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cambridgeshire archaeology
ARCHAEOLOGY FIELD OFFICE
FULBOURN COMMUNITY CENTRE
HAGGIS GAP, FULBOURN
CAMBRIDGE CB1 5HD Tel: 881614
(Fax 881678)

DIDDINGTON TO PRIORY HILL PIPELINE
An Archaeological Assessment 1992

Cambridgeshire County Council

DIDDINGTON TO PRIORY HILL PIPELINE

- AN ARCHAEOLOGICAL ASSESSMENT

Mary Alexander

1992

Archaeology Section
Property Department
Shire Hall Castle Hill
Cambridge CB3 OAP
Tel. (0223) 317312

Report no. 74 *Iron Age Ditch 008*

Cambridgeshire Archaeology

DIDDINGTON TO PRIORY HILL PIPELINE
an archaeological assessment

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Abstract

An archaeological assesssment was carried out in 3 archaeologically sensitive areas along the route of the proposed reinforcement of the trunk main between Diddington and Priory Hill.

Six trenches were machined in Area 1 and five in Area 2. In both areas disturbance from gravel quarrying was found to be more extensive than previously known,destroying most of the area presumed to have archaeological remains surviving. However, one trench in Area1 revealed a short length of ditch containing one tile fragment, and in Area 2, a section of a large ditch was shown to contain early !st century pottery and quern stone fragments.In Area 3, seven test pits showed extensive gravel quarrying had taken place throughout the area designated a Site of Special Scientific Interest, (S.S.S.I.).

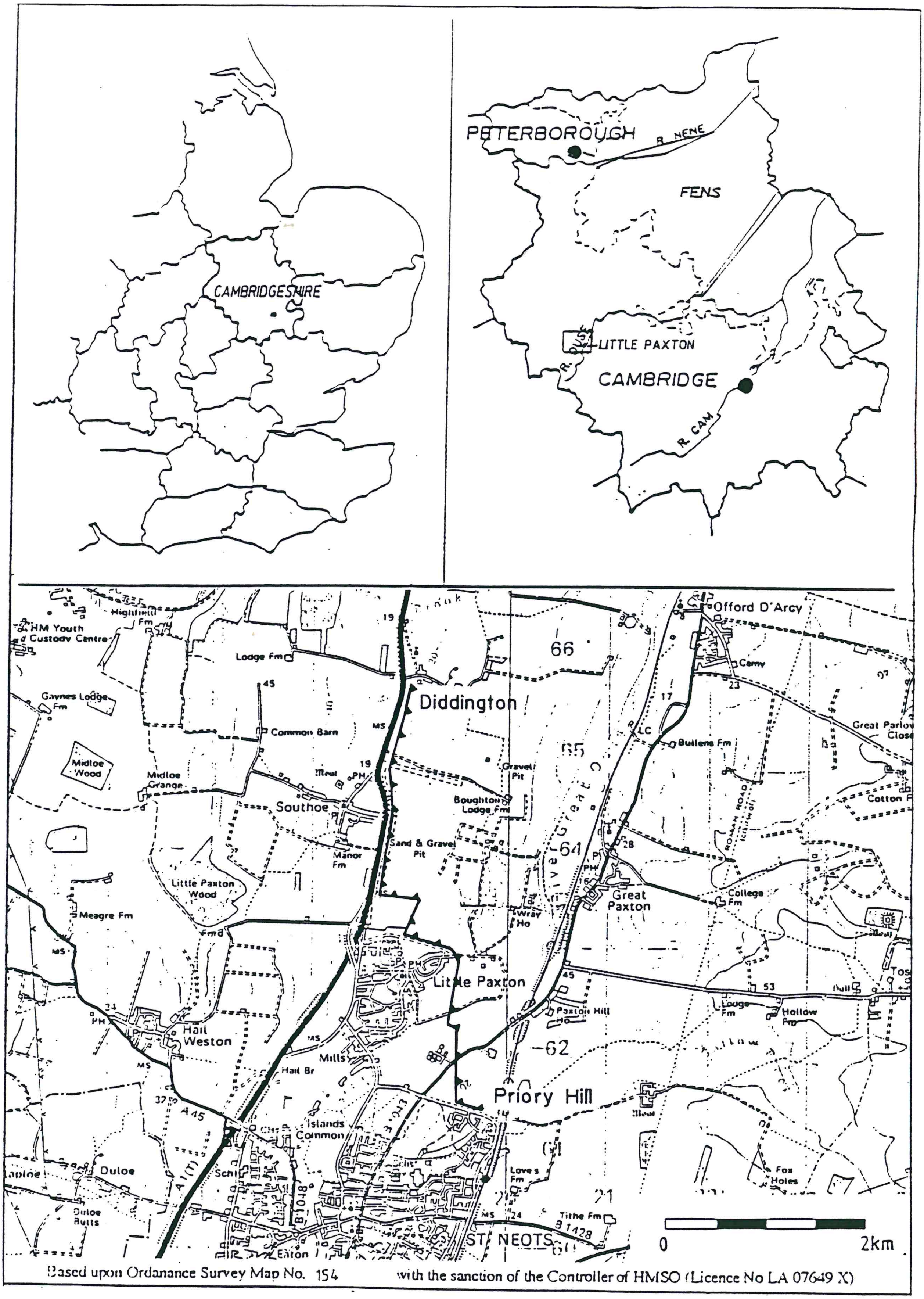
Introduction

In advance of construction for Anglian Water's new trunk main between Diddington (TL 190-/656-) and Priory Hill Road (TL 199-/614-), a programme of archaeological works was initiated to record archaeological remains likely to be damaged by the pipeline.Cambridgeshire Archaeology was commissioned by Anglian Water to undertake this work and also requested to find the line of an existing pipeline to ensure that this did not lie in the path of the new one. Three main areas were identified as being archaeologically sensitive because of associated cropmarks and excavated evidence.*[Fig. 2]* Two of these areas were investigated by the excavation of machine dug trenches. The works were carried out between 10th August and 18th August.

A third area of archaeological potential lay within a Site of Special Scientific Interest; the Paxton Pits Nature reserve. In this area the underlying deposits were investigated by a series of test pits, to ensure minimum disturbance of the area. Work in this area commenced on September 14th.

The route of the new pipeline runs southwards from Diddington, east of the A1 road, and to the west of the artificial lakes created after gravel extraction. Approximately 400m from Little Paxton, the pipeline turns eastwards to skirt the village, and passes through Little Paxton Pits Nature reserve, before crossing the Great River Ouse and continuing to Priory Hill. *[See Fig. 1]* The new pipe was laid using a mole plough to a maximum depth of 1. 20m

Figure 1: Location Map and Route of Pipeline



Based upon Ordanance Survey Map No. 154 with the sanction of the Controller of HMSO (Licence No LA 07649 X)

Archaeological Background

The Great Ouse valley gravels, through which the pipeline runs, have a long history of human exploitation, from the Pleistocene to the present time. Cropmarks recorded by aerial survey have revealed prolific archaeological activity commensurate with an area that combined good communications along the route of the valley with easily cultivated soils.

An interpretation of the history of the surrounding landscape can be attempted by applying a knowledge of the chronological changes in building styles,of land division, and of field size and layout to the evidence of cropmarks. However it must be borne in mind that later agricultural activity or habitation may mask the more important centres of early activity with cropmarks only surviving on more marginal ground. Moreover, it is often difficult to interpret the sequence of superimposed cropmarks, or distinguish between cropmarks of natural origin, such as drainage channels, and the archaeological record.The occurrence of cropmarks is also dependent on soil types. First terrace river gravels produce visible marks while the surrounding boulder clays and the river alluviums often do not *[Fig. 2]* . To produce a more accurate picture of early activity it is necessary to combine information from cropmarks with other forms of evidence: chance finds, excavation or observation during building work or quarrying, and documentary sources.

Earliest activity in the area is indicated from stray finds of worked flints and implements concentrated to the south of Little Paxton near the River Great Ouse [SMR 578,587,5849], probably a suitable fording point for the river. There is more widespread distribution of flint flakes and artefacts of Neolithic and Bronze Age date throughout the area.Just to the east of Area I *[see Fig.2]*, enclosures, ditches,pits and postholes dated by Bronze age and Iron Age pot, were observed during gravel extraction,[SMR 612,] and the complex cropmarks to the northeast and within the area [SMR 5739,4729] may be part of a Bronze Age or Iron Age settlement. Neolithic and Bronze Age flints were also found to the south and west of Area 2 [SMR 08993,08992] and may relate to the cropmarks to the northeast.

If the ring ditches and associated irregular enclosures and ditches observed in cropmarks [SMR 4748,8970,580,575,901] could be interpreted as Neolithic or Bronze age, there could be at least 2 settlement areas to the south and west of Little Paxton . A rescue excavation of a possible Neolithic hut and other features [SMR 589], with a distribution of Bronze Age and Neolithic flint finds in the area, appears to substantiate this interpretation.

Another occupation area undoubtedly lay to the east of Little Paxton, just to the west of Area 3, where numerous flints were found [SMR 8990,8989, 8988],and 650 prehistoric features were revealed by quarrying [Addyman, 1969]. A ring ditch and enclosure [SMR 4754], and the superimposed small enclosures represented by cropmarks [SMR 635] also suggest prolific prehistoric activity to the south of the river. It appears that the Little Paxton area offered optimum conditions for settlement in this period with the potential to exploit both land and river resources, and close to a possible fording point of the Great Ouse.

During the Roman period the area continued to be inhabited. Roman pits were found during gravel extraction to the southwest of Area 2, but the main focus of settlement may have shifted during the Iron Age and early Roman period to the east of Little Paxton.To the east of Area 3, excavations [Greenfield, 1968] revealed late Iron Age occupation of a small farmstead followed by a re-occupation in the 1st century AD, continuing to the mid 4th. Further to the east, in the vicinity of a Bronze Age barrow [SMR 2474], a series of pits and ditches show a continuity of occupation from the Iron Age to the Roman, and several wells produced waterlogged material, including construction timbers dated to the early 3rd and early 4th centuries AD. Nearby on the Great Ouse there was evidence of a Roman quay,and another may have lain to the south of Little Paxton, across the river. The linear ditches and large rectangular enclosures may represent a Roman field system overlying Prehistoric activity on a multi-phase cropmark recorded just to the south of a probable Roman cemetery [SMR 4747]. Here 3 Roman cremation urns (one lying under a mound), were rescued from gravel quarrying.[SMR 581] A "Barrow Close" is marked on the 1760 estate map of this area. This occcupation evidence may represent the widening choice of settlement site as the introduction of the heavy plough put new lands under cultivation.

Saxon occupation in Little Paxton was found directly to the west of Area 3 [Addyman, 1969.], [SMR 628]. Features excavated included at least 2 enclosures, several wells and domestic refuse, including pot dated from the late 9th to the early 11th centuries. More features were observed, prior to destruction towards the north where burial urns and a skeleton were recovered. Main settlement at this time could have been focused on Great Paxton, where the Saxon minster was established.

The medieval village of Little Paxton appears to have centred on the present day High Street where the church was in existence by the late 12th century [SMR 594,595]. Its westward and northward limits are indicated by cropmarks of ridge and furrow [SMR 4750,8007]. Medieval occupation could have masked any Saxon occupation in this area or it may indicate another shift in settlement . This move may have been prompted by flooding of the Great Ouse or the river altering course (the cropmarks [SMR 4747, 635] appear to be partially obscured by deposits of alluvium).

The shift may also have been the consequence of Post- Conquest changes in land ownership and enclosure. Cropmarks of structures and ridge and furrow show 2 other villages established at this time on previously sparsely populated land at Southoe [SMR 5854] and Boughton Farm [SMR 7757]. The area between Paxton lane and the river, surviving until the late 20th century as Paxton Park, may represent the extent of the deer park known to be in existence before 1328 [Jamison, 1932],[SMR 671]. This deer park in the lands of the manor held by Robert le Moyne, may well have been established as manor hunting grounds at an earlier date, necessitating a shift of settlement to the north.

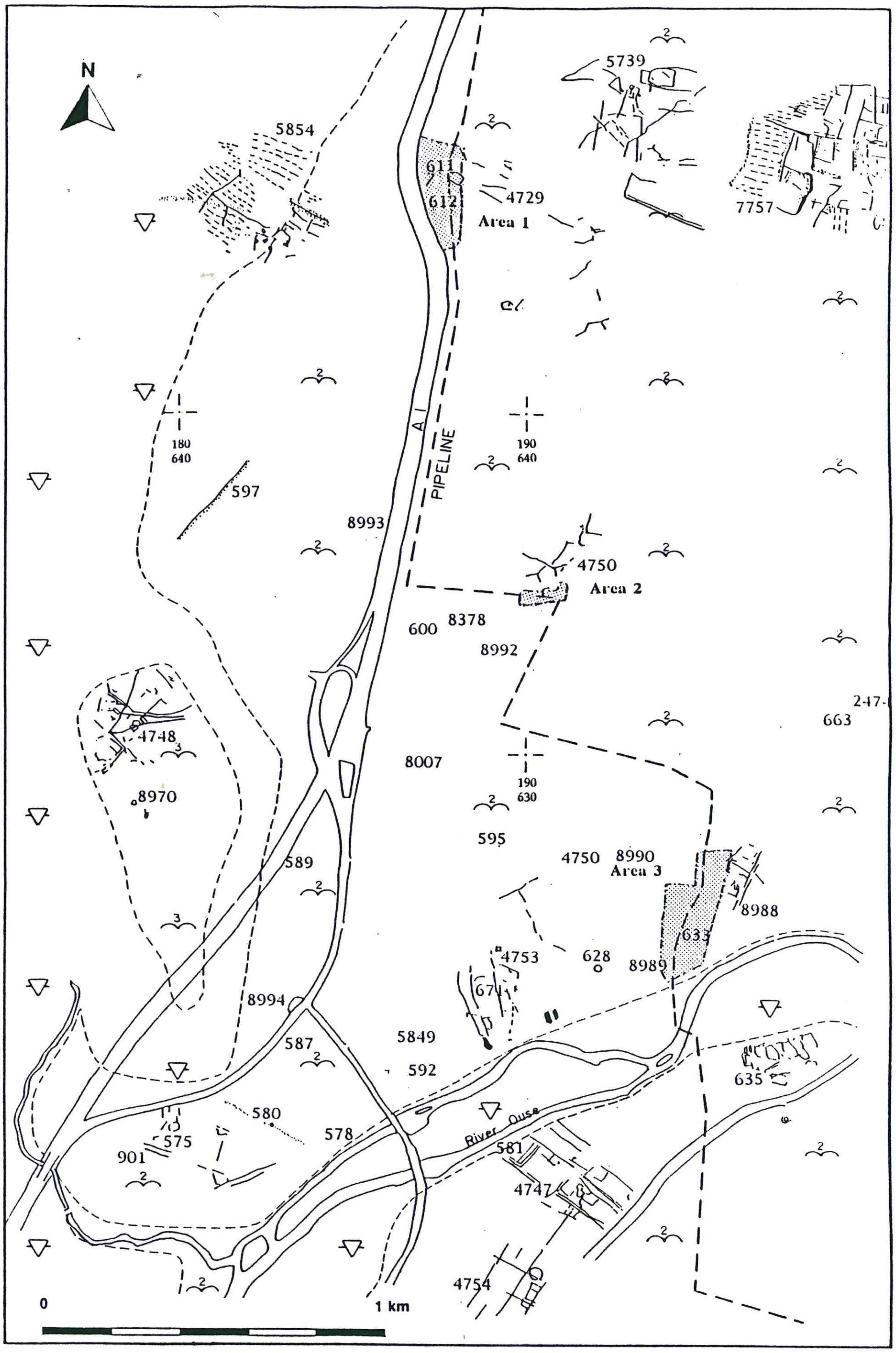


Figure 2: Drift Geology and Archaeology.
Shading denotes areas of archaeological investigation.

2 = 1st- 2nd Terrace River Gravels

3 = 3rd Terrace River Gravels

= Boulder Clay

Methodology

AREAS 1 + 2

A series of trenches were dug by a JCB 814 mechanical excavator, running transversely across the line of the proposed pipeline in 2 areas chosen for their high archaeological potential *[Figs. 3 + 4]*. Cropmarks suggestive of ditches and enclosures lay within Area 1, while directly to the east, traces of pits and postholes were observed during gravel extraction. To the west of Area 2, Neolithic and Mesolithic flints were found during gravel quarrying, which also destroyed a shallow feature containing Roman pottery. Prior to quarrying, a series of unidentified cropmarks were observed to the northeast and extending south into the area of investigation *[Fig. 2]* .

In Area 2, where the pipeline turned at a sharp angle, some of the trenches were positioned to cover the area likely to suffer substantial damage.Although in general the use of a mole plough causes minimal damage, where a change of direction is required a more significant amount of ground disturbance is to be expected.

All trenches were excavated to subsoil, where it existed, or to a maximum depth of 2.2m where gravel extraction had removed all deposits above the natural river gravels. Size and shape of trenches was determined by the time allowed for excavation, safety considerations and the presence or absence of archaeological features.

In Area 1, five trenches were dug: A, B, C, D and E; a sixth trench: F was dug after trenches B and C had been backfilled.
In Area 2, five trenches were excavated: G, H, I, J, K. Subsequently, trench I was enlarged to investigate feature 008 more fully.

All trenches were cleaned by hand, photographed, and one section in each trench was recorded, except for trenches B and C, where the depth and unstable nature of the trench sides made it necessary to photograph and backfill immediately. Considerations of safety were heightened by the proximity of a family camping site and water sports club. All archaeological features were fully excavated and recorded using standard Cambridgeshire County Council Archaeological Section context sheets.

In Area 3, a programme of Test Pits had been proposed which required twelve, 2m x 1m pits to be excavated, recorded and reinstated within 2 weeks. The Test Pits were positioned in relation to the proposed pipeline, and within the zones of archaeological potential as suggested by the results of the geophysical survey*[Appendix 1]*, .The seven Test Pits excavated revealed only backfilled land, suggesting total quarrying of the area. After confirmation by Redlands Ltd that the area was all quarried, the programme was abandoned.

Results

AREA 1

Trench A: No archaeological features. South-facing section showed cut for gravel sloping down towards the east and destroying all deposits to within 1.5m of western edge of trench, where a small area of subsoils survived. Ground level: 17.97m.

Trenches B and C: No archaeological features. Sections showed dumped material and backfill from gravel extraction to a depth of 1.8m in trench B, and 2.0m in trench C. North-facing sections photographed and trenches backfilled. Ground level trench B: 18.56m, trench C: 19.01m.

Trench D: No archaeological features. North-facing section drawn showing natural sandy gravels at a depth of 16.46m covered by a layer of subsoil truncated to a maximum thickness of 0.18m by modern machining. Backfilled and overlaid by thick layers of dark grey clay and dirty brown gravels. Ground level: 18.60m.

Trench E: Cut [006], Fill (007). Linear cut; width 0.36m, length 1.60m running SE-NW continuing beyond the edges of excavation. Truncated above by gravel workings to a maximum depth of 0.31m, sides dropped steeply towards a slightly rounded bottom which ran level for approx. 1.20m before sloping down to western edge of trench. A small cut in bottom appeared to be a spade mark. Filled with a soft mid grey and orange/brown mottled, slightly sandy, silty clay with occasional pebbles, burnt clay flecks and one piece of tile. [006] was cut into bands of orange/brown natural sands and gravels. Cut for gravel extraction sloped down towards the east, and was backfilled with mixed bands of compacted gravels and clays. Ground level: 17.57m.

Trench F: No archaeological features. Approx. 0.40m of topsoil overlay a leached 'B' horizon of moderately compact mid orange/brown silty,sandy clay with occasional flint gravels - maximum height:17.50m. Below this at a depth of 17.17m was natural pale/mid brown sandy clay with frequent lenses of pea grit. Features observed in the natural proved to be tree boles and periglacial features. Ground level: 17.90m.

Trenches G and H: No archaeological features. Quarrying had cut into subsoils to adepth of 14.40m in trench G, and 14.71m in trench H. A thin layer of topsoil <0.06m covered backfill of thick layers of gravels and silty clays. Ground level trench G: 15.68m, trench H: 15.53m.

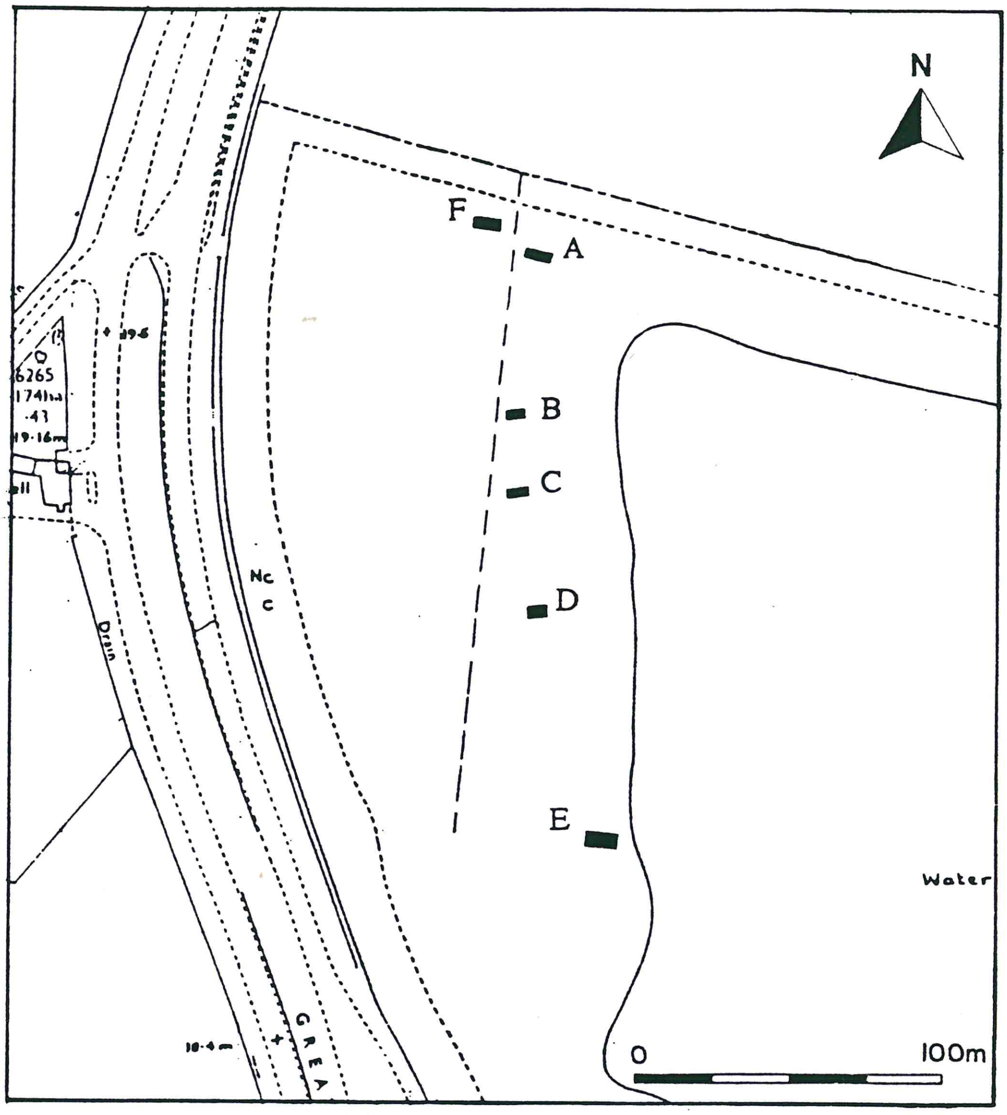


Figure 3: Area 1, Trench Plan.

AREA 2

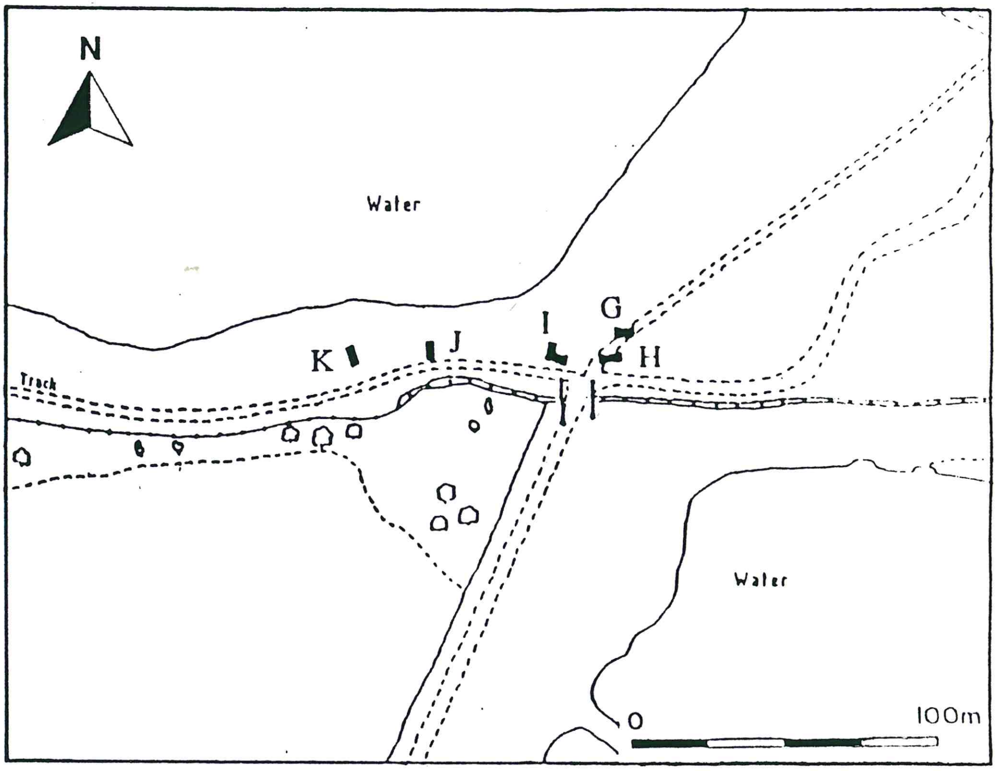


Figure 4: Area 2, Trench Plan.

Trench I: Cut [008], Fill (007). Parallel straight-sided linear cut running east-west and continuing beyond the edge of excavation. Top truncated by quarrying. Sides sloped steeply towards a slightly concave base, which sloped slightly to the east. Maximum depth 0.70m. A length 3.60m was excavated, and the trench extended to reveal, and plan, another 5.30m.*[Fig. 6]* ..Ditch appeared to narrow slightly towards the east. Filled with a greenish grey silty, sandy clay, which became almost pure clay towards the bottom, and contained decayed bone and pottery dated to the 1st century AD. A fragment of quern stone *[Fig. 7]* and a fragment possibly of lower quern stone were found at the base of the fill.

Cut [011], Fill (010). Linear cut running east-west and lying to the north of [008]. North edge destroyed by machining, cut appears to end 2.20m. from the western edge of trench. Filled by a silty clay heavily disturbed by machining. No finds.

Cut [013], Fill (012). shallow sub-circular feature running into east-facing section. Very truncated and disturbed from above by quarrying. No finds. East-facing section showed 2 cuts for gravel extraction, sloping down towards the south and north, and backfilled with bands of dark sandy silt containing organic matter, silty clays and gravels. Ground level: 16.13m.

Trenches J and K: No archaeological features. Quarrying had cut into natural gravels to a depth of 15.05m in trench J, and 15.37m in trench K. Both trenches were backfilled with layers of sandy, clayey silts overlying layers and lenses of redeposited gravels. Ground level trench J: 16.45m, trench K: 16.72m.

AREA 3

Topsoil in all test pits was a sandy loam. Each test pit was given one context number for all backfilled/reinstated deposits.

Test Pit A, [context 14]: No archaeological features. Topsoil 0.45m deep covered a highly compacted orange/brown clayey,sandy gravel containing Post Medieval pot, brick, tile and clay pipe. Excavated to a depth of 0.90m, backfill continued below .

Test Pit B, [context 15]: No archaeological features. Approx 0.35m of topsoil covered a backfill of dark yellowish brown, silty clay loam with lenses of gravel. Deposit contained modern debris including plastic. Excavated depth: 0.80m, backfill continued below.

Test Pit C, [context 16]: No archaeological features. 0.25m of topsoil lay over 0.75m of orange/ brown and grey /brown sandy, silty clay with gravel lenses. At a depth of 0.90m was a grey,very coarse natural sand with frequent coarse stones and occasional lenses of dark grey clay. Water table was reached at a depth of 1.0m and excavation abandoned.

Test Pit D, [context 17]: No archaeological features. 0.15m of topsoil covered highly compacted, dark yellowish brown, silty clay loam with gravel lenses. Excavation stopped at a depth of 0.85m due to compaction. Layer continued below this level.

Test Pit E, [context 18]: No archaeological features. 0.35m of topsoil lay over orange brown silty clay to a depth of 0.75m overlying dark brown, clayey sand to a depth of 1.20m. Modern brick found in all layers plus one fragment of pot.This overlay a mixed dark grey clay, with lenses of gravel and black organic clay with grass. Water table was reached at this level and excavation abandoned.

Test Pit F, [context 19]: No archaeological features. 0.25m of topsoil over an orange/grey brown, silty clay mixed with grey clay/silt towards the bottom. Gravel lenses throughout. Below lay a sandy gravel, reached at a depth of 1.0m .Water table lay at this depth and excavation stopped.

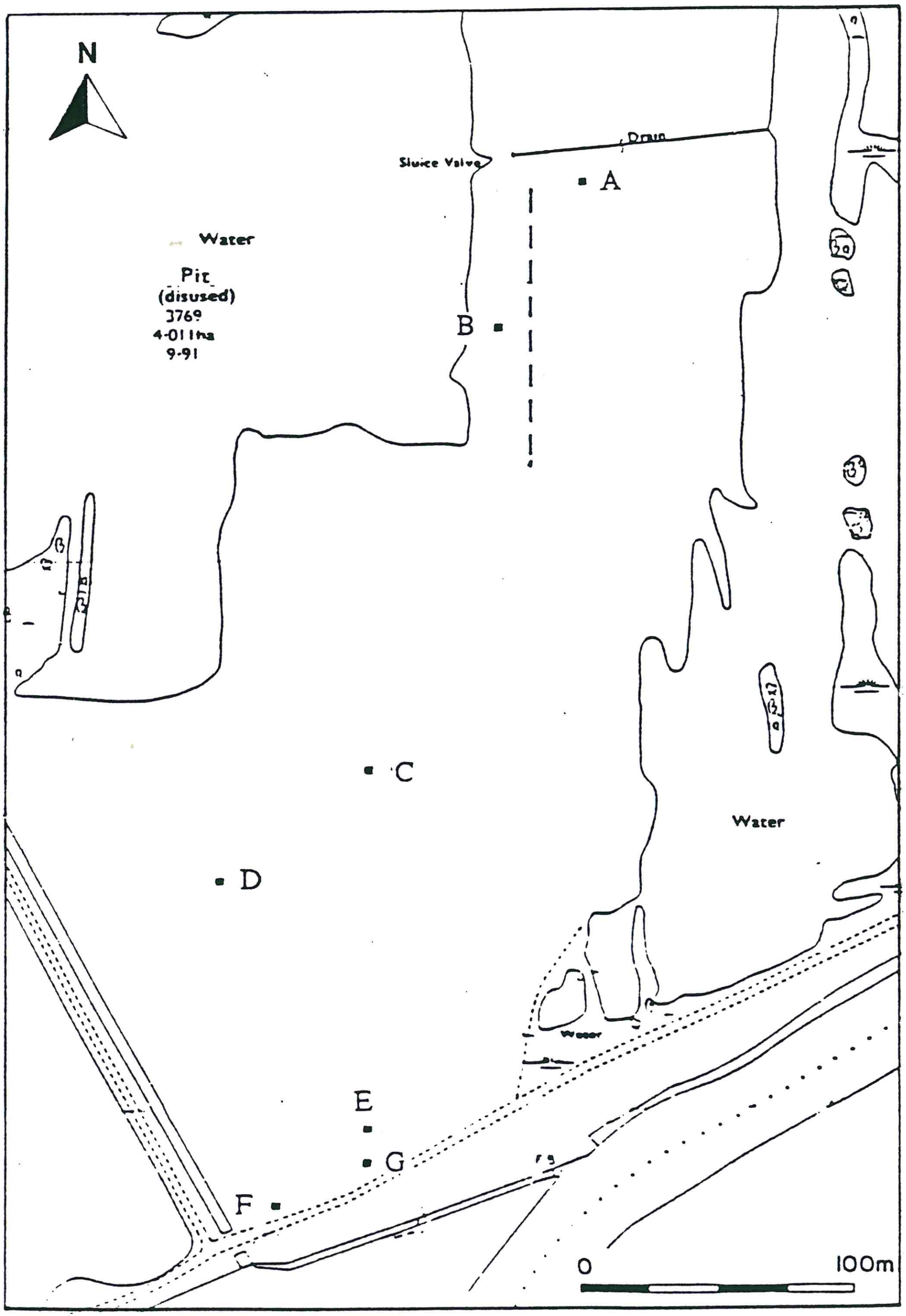


Figure 5: Area 3, Test Pits

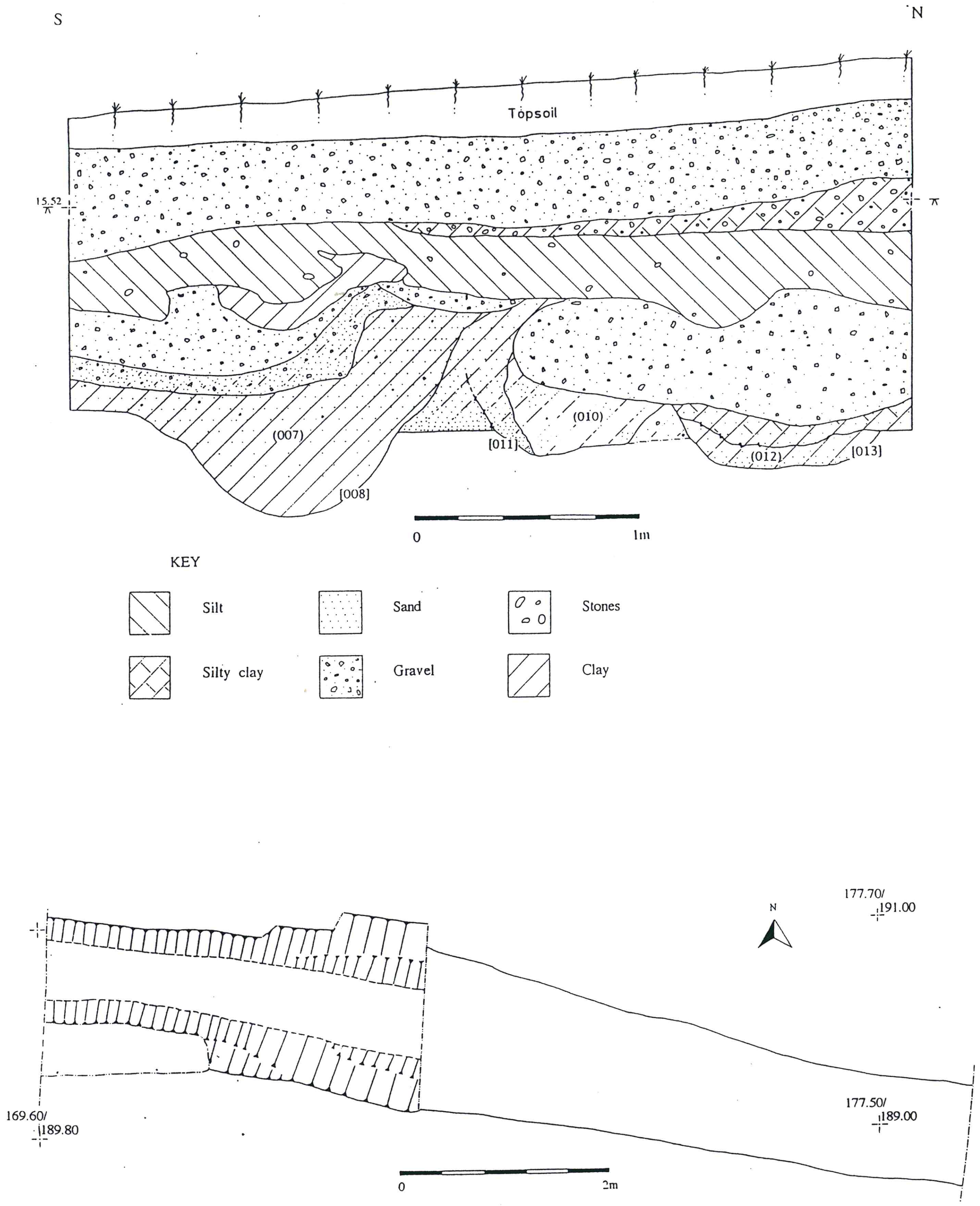


Figure 6: Trench I. Section and Plan of Ditch 008.

Figure 7: Photograph of Quern Stone.

Discussion

In Areas 1 and 2, trenching indicated that the edges of the artificial lakes did not represent the edges of the area disturbed by gravel extraction. In Area 1 a degree of 'landscaping' was evident to the naked eye, and trenches A- E showed extensive dumping of material to raise the ground level of most of the area. Only trench F, lying at the north end of the field, and furthest away from the lake edge, cut through undisturbed strata. In the other trenches, gravel quarrying had destroyed almost everything above natural sands and gravels, and no evidence of features recorded in APs appeared to survive.

In Area 2, gravel quarrying had also destroyed almost all deposits. The presence of features in Trench I, was the result of a lucky survival of deposits between 2 machine scoops, although more of ditch [008] may have existed beyond the limit of excavation. The ditch appears to be substantial, even in it's truncated form, and could represent a property, or settlement boundary.The nature of the ditchfill indicates a fairly rapid, naturally occurring, silting up, with no indications of attempts to recut the ditch to it's original depth. The pottery from the ditchfill may be of pre-conquest date, as all the pottery was locally made, with no Roman material, except for the sherds of amphora, of a type that has been commonly found in Cambridgeshire in pre-conquest contexts, and is possibly of Spanish manufacture. [Gavin Lucas pers. comm.] The ditch may have been made redundant by a change of land ownership or use, possibly as aconsequence of Roman conquest. The two other features in Trench I: [011] and [013] were so damaged by quarrying that interpretation was impossible.

In Area 3 the test pits suggested all deposits had been quarried away, a conclusion borne out by consultation with Mr. Ron Foster of Redlands Ltd who said quarrying had taken place in this area circa 1962.

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Also many thanks to all the staff at Cambridgeshire Archaeology who worked on this project.

Glossary of Archaeological terms

Anglo-Saxon. The period dating between the withdrawal of the Roman legions in 410 and the Norman invasion of 1066. Within this period several ethnic groups from northern Europe vied for control of the British Isles, including the Angles, Saxons, Jutes, Danes, and Norwegians. The latter two groups are collectively known as the Vikings and became involved in British politics from the eighth century, later than the others. The Vikings were successful in occupying a large part of the north and Midlands of England, before providing a King (Cnut) for the whole of England. For most of this time England was divided up into several kingdoms until Saxon resistance to Viking incursions led to the unification of England under Aethelstan and Alfred.

Artefact. Any object made by people. Generally, this word is used for finds such as pottery, stone tools, or metal objects, but it can be used in a much wider context in that the landscape we have today is a product of human activity and is thus an artefact itself.

Bronze Age. Prehistoric period c. 2000 - 700 BC when bronze was used for many types of tools and weapons.

Cropmarks. Archaeological features below the ploughsoil can affect the growth of sensitive crops through moisture retention or loss. For example, the growth of cereal crops over buried ditches or pits will encourage rapid growth leading to tall, dark coloured plants, whereas walls and roads will lead to stunting and faster yellowing of the crop. These discrepancies in crop growth can be easily detected from the air, and by taking photographs the cropmark patterns can be plotted onto maps and given provisional interpretation.

Enclosures. An area defined by a continuous surrounding ditch. These may be enclosures around human settlements, fields, or paddocks for stock. Rectilinear enclosures are ones with straight sides and corners, whilst curvilinear enclosures are ones with rounded sides.

Geophysical Survey. Investigation of changes occuring in the magnetic and electrical characteristics of the soil, which can often be induced by human activity.

Iron Age. Prehistoric period c. 700 BC - AD 43 when iron was used extensively for tools and weapons. The period traditionally ends with the Roman invasions of AD 43 but in fact there was a considerable time of adjustment after this date when the Iron Age way of life continued with little change from Roman influence.

Medieval. Historic period that begins with William the Conqueror's invasion in 1066. Post-Medieval is generally considered to date from 1500.

Neolithic. Prehistoric period c. 3500 - 2000 BC when farming and pottery were introduced. Stone tools of fine workmanship were produced and exchanged over long distances, but before the use of metals.

Ridge and Furrow. Medieval cultivation techniques led to a phenomenon of corrugated fields. Strips of land were allotted to individuals and a furrow was left between one person's strip and the next, leading to a corrugated ridge and furrow effect. Ridge and furrow shows up as cropmarks on air photographs and more rarely as earthworks in pasture fields.

Ring-ditch. A continuous circular ditch which is all that remains of a ploughed out round barrow, or the drainage ditch (eavesdrip gully) that surrounded a round-house.

Roman. Historic period AD 43 - 410 when much of Britain was part of the Roman empire. The term Romano-British is now widely used to describe the people of this period, as few were Roman themselves, but they were a provincial manifestation of the empire developing in a unique way. AD 410 was the date the legions were withdrawn, but the Romano-British culture continued for some time into the 5th century in tandem with Anglo-Saxon migration.

Round barrow. A Bronze Age burial mound formed by heaping up earth over a central burial. They have several forms, including numbers of encircling ditches and can have many burials in them. The first burial is known as the primary burial, subsequent ones are referred to as secondary burials. It has been suggested that these burial mounds are a way of marking tribal territories, and tney are often placed in prominent locations. They can occur in clusters known as 'barrow cemetries'.

REPORT ON GEOPHYSICAL SURVEY

PAXTON PITS NATURE RESERVE

Report Number 92/55

Work commissioned by :

Cambridgeshire County Council

Geophysical Surveys of Bradford

The Old Sunday School, Kipping Lane,
Thornton, Bradford BD13 3EL
Telephone (0274) 835016
Fax (0274) 830212

SITE SUMMARY SHEET

92 / 55 Paxton Pits Nature Reserve
Diddington

NGR: TL 196 635 (approx)

Location and topography

The site lies directly east of the A1, adjacent to the village of Little Paxton and approximately 3 km south of Diddington. The ground is fairly level rough grassland and the underlying geology comprises sands and gravels.

Archaeology

There is a variety of archaeological information for this area, drawn from APs, excavation and stray finds. Immediately to the east of the current survey (in an area now lying mostly underwater) is a series of linear cropmarks. Excavations in this area revealed evidence of Iron Age and Romano-British occupation (Greenfield, 1969), while excavations to the west of the current grid uncovered prehistoric and Late Saxon occupation levels (Addyman, 1969). Three individual features - a ring ditch, a single burial and a group of burial urns - were located to the north of the survey area (*ibid*).

Aims of Survey

A magnetic susceptibility survey was carried out, as part of a wider archaeological assessment, in advance of a proposed water main running through the site. The aim of the survey was to locate any general areas of archaeological activity at the site. The technique and methodology chosen for this evaluation does not purport to identify individual features.

Summary of Results *

The survey has revealed several areas of increased susceptibility. Some of these are likely to be caused by modern disturbance and/or geological changes. However there are four particular areas for which an archaeological interpretation is tentatively offered.

*** It is essential that this summary is read in conjunction with the detailed results of the survey.**

SURVEY RESULTS

92 / 55 Paxton Pits Nature Reserve
Diddington

1. Survey Area

1.1 The sample area covered just over 3.5 hectares and soil samples were taken at 20m intervals using a grid system, as shown in figure 1.

1.2 The survey grid was set out by **Geophysical Surveys of Bradford** using an existing baseline established and tied in by **Cambridgeshire Archaeology** (CA).

2. Display

2.1 The results are displayed in two formats:- 3D mesh and contour plots. These display formats are discussed in the *Technical Information* section, at the end of the text.

2.2 For the purpose of data presentation, each value is plotted as the centre point of a 20m grid.

2.3 Data plots (Figures 2 & 3) are produced at a scale of 1:2500 and an annotated interpretation diagram (Figure 4) at the same scale is also included.

3. General Considerations - Complicating factors

3.1 The site presented no hindrance to the collection of samples, although thick vegetation around the perimeter of the field prevented coverage of these areas

3.2 It was noted that in the southern half of the field, the soils became progressively less sandy, with increased clay content; and this is reflected in the survey results.

4. Method and Results

4.1 The ground was deturfed and soil samples collected from beneath the surface. These were dried and crushed, and stone and organic matter removed. They were then weighed into 50g samples and measured in the laboratory on an AC Susceptibility Bridge. All values are in emu/g x 10^{-6}.

4.2 For data presentation, the plotting intervals are the mean and the mean plus one standard deviation (after Gurney, 1985).

4.3 The geological change noted in paragraph 3.2 above can clearly be seen in the contour plot (Figure 3), showing a general rise in susceptibility values in the southern half of the survey area.

4.4 A drain runs along the extreme northern edge of the survey area and the high values at (A) may reflect the disturbance caused by its construction.

4.5 A series of peaks (B) running north-south along the proposed pipeline route may be archaeologically significant: however since they lie at the limit of the survey area, no definite interpretation can be given.

4.6 The peak at (C) is generated by one sample and is associated with surface burning nearby. It is therefore unlikely to be archaeological in origin.

4.7 In the southern half of the survey grid there are four relatively large areas of enhancement (D to G). These may a product of geological changes or localised natural variations in susceptibility: alternatively they may be caused by anthropogenic/archaeological activity. The mean susceptibility value for this data set (18.39 emu/g x 10^{-6}) is fairly typical of background values on gravel sites (see Tite & Mullins, 1971) and this would support an archaeological interpretation.

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5. Magnetic Scanning

5.1 Although not included in the original project brief, a small amount of scanning was carried out using a fluxgate gradiometer. Three traverses were made, in the northern part of the survey area; two running north-south and one east-west.

5.2 The traverse along the eastern edge of the grid revealed a number of ferrous peaks and several anomalies of possible anthropogenic origin.

5.3 The second traverse ran along the western edge of the site. The northwestern corner was particularly disturbed (possibly by construction of the drain). The remainder of the traverse was relatively quiet.

5.4 The third traverse, running east-west approximately 100m south of the field boundary, produced tentative evidence of archaeology: approximately half way along the line a few small pit-like anomalies were noted.

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6. Conclusions

The magnetic susceptibility sampling has located several areas of possible archaeological significance, in the southern half of the survey area. Because of the large sampling interval, the survey was unlikely to locate individual features and any anomalies noted indicate broader areas of possible archaeological activity.

Project Co-ordinators: D Redhouse & C Stephens
Project Assistant: D Shiel, A Shields

August 1992
Geophysical Surveys of Bradford

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Appendix 1

92/55 Paxton Pits Nature Reserve
Magnetic Susceptibility Data

y	x	emu/g x 10^{-6}
10.5	9.5	20
11.5	9.5	21
12.5	9.5	22
13.5	9.5	20
10.5	10.5	18
11.5	10.5	22
12.5	10.5	25
13.5	10.5	23
14.5	10.5	22
15.5	10.5	20
9.5	11.5	21
10.5	11.5	23
11.5	11.5	20
12.5	11.5	19
14.5	11.5	22
15.5	11.5	23
16.5	11.5	26
17.5	11.5	24
6.5	12.5	13
7.5	12.5	no sample/ dummy reading
8.5	12.5	18
9.5	12.5	20
11.5	12.5	19
12.5	12.5	17
13.5	12.5	23
14.5	12.5	22
15.5	12.5	18
16.5	12.5	21
17.5	12.5	22
6.5	13.5	12
7.5	13.5	17
8.5	13.5	22
9.5	13.5	19
10.5	13.5	29
11.5	13.5	28
12.5	13.5	20
13.5	13.5	20
14.5	13.5	21
15.5	13.5	22
16.5	13.5	21
17.5	13.5	29
18.5	13.5	28
6.5	14.5	15
7.5	14.5	17
8.5	14.5	19

y	x	emu/g x 10^{-6}
9.5	14.5	20
10.5	14.5	20
11.5	14.5	19
12.5	14.5	19
13.5	14.5	20
14.5	14.5	21
15.5	14.5	18
16.5	14.5	20
17.5	14.5	23
6.5	15.5	15
7.5	15.5	14
8.5	15.5	16
9.5	15.5	14
10.5	15.5	12
11.5	15.5	19
12.5	15.5	19
.5	16.5	22
1.5	16.5	22
2.5	16.5	9
3.5	16.5	13
4.5	16.5	13
5.5	16.5	18
6.5	16.5	10
7.5	16.5	14
8.5	16.5	23
9.5	16.5	13
10.5	16.5	12
11.5	16.5	13
.5	17.5	28
1.5	17.5	16
2.5	17.5	13
3.5	17.5	15
4.5	17.5	16
5.5	17.5	12
6.5	17.5	14
7.5	17.5	12
8.5	17.5	10
9.5	17.5	13
10.5	17.5	11
.5	18.5	16
1.5	18.5	18
2.5	18.5	16
3.5	18.5	12
4.5	18.5	15
5.5	18.5	17
6.5	18.5	12

y	x	emu/g x 10^{-6}
7.5	18.5	12
.5	19.5	26
1.5	19.5	19
2.5	19.5	14
3.5	19.5	21
4.5	19.5	17

Appendix 2

Magnetic Susceptibility and Viscosity in Archaeology

1 Magnetic Susceptibility

1.1 Definition

The magnetic susceptibility (χ) of a soil is an expression of the ratio of the strength of the magnetisation induced in a sample when a magnetic field is applied, and the strength of the applied magnetic field. The induced magnetisation is a consequence of the interaction between the applied field and the magnetic moments resulting from the movement of the charged particles around individual atoms. It may be seen that χ is a measurement of the reaction of individual atoms to an applied magnetic field. For archaeological purposes, magnetic susceptibility is often measured in emu/g, because it is most convenient to consider susceptibility as a mass specific function. However, it is also normal to use Systeme Internationale units

1.2 Susceptibility enhancement

The use of magnetic susceptibility as a prospection technique is possible because of variations in the magnetic susceptibility of a soil throughout its history. Generally, subsoils exhibit very low values of χ and topsoil is usually enhanced to a greater or lesser degree, while archaeological features may often have a greater value. (Tite & Mullins 1971). The maximum susceptibility of a soil may be found by heating the sample to 550° C in a nitrogen-then-air atmosphere to give a value χ_N. Tite and Mullins (1971) noted that χ_N is proportional to the percentage weight of ferric oxide within the soil sample. However, given the nature of human activity, this maximum value is unlikely to encountered in the field. It has been shown that the enhancement of magnetic susceptibility in soils is a consequence of the operation of several processes, rather than simply a mechanism by which the concentration of iron oxide in the soil is increased. The enhancement of susceptibility values is primarily a result of the conversion of haematite to maghaemite by redox reactions, the appropriate conditions for which may occur as a result of a number of processes (Le Borgne 1955):

haematite		magnetite		maghaemite
	---- reduction ---->		---- oxidation ---->	
(αFe_2O_3)		(Fe_3O_4)		(γFe_2O_3)

However, other reactions can lead to susceptibility enhancement, for example the dehydration of Lepidocrocite ($\gamma FeOOH$) which occurs when poorly-drained soil is subjected to burning (Skinner 1990)

1.21 Geological origin

As noted above, the magnetic susceptibility of a soil is initially dependent upon its content of ferric oxide. This is a function of the geological origin of the soil. For example, those based on chalk or limestone geologies will typically exhibit very low susceptibilities in the subsoil, because of the absence of iron within the geology. Where the soils are deposited by fluvial, pluvial or aeoloian processes, the length of time for which the soil is exposed and subject to weathering before the deposit is sealed will also effect the soil susceptibility.

1.22 Pedogenic activity

Various geochemical factors contribute towards the weathering of soils, and many of these will result in an alteration of the soils susceptibility. For example, leaching may result in the removal of iron oxide from the soil. Naturally occurring redox reactions will also change the susceptibility values and it has been suggested that wetting and drying will have a similar effect (Le Borgne 1955;Allen 1990). Fassbinder et al (1990) have reported the presence of magnetic bacteria in soils, but noted that they appeared to have little effect on the measurable magnetic characteristics of such soils.

1.23 Anthropogenic activity

It is because human activity causes susceptibility enhancement that this technique can be used in an archaeological context. Le Borgne (1955) suggested two cultural mechanisms for susceptibility enhancement. The primary mechanism is heating, usually caused by fires, because it promotes the occurrence of redox reactions resulting in the conversion of haematite and magnetite to maghaemite. Industrial activity, such as the use of kilns will result in even greater enhancement. The second effect was described as a fermentation process, whereby the decay of excrement, urine and rubbish in the wet, anaerobic conditions caused the necessary redox reactions to alter haematite to maghaemite. Allen (1990) has suggested that trampling and puddling associated with occupation will also cause a degree of magnetic enhancement.

2 Magnetic viscosity

2.1 Definition

Magnetic viscosity (V) is an expression of the ratio between the component of susceptibility that is 90^{o} out of phase with the alternating field used for susceptibility measurement and the AC (or 'in-phase') susceptibility of a soil sample. It is expressed as a percentage value. Upon application of a magnetic field to the soil sample, there is a time delay between the application of the field and occurrence of the induced field. The speed with which the atoms respond to the applied field is dependent upon the size of the constituent magnetic grains. Smaller grains will respond to the applied field more quickly than larger ones and they are said to be less viscous.

2.2 Alteration of viscosity

Past industrial activity will result in smaller magnetic grains within the soil sample. This will give a lower value for V and consequently a low magnetic viscosity may be indicative of past industrial activity. By combining V and χ, usually in the form of a scattergram, areas of past industrial activity may be more easily identifiable because they will typically exhibit low values of V in association with high values of χ.

3 Sampling

For archaeological purposes, soil samples are collected in the field, either from individual contexts (including topsoil and subsoil where possible) or on a grid system with a typical sample interval of five, ten or fifteen metres. The samples are then dried, crushed and sieved through a two millimetre mesh. After weighing out fifty gramme samples and placing them in individual plastic bottles, magnetic susceptibility is determined using an AC Susceptibility Bridge, calibrated using samples of known mass and χ. Measurements of magnetic viscosity are made using a Pulsed Induction Meter (PIM). The readings given by this instrument are proportional to quadrature susceptibility, from which V may be calculated. The values thus obtained may be displayed graphically or simply related to the contexts from which the samples were taken.

4 Interpretation

Because other factors beside anthropogenic activity will cause susceptibility enhancement or viscosity alteration, it is necessary to obtain background readings. This can be done either by sampling subsoil and topsoil when examining individual contexts, or by extending a grid system beyond the probable limit of the site. It is not possible to attribute absolute values to different types of archaeological context, even when the geology is uniform, i.e. the enhancement of susceptibility can vary tremendously due to variations in the nature and intensity of activity. As with magnetometry, archaeological interpretation of susceptibility data relies on the examination of contrasts within the data set. It has been shown (Reynolds 1976 cited in Clark 1983; Odell & Cowan 1987) that ploughing does not always result in extensive horizontal displacement of artefacts and archaeological remains. Although the morphology of features may be destroyed, the magnetically enhanced soils of which they consisted will have been brought up into the ploughsoil, but not widely distributed. Consequently, although the susceptibility of the archaeological deposits will be diluted by that of the topsoil, a contrast in the enhancement of the surrounding topsoil should be detectable (Clark 1990). The results of topsoil surveys using susceptibility and viscosity measurements may be seen at Guiting Power (Gaffney et al forthcoming) and Coneybury Henge (Clarke 1990).

Conclusion

Magnetic susceptibility may be used as a non-invasive prospection technique to assist the determination of site and area function, which in conjunction with magnetic viscosity readings will often give an indication of the nature and intensity of activity. Susceptibility measurements can be applied to exposed contexts in order to examine the probable responses of features to magnetometry. The technique can also be applied to paleoenvironmental questions, but such studies are usually outside the remit of evaluation reports.

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TECHNICAL INFORMATION

The following is a description of the equipment and display formats used in **GEOPHYSICAL SURVEYS OF BRADFORD** reports. It should be emphasised that whilst all of the display options are regularly used, the diagrams produced in the final reports are the most suitable to illustrate the data from each site. The choice of diagrams results from the experience and knowledge of the staff of **GEOPHYSICAL SURVEYS OF BRADFORD**.

All survey reports are prepared and submitted on the basis that whilst they are based on a thorough survey of the site, no responsibility is accepted for any errors or omissions.

Magnetic readings are logged at 0.5m intervals along one axis in 1m traverses giving 800 readings per 20m x 20m grid, unless otherwise stated. Resistance readings are logged at 1m intervals giving 400 readings per 20m x 20m grid. The data are then transferred to portable computers and stored on 3.5" floppy discs. Field plots are produced on a portable Hewlett Packard Thinkjet. Further processing is carried out back at base on computers linked to appropriate printers and plotters.

Instrumentation

(a) Fluxgate Gradiometer - Geoscan FM36

This instrument comprises of two fluxgates mounted vertically apart, at a distance of 500mm. The gradiometer is carried by hand, with the bottom sensor approximately 100-300mm from the ground surface. At each survey station, the difference in the magnetic field between the two fluxgates is conventionally measured in nanoTesla (nT) or gamma. The fluxgate gradiometer suppresses any diurnal or regional effects. Generally features up to one metre deep may be detected by this method.

(b) Resistance Meter - Geoscan RM4 or RM15

This measures the electrical resistance of the earth, using a system of four electrodes (two current and two potential.) Depending on the arrangement of these electrodes an exact measurement of a specific volume of earth may be acquired. This resistance value may then be used to calculate the earth resistivity. The "Twin Probe" arrangement involves the paring of electrodes (one current and one potential) with one pair remaining in a fixed position, whilst the other measures the resistance variations across a fixed grid. The resistance is measured in Ohms and the calculated resistivity is in Ohm-metres. The resistance method as used for area survey has a depth resolution of approximately 0.75m, although the nature of the overburden and underlying geology will cause variations in this generality. The technique can be adapted to sample greater depths of earth and can therefore be used to produce vertical "pseudo sections".

(c) Magnetic Susceptibility

Variations in the magnetic susceptibility of subsoils and topsoils occur naturally, but greater enhanced susceptibility can also be a product of increased human/anthropogenic activity. This phenomenon of susceptibility enhancement can therefore be used to provide information about the "level of archaeological activity" associated with a site. It can also be used in a predictive manner to ascertain the suitability of a site for a magnetic survey. The instrument employed for measuring this phenomenon is either a field coil or a laboratory based susceptibility bridge. For the latter 50g soil samples are collected in the field.

Display Options

The following is a description of the display options used. Unless specifically mentioned in the text, it may be assumed that no filtering or smoothing has been used to enhance the data. For any particular report a limited number of display modes may be used.

(a) X-Y Plot

This involves a line representation of the data. Each successive row of data is equally incremented in the Y axis, to produce a stacked profile effect. This display may incorporate a hidden-line removal algorithm, which blocks out lines behind the major peaks and can aid interpretation. Advantages of this type of display are that it allows the full range of the data to be viewed and shows the shape of the indiviual anomalies. Results are produced on a flatbed plotter.

(b) Dot-Density

In this display, minimum and maximum cut-off levels are chosen. Any value that is below the minimum cut-off value will appear white, whilst any value above the maximum cut-off value will appear black. Any value that lies between these two cut-off levels will have a specified number of dots depending on the relative position between the two levels. The focus of the display may be changed using different levels and a contrast factor (C.F.). Usually the C.F. = 1, producing a linear scale between the cut-off levels. Assessing a lower than normal reading involves the use of an inverse plot, This plot simply reverses the minimum and maximum values, resulting in the lower values being presented by more dots. In either representation, each reading is allocated a unique area dependent on its position on the survey grid, within which numbers of dots are randomly placed. The main limitation of this display method is that multiple plots have to be produced in order to view the whole range of the data. It is also difficult to gauge the true strength of any anomaly without looking at the raw data values. This display is much favoured for producing plans of sites, where positioning of the anomalies and features is important.

(c) Contour

This display joins data points of an equal value by a contour line. Displays are generated on the computer screen or plotted directly on a flat bed plotter / inkjet printer.

(d) 3-D Mesh

This display joins the data values in both the X and Y axis. The display may be changed by altering the horizontal viewing angle and the angle above the plane. The output may be either colour or black and white. A hidden line option is occasionally used (see (a) above).

(e) Grey-Scale

This format divides a given range of readings into a set number of classes. These classes have a predefined arrangement of dots or shade of grey, the intensity increasing with value. This gives an appearance of a toned or grey scale.

Similar plots can be produced in colour, either using a wide range of colours or by selecting two or three colours to represent positive and negative values. While colour plots can look impressive and can be used to highlight certain anomalies, grey-scales tend to be more informative.

Paxton Pits Nature Reserve
Grid Location Diagram

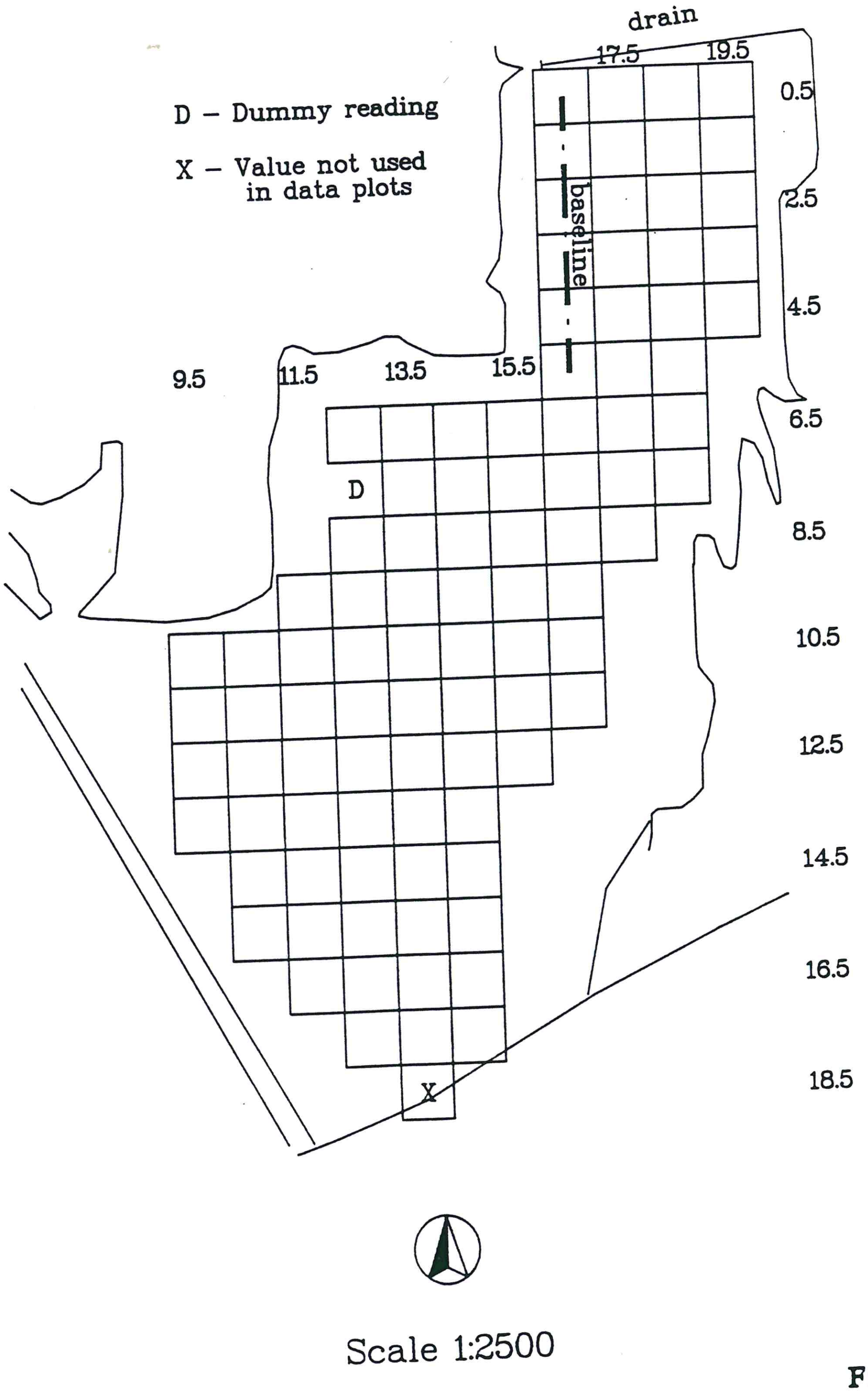
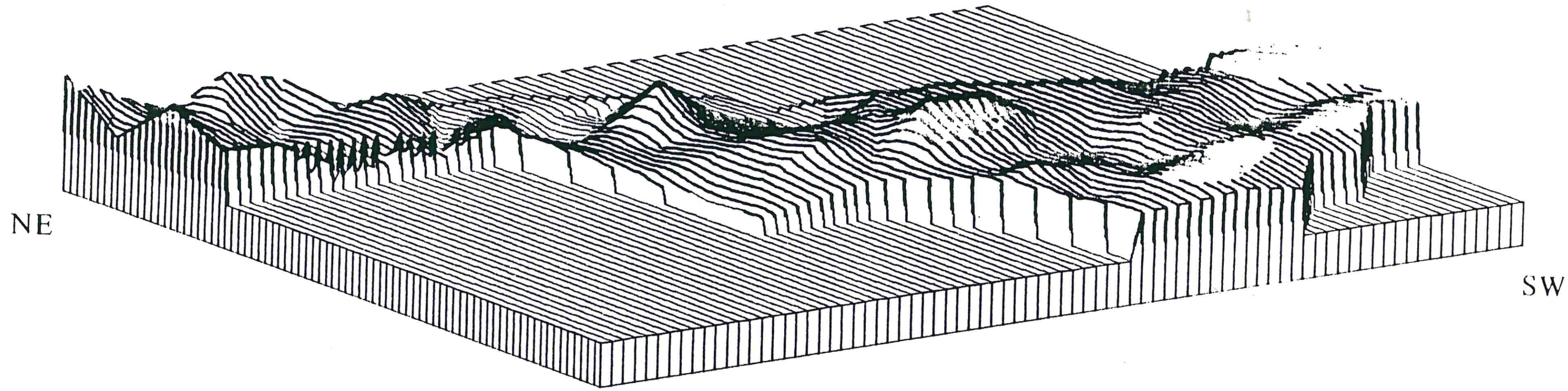


Figure 1

Paxton Pits Nature Reserve
3D Mesh



Magnetic Susceptibility Data

Figure 2

Paxton Pits Nature Reserve
Contour Plot

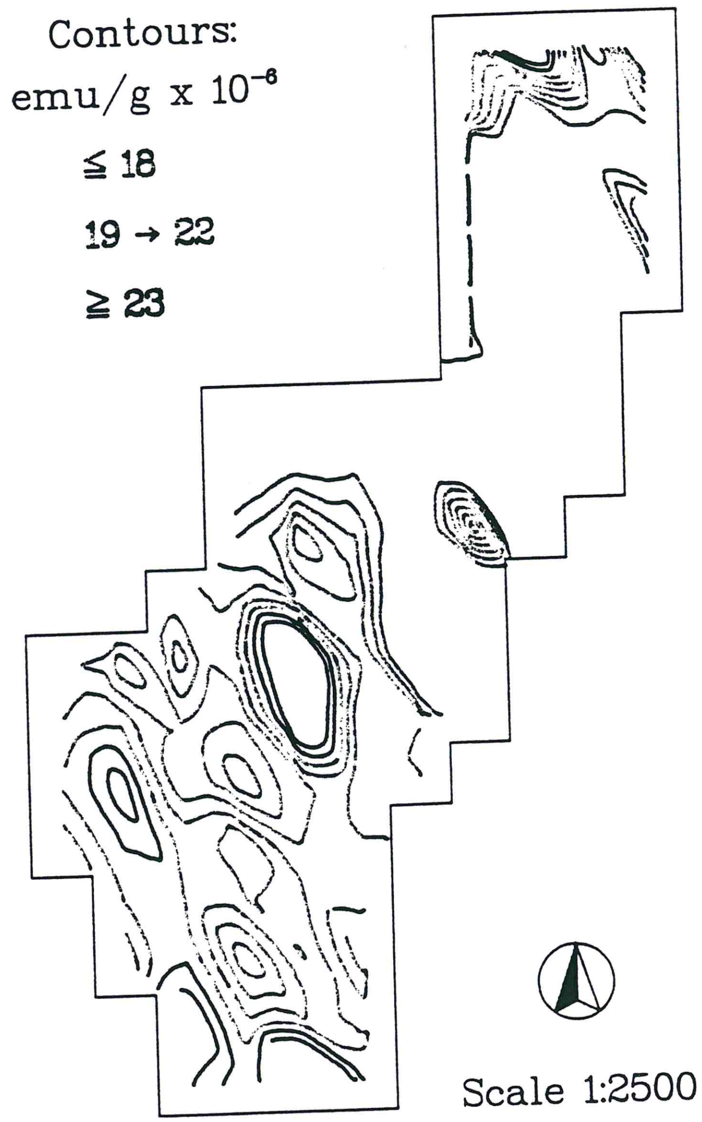


Figure 3

Paxton Pits Nature Reserve
Interpretation

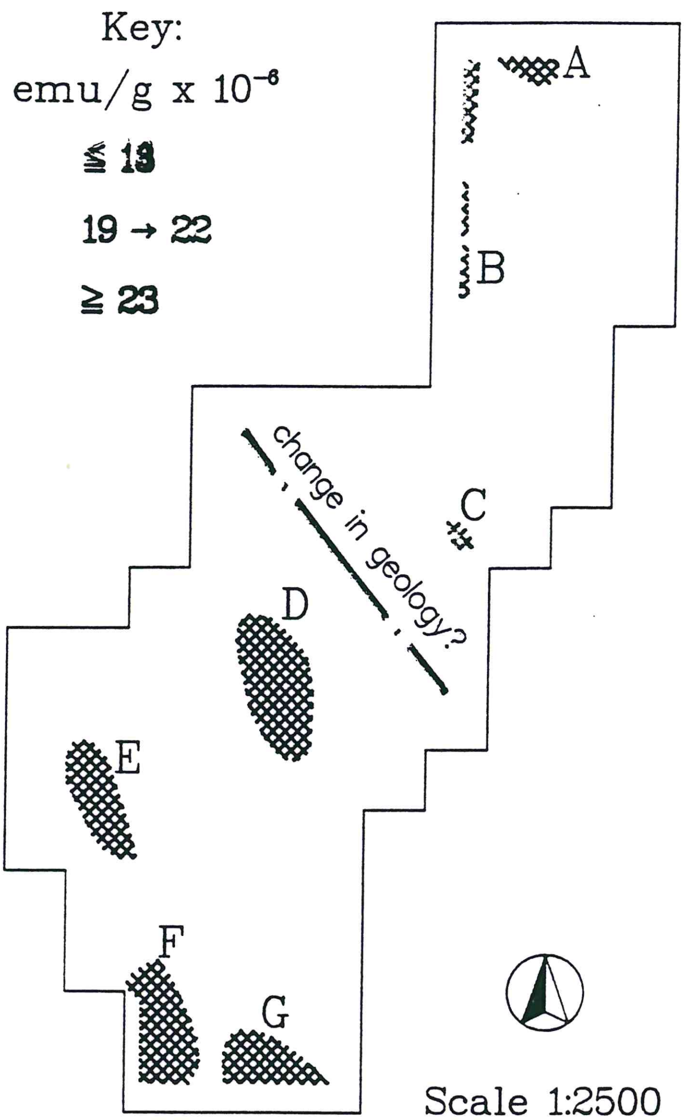


Figure 4