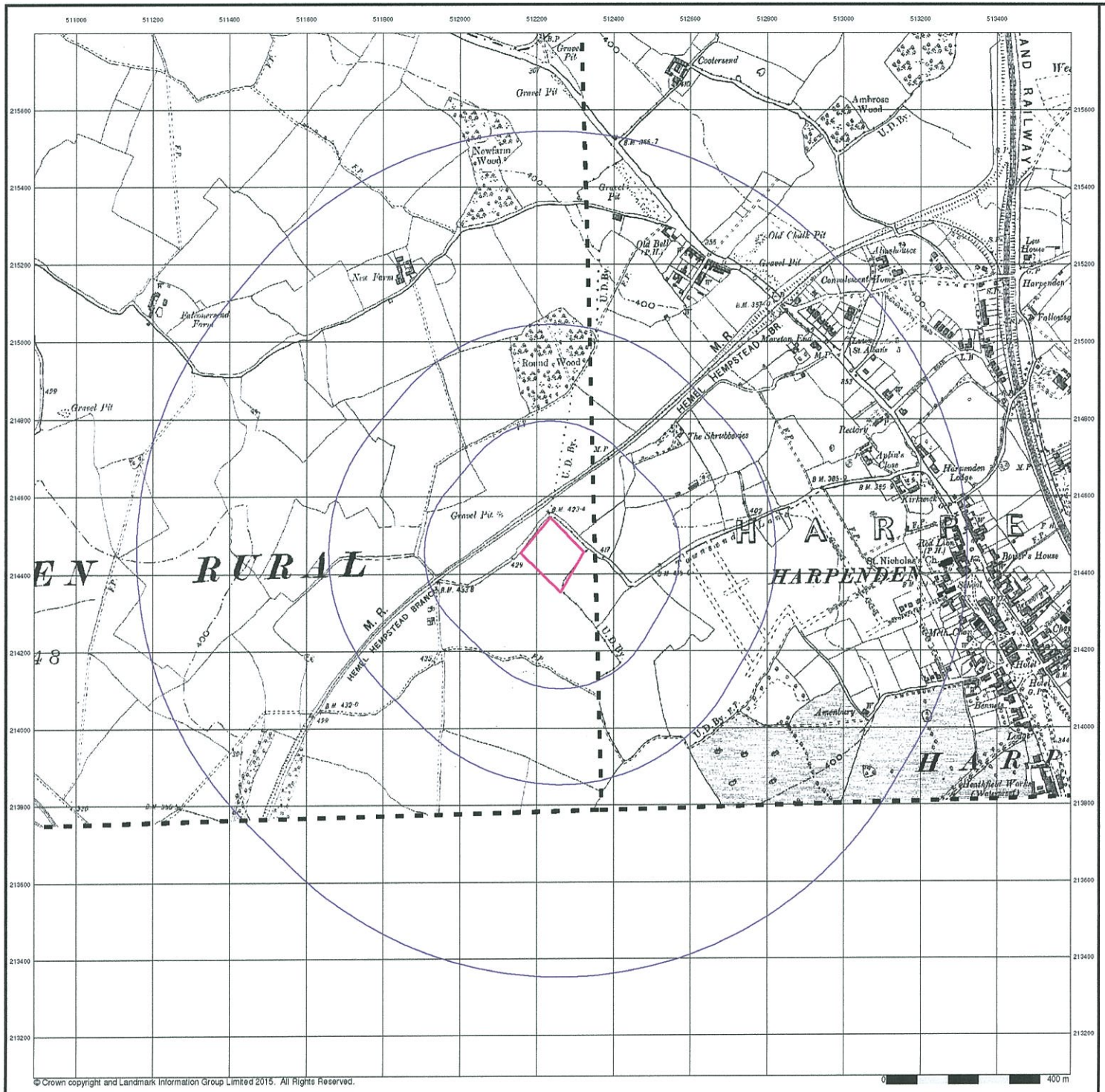

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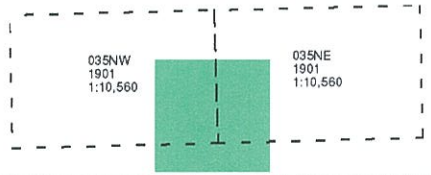
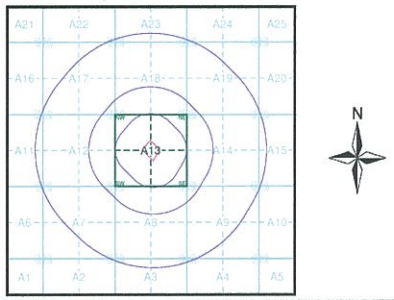
Map Name(s) and Date(s)



Historical Map - Slice A



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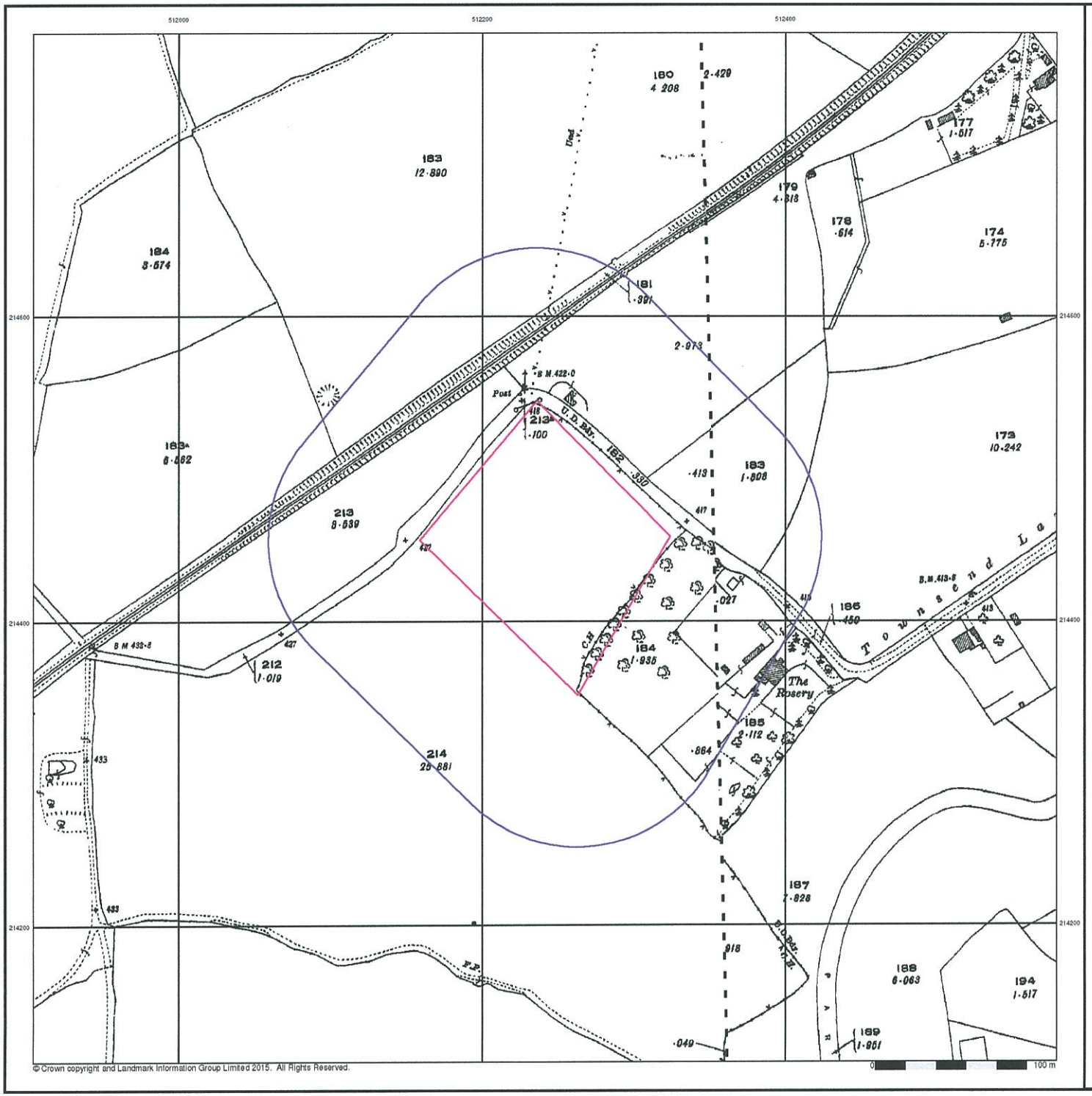

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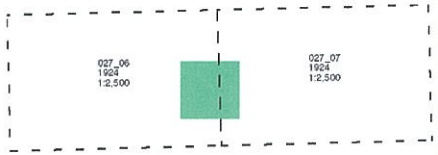

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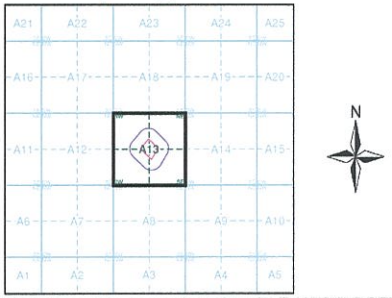

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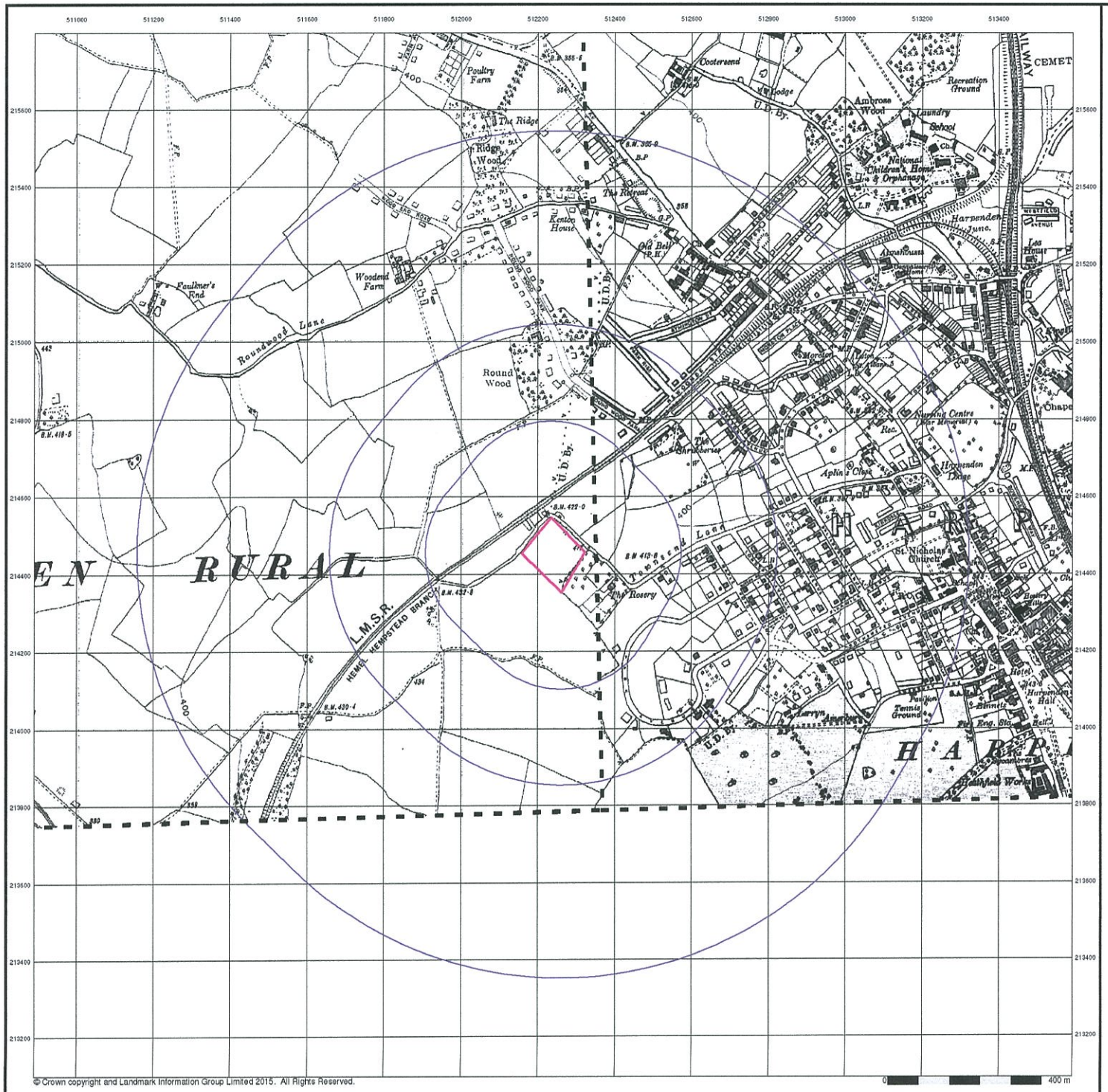

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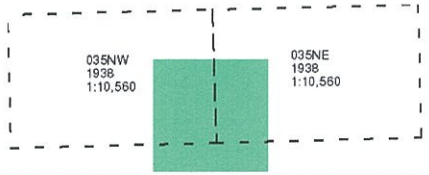
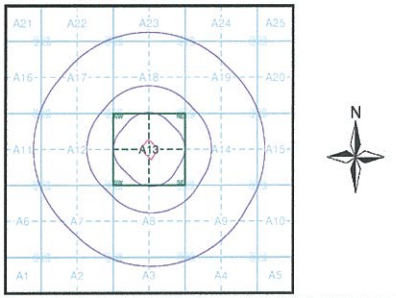
Map Name(s) and Date(s)



Historical Map - Slice A



Order Details

Order Number:	70805370_1_1
Customer Ref:	hap334
National Grid Reference:	512240, 214450
Slice:	A
Site Area (Ha):	1.6
Search Buffer (m):	1000

Site Details

94 Townsend Lane, HARPENDEN, Hertfordshire, AL5 2RH

Landmark® Information Group

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Envirocheck®

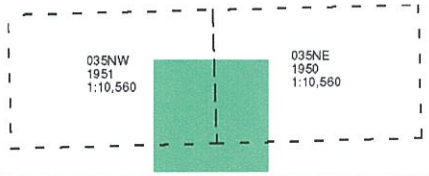
Bedfordshire

Published 1950 - 1951

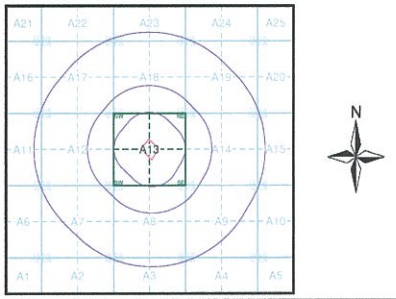
Source map scale - 1:10,560

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

Map Name(s) and Date(s)



Historical Map - Slice A



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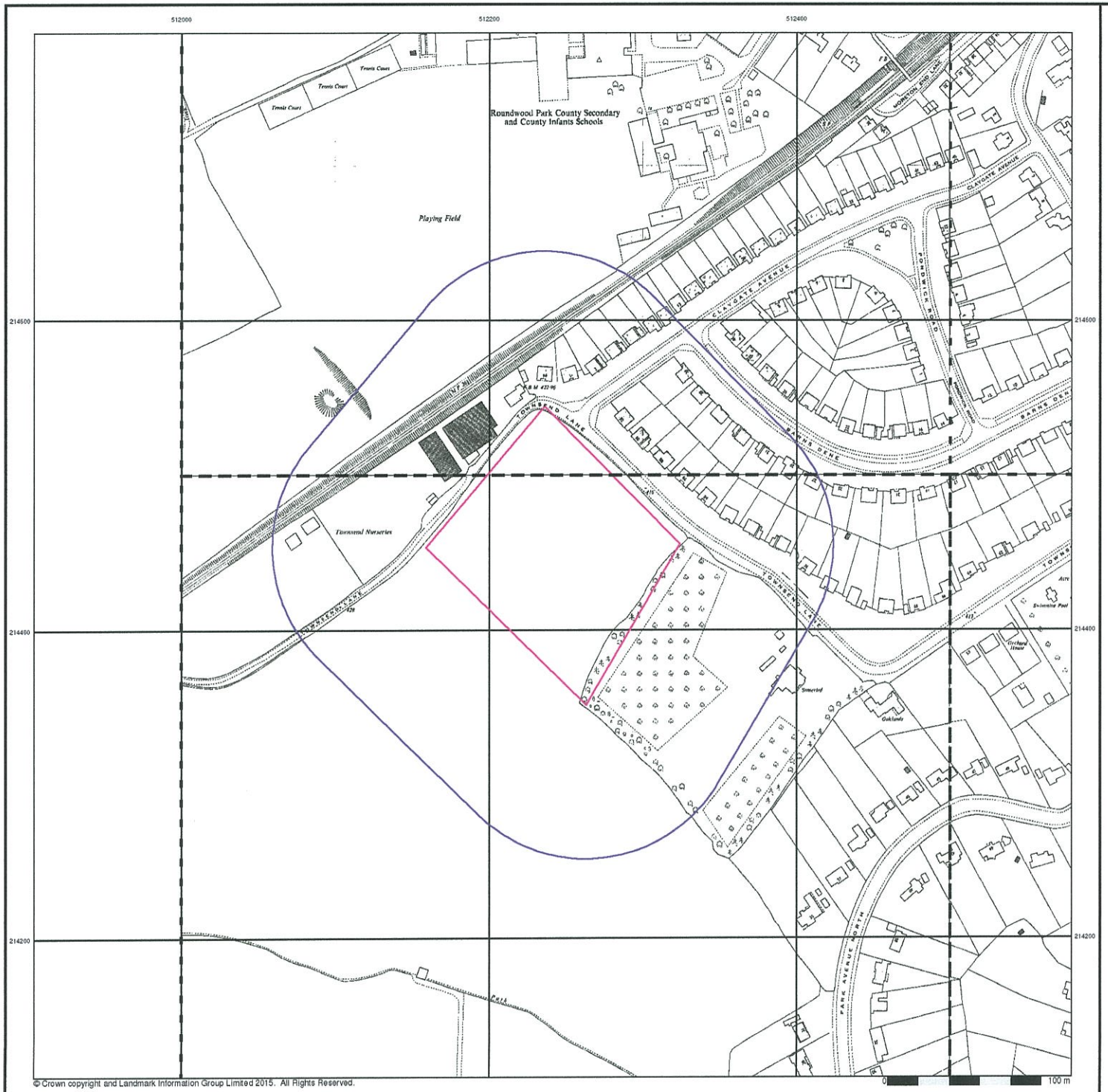

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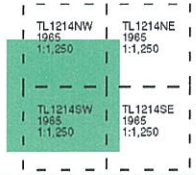
Ordnance Survey Plan

Published 1965

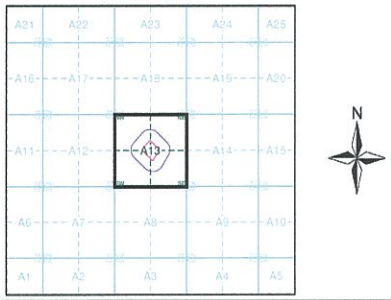
Source map scale - 1:1,250

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



Order Details

Order Number:	70805370_1_1
Customer Ref:	hap334
National Grid Reference:	512240, 214450
Slice:	A
Site Area (Ha):	1.6
Search Buffer (m):	100

Site Details

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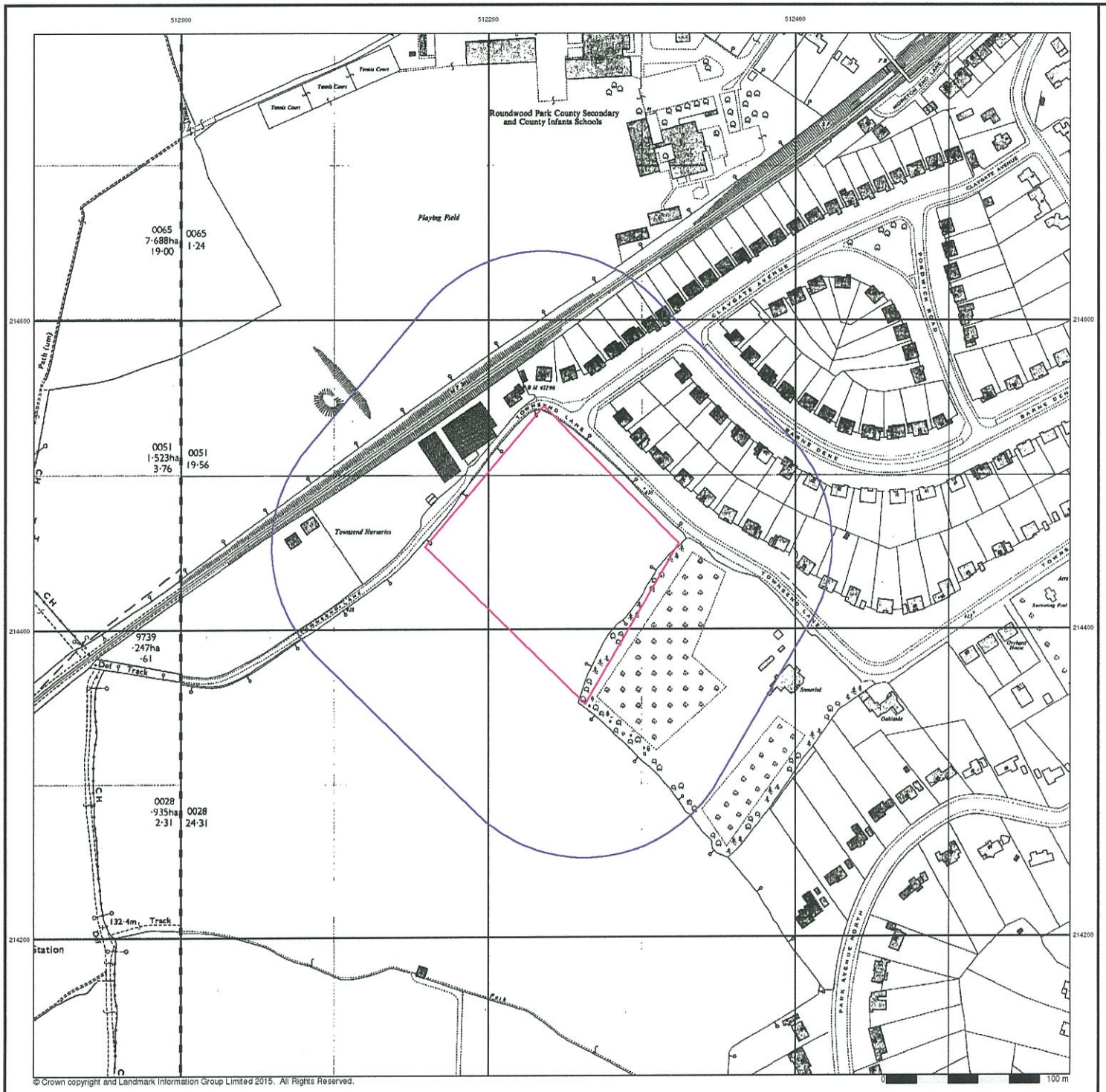

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Ordnance Survey Plan

Published 1967 - 1975

Source map scale - 1:2,500

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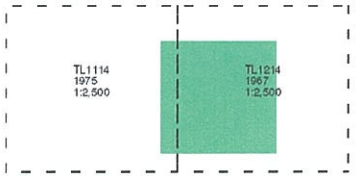
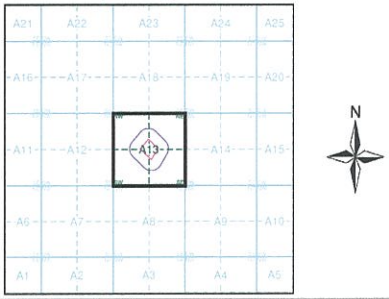
Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	70805370_1_1
Customer Ref:	hap334
National Grid Reference:	512240, 214450
Slice:	A
Site Area (Ha):	1.6
Search Buffer (m):	100

Site Details

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