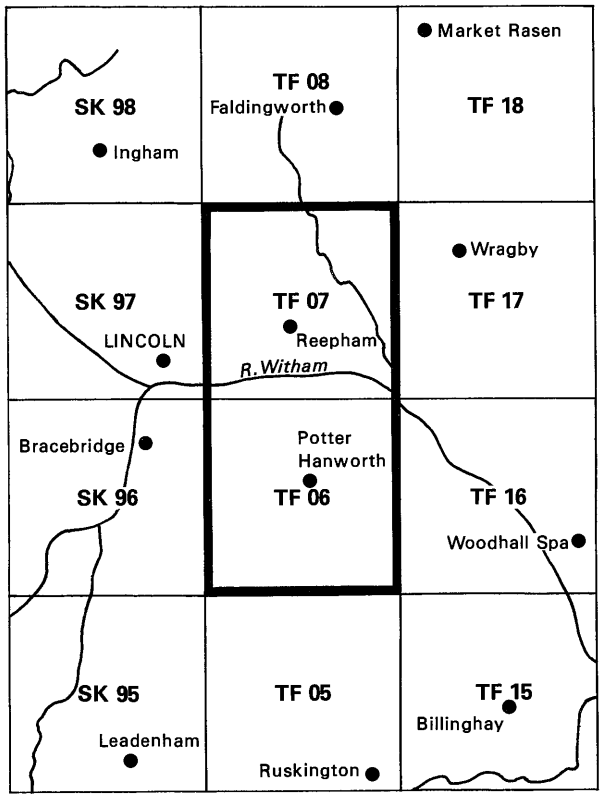
INSTITUTE OF GEOLOGICAL SCIENCES

Natural Environment Research Council

Mineral Assessment Report 96



The sand and gravel resources of the country around Potter Hanworth and Reepham, Lincolnshire

Description of 1:25 000 sheets TF 06 and 07

R. G. Crofts

ISBN 0 11 884219 6

London Her Majesty's Stationery Office 1982

The first twelve reports on the assessment of British sand and gravel resources appeared in the Report Series of the Institute of Geological Sciences as a subseries. Report No. 13 and subsequent reports appear as Mineral Assessment Reports of the Institute.

Details of published reports appear at the end of this Report.

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PREFACE

National resources of many industrial minerals may seem so large that stocktaking appears unnecessary, but the demand for minerals and for land for all purposes is intensifying and it has become increasingly clear in recent years that regional assessments of the resources of these minerals should be undertaken. The publication of information about the quantity and quality of deposits over large areas is intended to provide a comprehensive factual background against which planning decisions can be made.

Sand and gravel, considered together as naturally occurring aggregate, was selected as the bulk mineral demanding the most urgent attention, initially in the south-east of England, where about half the national output is won and very few sources of alternative aggregates are available. Following a short feasibility project, initiated in 1966 by the Ministry of Land and Natural Resources, the Industrial Minerals Assessment Unit (formerly the Mineral Assessment Unit) began systematic surveys in 1968. The work is now being financed by the Department of the Environment and is being undertaken with the cooperation of the Sand and Gravel Association of Great Britain.

This report describes the resources of sand and gravel of 200 km^2 of country around Potter Hanworth and Reepham, Lincolnshire, shown on the accompanying 1:25 000 resource sheet TF 06 and 07. The survey was conducted by I. Jackson who was assisted in the drilling and sampling programme by J. B. L. Wild. The work is based on one-inch scale geological surveys carried out in 1878, partly revised on the six-inch scale in 1937, 1941 and 1980, and provisionally published in part at 1:50 000 as New Series-Sheet 114 (Lincoln).

J. D. Burnell ISO, FRICS (Land Agent) was responsible for negotiating access to land for drilling. The ready cooperation of landowners, tenants, Lincolnshire County Council and the Anglian Water Authority is gratefully acknowledged.

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1 October 1981

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The sand and gravel resources of the country around Potter Hanworth and Reepham, Lincolnshire

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R. G. CROFTS

SUMMARY

The geological maps of the Institute of Geological Sciences, pre-existing borehole information, and 57 boreholes drilled for the Industrial Minerals Assessment Unit form the basis of the assessment of the sand and gravel resources of the Potter Hanworth and Reepham area of Lincolnshire.

All deposits of the district that might be potentially workable for sand and gravel have been investigated and a simple statistical method has been used to estimate the volume. The reliability of the volume estimates is given at the symmetrical 95 per cent probability level.

The 1:25 000 map is divided into four resource blocks, containing between 7.6 and 19.9 km^2 of sand and gravel. For each block the geology of the deposits is described, and the mineral-bearing area, the mean thickness of overburden and mineral and the mean gradings are stated. Detailed borehole data are also given. The geology, the position of the boreholes and the outlines of the resource blocks are shown on the accompanying map.

Notes

Each borehole registered with the Institute is identified by a four-element code (e.g. TF 07 NE 14). The first two elements define the 10-km square (of the National Grid) in which the borehole is situated; the third element defines a quadrant of that square, and the fourth is the accession number of the borehole. In the text of the report the borehole is normally referred to by the last three elements alone (e.g. 07 NE 14).

All National Grid references in this publication lie within the 100-km square TF unless otherwise stated. Grid references are given to eight figures, accurate to within 10 m for borehole locations (In the text, four- and six-figure grid references are used for more extensive locations, for example for farms).

Bibliographical reference

CROFTS, R. G. 1982. The sand and gravel resources of the country around Potter Hanworth and Reepham, Lincolnshire: description of 1:25 000 resource sheet TF 06 and 07. Miner. Assess. Rep. Inst. Geol. Sci., No 96.

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INTRODUCTION

The survey is concerned with the estimation of resources, which include deposits that are not currently exploitable but have a foreseeable use, rather than reserves, which can only be assessed in the light of current, locally prevailing, economic considerations. Clearly, neither the economic nor the social factors used to decide whether a deposit may be workable in the future can be predicted; they are likely to change with time. Deposits not currently economically workable may be exploited as demand increases, as higher-grade or alternative materials become scarce, or as improved processing techniques are applied to them. The improved knowledge of the main physical properties of the resource and their variability, which this survey seeks to provide, will add significantly to the factual background against which planning policies can be decided (Archer, 1969; Thurrell, 1971, 1981; Harris and others, 1974).

The survey provides information at the 'indicated' level "for which tonnage and grade are computed partly from specific measurements, samples or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to permit the mineral bodies to be outlined completely or the grade established throughout" (Bureau of Mines and Geological Survey, 1948, p. 15).

It follows that the whereabouts of reserves must still be established and their size and quality proved by the customary detailed exploration and evaluation undertaken by the industry. However, the information provided by this survey should assist in the selection of the best targets for such further work. The following arbitrary physical criteria have been adopted:

a The deposit should average at least 1 m in thickness.
b The ratio of overburden to sand and gravel should be no more than 3:1.
c The proportion of fines (particles passing the No. 240-mesh B.S. sieve, about 1/16 mm) should not exceed 40 per cent.
d The deposit should lie within 25 m of the surface, this being taken as the likely maximum working depth under most circumstances. It follows from the second criterion that boreholes are drilled no deeper than 18 m if no sand and gravel has been proved.

A deposit of sand and gravel that broadly meets these criteria is regarded as 'potentially workable' and is described and assessed as 'mineral' in this report. As the assessment is at the indicated level, parts of such a deposit may not satisfy all the criteria.

Pre-Pleistocene rocks, which are usually consolidated and devoid of potentially workable sand and gravel, are referred to as 'bedrock'; 'waste' is any material other than bedrock or mineral; 'overburden' is waste that occurs between the surface and an underlying body of mineral.

For the particular needs of assessing sand and gravel resources, a grain-size classification based on the geometric scale 1/16 mm, ¼ mm, 1 mm, 4 mm, 16 mm, 64 mm has been adopted. The boundaries between fines (that is, the clay and silt fractions) and sand, and between sand and gravel material, are placed at 1/16 mm and 4 mm respectively (see Appendix C).

The volume and other characteristics are assessed within resource blocks, each of which, ideally, contains

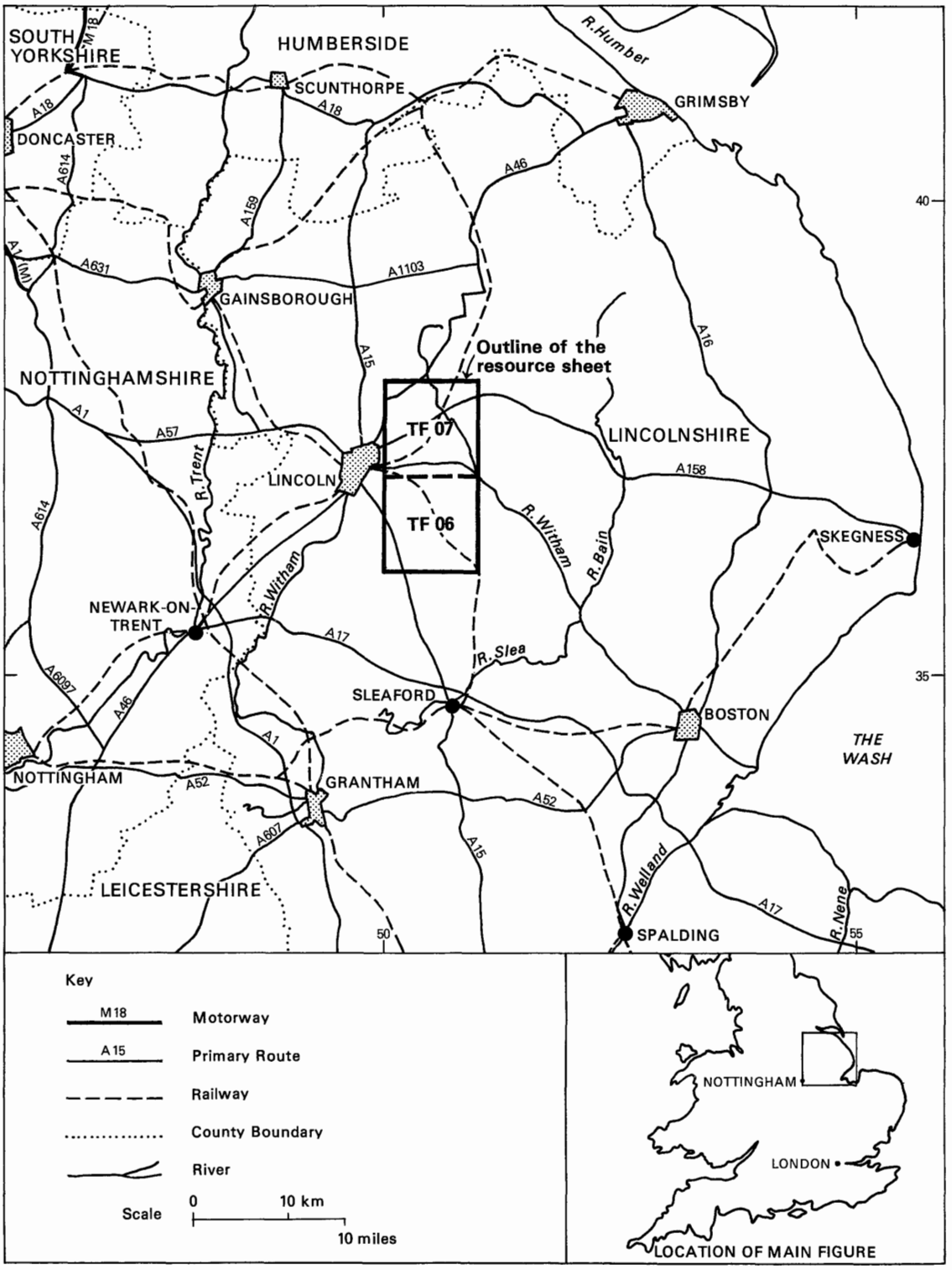


Figure 1 Sketch map showing the location of the resource sheet area.

approximately 10 km^2 of sand and gravel. No account is taken of any factors, for example roads, villages or land of high agricultural or landscape value, which might stand in the way of sand and gravel being exploited, although towns are excluded. The estimated total volume therefore bears no simple relationship to the amount that could be extracted in practice.

It must be emphasised that the assessment applies to the resource block as a whole; valid conclusions cannot be drawn about mineral in parts of a block, except in the immediate vicinity of the actual sample points.

DESCRIPTION OF THE RESOURCE SHEET AREA

The district lies immediately east of Lincoln (Figure 1). In the west, on the dip slope of the Lincoln Edge, the ground falls gently eastwards from 200 ft (61 m) to 15 ft (5 m) above Ordnance Datum on the edge of the Fenland (Figure 2). To the east is the Lincoln Clay Vale, a predominantly low-lying area 'mantled with glacial deposits' (Wilson, 1948, p. 9). Around Langworth [062 762], where relatively thin drift drapes the clay vale, the surface is gently undulating with elevations

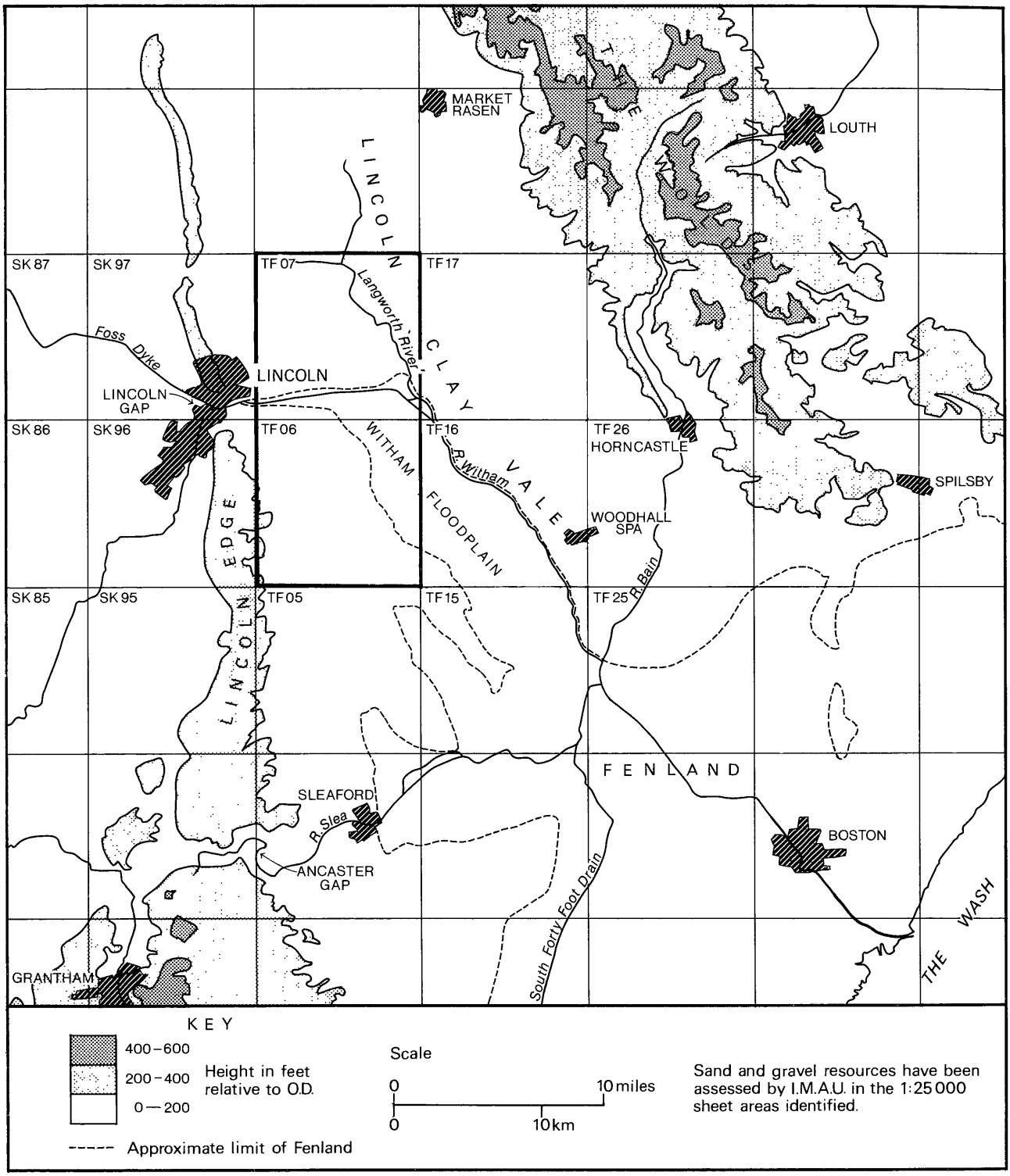


Figure 2 The main physical features of central Lincolnshire in relation to the resource sheet area.

between 25 ft (8 m) and 75 ft (23 m); however, to the south, alluvial infilling has created the typical Fenland which is commonly less than 10 ft (3 m) above sea level. The River Witham, contained within artificial levees, flows eastwards from Lincoln to Short Ferry [093 714] where it is joined by a southerly-flowing stream that passes through Langworth (henceforth referred to here as the Langworth river). The Fenland is drained by a grid-iron pattern of artificial ditches whose collective waters, controlled by sluice gates, outfall into the Witham.

The district is mostly agricultural with much arable land, but related industries, i.e. sugar refining and pea canning, exist at Bardney to the east of the survey area. South of Langworth, sand and gravel have been worked and at Greetwell [005 722] ironstone was both quarried and mined.

GEOLOGY

The geological sequence is summarised in Table 1 and described briefly below. Further details can be found in the regional guide to the area (Wilson, 1948) and the Lincoln memoir (Ussher and others, 1888).

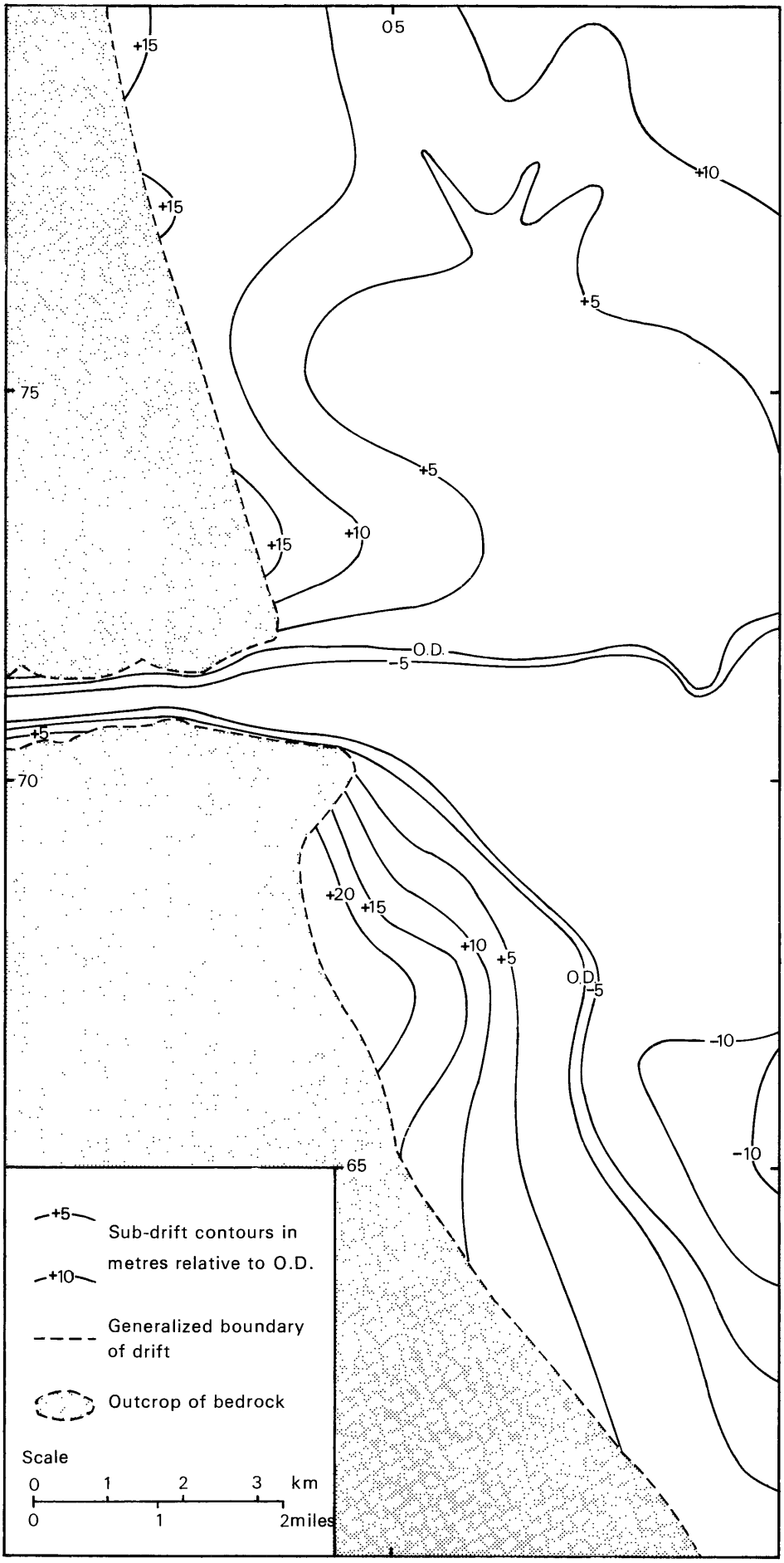


Figure 3 Sub-drift bedrock surface contours.

Table 1 Geological sequence.

DRIFT		
Quaternary (Recent and Pleistocene)		Blown Sand Alluvium Marine or Estuarine Alluvium Head, including downwash River Gravels, undifferentiated Fluvio-glacial and Older River Sand and Gravel Till
SOLID		
Jurassic	Upper	Ancholme Clay Group including Kellaways Beds at base Cornbrash
	Middle	Blisworth Clay Great Oolite Limestone Upper Estuarine Beds Lincolnshire Limestone, undivided Grantham Formation and Northampton Sand Ironstone
	Lower	Lias, undivided

Solid

Lias In this district, approximately 45 m of Lias is present but only the upper 20 m is exposed in the Lincoln Gap, where the group comprises mudstones and dark fossiliferous shales.

Grantham Formation and Northampton Sand Ironstone These beds (up to 5.5 m thick) are mainly of estuarine origin and consist of ferruginous, arenaceous and argillaceous rocks; the ironstones were formerly worked at Greetwell.

Lincolnshire Limestone This formation caps the Lincoln Edge and forms an extensive dip slope, which is well developed south of the Witham [045 715]. It is approximately 30 m thick and consists of oolitic limestones with thin mudstones.

Upper Estuarine Beds These are well exposed in the district and consist of about 10 m of estuarine and marine mudstones, sandy mudstones and sands with lignite and thin limestones.

Great Oolite Limestone Cropping out throughout the district, this sequence of limestones and intercalated mudstones is approximately 4.5 m thick.

Blisworth Clay This formation crops out extensively and consists of about 7.5 m of dark grey-brown and green fossiliferous mudstone.

Cornbrash This formation is a transgressive deposit (Wilson, 1948, p. 41) consisting of two thin limestones separated by a thinner layer of marl. The formation is fossiliferous throughout.

Kellaways Beds Mostly concealed beneath alluvium and till, these beds consist of 6 m of fine sand, silty clays and mudstone with a thin capping of hard calcareous sandstone.

Ancholme Clay Group above the Kellaways Beds In this district only the lowermost 75 m is present and consists of a stiff dark greenish grey or dark grey silty mudstone and shale containing bivalves and ammonites.

Drift

Till Outside the Witham and Langworth floodplains, till, considered to be of pre-Devensian age (Perrin, Rose and Davies, 1979), is found on all ground below the 75 ft contour. It consists of dark grey clay with fine gravel and coarse sand-sized erratics of chalk, flint and dark mudstone. The till is thickest in the west and south (13.6 m in borehole 06 SE 24) where it overlies the Ancholme Clay Group, and thins towards the north and east where thicknesses of 1.2 m (borehole 06 NE 27) and 3.3 m (borehole 07 SW 28) were recorded. A 0.3-0.7 m band of laminated clay with a base level of about 3.0 m above OD occurs within the more well-developed till sequences, e.g. boreholes 06 NE 22 and 06 SE 26.

The base of the till rests on bedrock at 0.1 m below OD in the south (borehole 06 SE 26) and rises steadily northwards to 8.9 m above OD (borehole 07 NE 15). IMAU boreholes indicate that fluvial erosion has removed almost all traces of till from beneath the Fenland.

Fluvio-glacial and Older River Sand and Gravel These deposits are well developed south of Washingborough [020 709], where they cap a bevelled till ridge and have a surface level of about 65 ft (20 m) above OD. They also crop out at Stainton by Langworth [065 788] but here lie at about 50 ft (15 m) above OD. Confidential borehole records prove the sand and gravel to be at least 6.4 m thick. These deposits were probably laid down when a river, draining the crop of the 'Bunter' (i.e. Sherwood Sandstone Group), flowed through the Lincoln Gap (Jukes-Browne, 1883, pp. 607-608). They have been equated with sediments on the west side of the Lincoln Gap which in turn have been correlated with the Hilton Terrace of the Middle Trent (Clayton, 1957, p. 38). The Hilton Terrace, which extends into the Witham valley as the Martin Terrace (Straw, 1958, figure 4 and p. 37), is considered to be fluvio-glacial (Stevenson and Mitchell, 1955, p. 93), fluvial (Clayton, 1953, p. 198; Pocock, 1929, p. 312) or both fluvio-glacial and fluvial in origin (Posnansky, 1960, pp. 299-300).

River Gravels, undifferentiated River Gravels in the Witham valley are concealed beneath alluvium whereas those in the valley of the Langworth river, between Reasby [066 796] and Short Ferry are exposed. IMAU boreholes demonstrate that the gravels beneath the Witham floodplain infill a channel cut into older drift deposits and the Jurassic strata. They consist mainly of layers of 'Bunter'-derived quartzitic pebbles which in places interdigitate with and are overlain by gravels of a more local origin; for example, those deposited by the Langworth river (see Composition of the sand and gravel deposits, below). A maximum of 12.3 m of gravel was recorded in borehole 06 SE 26 where the base of the channel is 9.7 m below OD (Figure 3). These sub-alluvial quartzitic gravels have been correlated with the Floodplain Terrace of the River Trent (Clayton, 1957, p. 38).

Immediately east of the Lincoln Gap, the River Gravels consist of an upper sequence of sands and pebbly sands separated (at about 3.5 m below OD) by a 0.3 to 0.5-m thick reddish brown laminated sandy clay from the more typical quartzitic gravels beneath.

The exposed river gravels in the valley of the Langworth river are up to 5.3 m thick and consist mainly of flint and limestone pebbles of relatively local origin.

Head, including downwash Of variable composition, this soliflucted deposit is found on or at the foot of slopes and in minor valleys. It is probably fairly extensive throughout the district although it has only been mapped over a small area (by W. D. Evans in 1941).

Marine or Estuarine Alluvium and Alluvium These deposits are extensively developed as the Witham floodplain, occur as ribbon-like deposits paralleling the

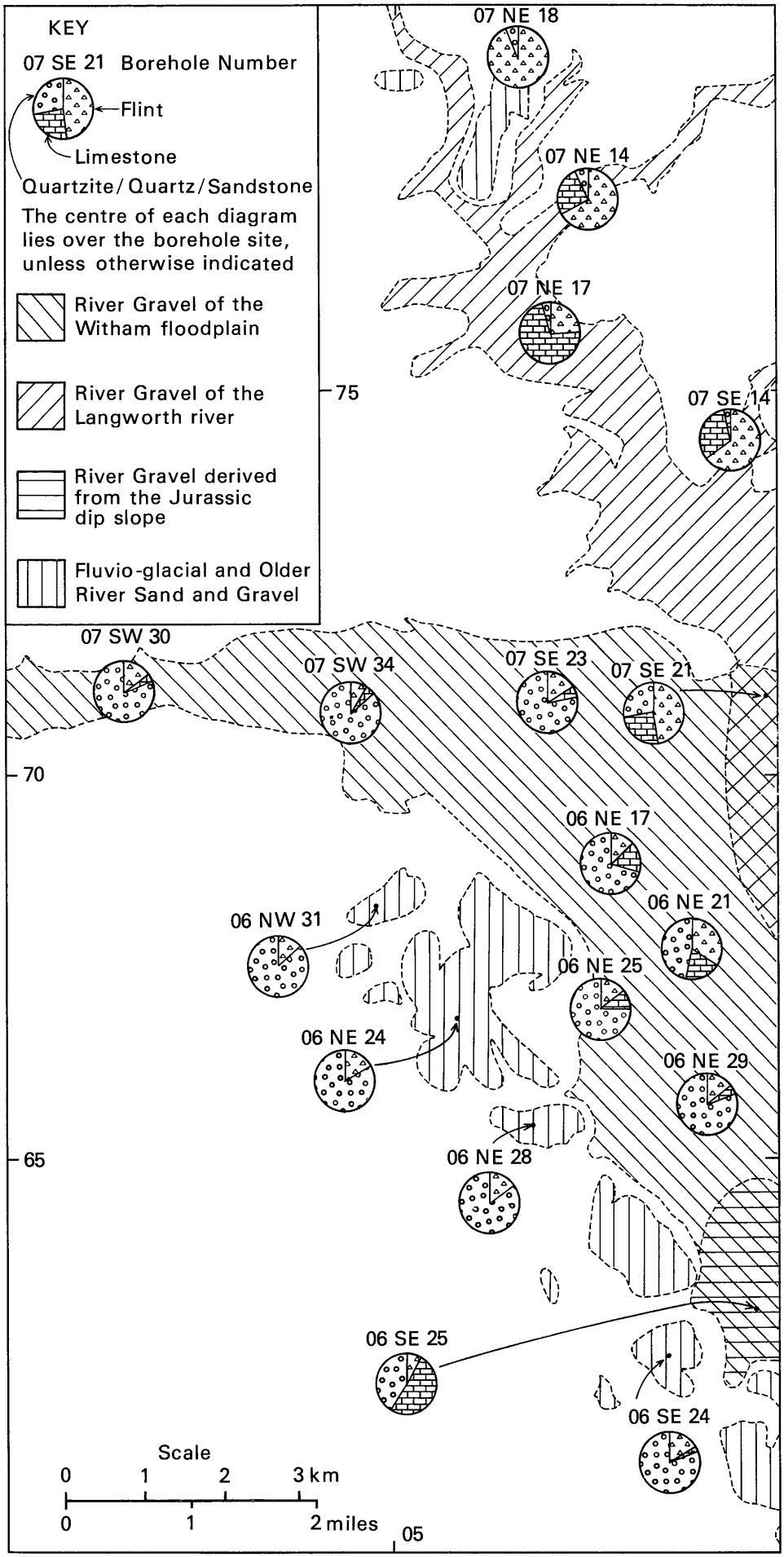
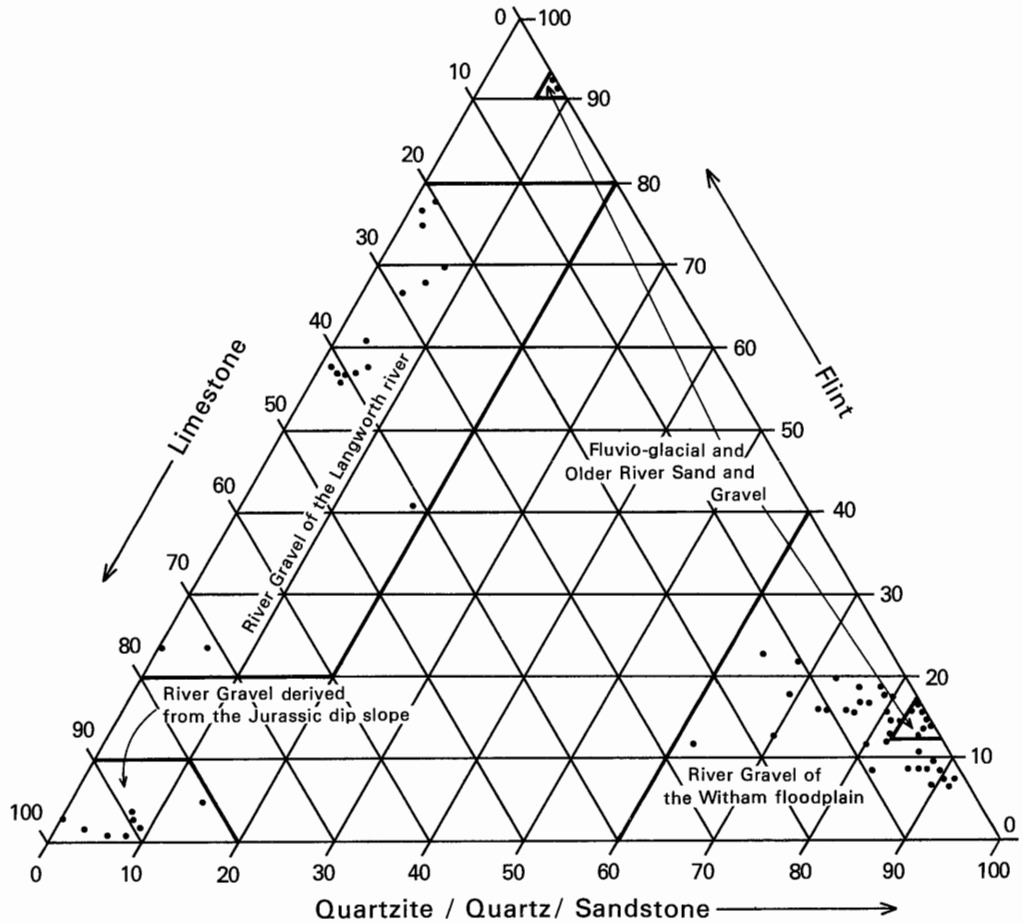
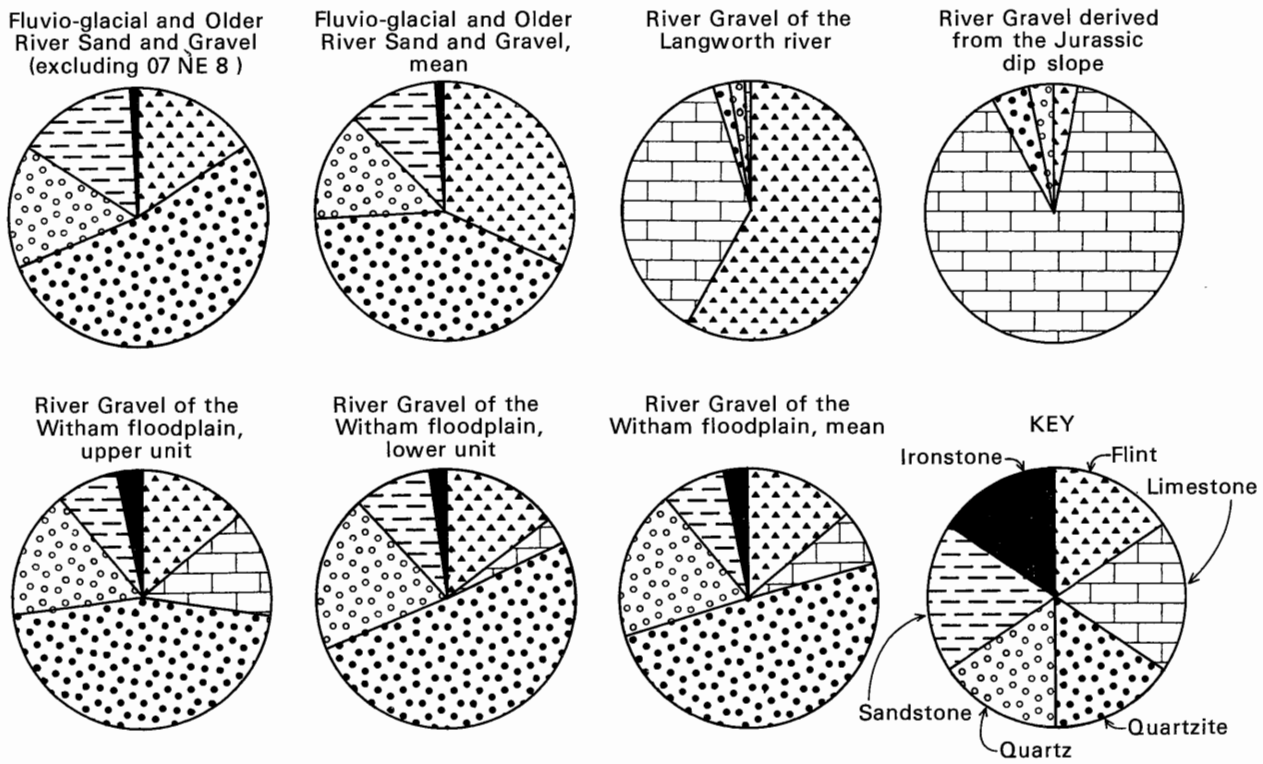


Figure 4 Compositional variation and distribution of sand and gravel.



a. Lithology expressed as percentages of limestone : flint: quartzite/ quartz / sandstone for individual IMAU samples



b. Mean lithological composition of sand and gravel deposits (based on weighted means from selected boreholes)

Figure 5 Composition of sand and gravel.

Langworth drainage system, and extend into embayments on the west side of the Fenland where tributary streams drain the Jurassic dip slope. They generally consist of silts and clays with thin peat lenses and sands, the sands becoming more common in alluvium bordering the River Witham upstream from Branston Delph [075 700]. Boreholes show that the Alluvium has a maximum thickness of 5.5 m in the Lincoln Gap area, whereas in the Fenland to the south recorded thicknesses of 3 m are more usual. However, where the River Gravels are thickest, as around Willow Farm [095 642], only a veneer of alluvium is present.

Blown Sand Blown Sand is present on the south side of the Lincoln Gap, where it forms low irregular mounds of fine-grained quartz sand on the Jurassic dip slope.

COMPOSITION OF THE SAND AND GRAVEL DEPOSITS

Within the resource sheet area Fluvio-glacial and Older River Sand and Gravel, River Gravels and Alluvium contain potentially workable sand and gravel (Figures 4 and 5).

Fluvio-glacial and Older River Sand and Gravel Mineral within this deposit has a mean grading of 5 per cent fines, 59 per cent sand and 36 per cent gravel. The fines content ranges from 3 to 9 per cent in boreholes 07 NE 10 and 06 NE 28 respectively, and the gravel content ranges from 25 per cent in borehole 06 NE 24 to 53 per cent in borehole 06 SE 23.

The gravel fraction is generally of fine grade but coarse pebbles are common and may be dominant locally, as in borehole 06 SE 23. The major constituent is 'Bunter'-derived rounded to well-rounded brown- and liver-coloured quartzite with subordinate amounts of vein quartz, fine-grained sandstone and angular to subrounded yellow and white flint present in roughly equal amounts; limestone and ironstone may also be present but rarely account for more than 1 per cent of the gravel fraction (Figure 5). The sand fraction is mainly medium-grained; it is composed mainly of quartz with some flint and quartzite.

River Gravels These extensive deposits have a mean grading of 2 per cent fines, 64 per cent sand and 34 per cent gravel. The fines reach a maximum of 8 per cent in borehole 07 NE 20 while the gravel content ranges from 4 per cent in borehole 07 SE 17 to 53 per cent in boreholes 07 NE 11 and 07 SE 18. The gravel fraction is dominantly fine (+4-16 mm) throughout but coarse pebbles are common. Lithologically there are two distinct gravel deposits: one dominated by relatively locally derived Cretaceous rocks transported from the north and east and the other dominated by 'Bunter'-derived material originating from the west (Figure 4).

The 'Bunter'-rich gravel is ubiquitous beneath the Witham floodplain but shows varying degrees of contamination by the Cretaceous material. These gravels consist of rounded to well-rounded brown- and liver-coloured quartzite with quartz, yellow and white angular flint, some sandstone and limestone (including chalk and Jurassic oolitic limestones), the last-named rarely accounting for more than 8 per cent. However, south of Branston Fen [085 694] a 'Bunter'-rich gravel with significantly more limestone (up to 15 per cent) forms a recognisable upper unit within these gravels.

River Gravels rich in erratics derived from the Cretaceous uplands (The Wolds) are found extensively in fluvial deposits paralleling the Langworth river but also spill out into the Fenland at Short Ferry to form a tongue over the gravels beneath the Witham floodplain (Figure 4). The gravel consists of angular to subangular flint and rounded limestone. The flint is generally yellow and white, although locally black flint is common (see Roeder, 1977); the limestone consists of chalk (34 per cent in borehole 07 NE 21) and locally Jurassic oolitic limestone which is present in considerable amounts, for example, in borehole 07 NE 17 where it is in excess of 60 per cent by weight. Minor amounts of quartz, sandstone and ironstone may be present but these never total more than 5 per cent of the gravel fraction.

Locally, a third lithologically distinctive River Gravel is developed east of the Jurassic dip slope. This gravel is best seen in borehole 06 SE 25 and overlies the 'Bunter'-rich gravel. It is comprised almost entirely of subangular to subrounded Jurassic oolitic limestone.

The sand fraction of the river gravels as a whole comprises 20 per cent fine sand, 63 per cent medium sand and 17 per cent coarse sand. It is generally composed of quartz with varying amounts of flint and small amounts of limestone and quartzite.

Alluvium Alluvial mineral deposits in the Witham floodplain have a mean grading of 10 per cent fines, 88 per cent sand and 2 per cent gravel. Sands and pebbly sands are widespread whereas gravelly deposits tend to occur in irregularly distributed pockets. This is illustrated by borehole 07 SE 23 which has a 0.3-m thick gravel layer near the base of the Alluvium. The fines range from 7 per cent in borehole 07 SW 29 to 13 per cent in borehole 07 SE 23.

The gravel fraction is fine in grade and mainly subrounded to rounded. The main constituents are brown- and liver-coloured quartzite and vein quartz with fine-grained sandstone, limestone (including chalk and Jurassic oolitic limestones) and ironstone concretions.

The sand fraction comprises 53 per cent fine sand, 44 per cent medium sand and 3 per cent coarse sand. It is composed mainly of quartz with small amounts of flint and limestone.

Blown Sand Although no boreholes were sunk in this deposit, it is known from field examination to consist of fine-grained quartz sand.

Mechanical and physical properties

A series of tests (see Table 2) were carried out on standard-sized material (+10-14 mm) in accordance with BS 812, Parts 2 and 3, (British Standards Institution, 1975). Five samples were prepared using material from several boreholes (see Table 4); these samples represent the different gravel assemblages recognised in the district. Their lithological compositions are set out in Table 3. The results (Table 2) in all cases are the mean of two determinations.

THE MAP

The sand and gravel resource map is folded into the pocket at the end of this report. The base map is the Ordnance Survey 1:25 000 Outline Edition in grey, on which the topography is shown by contours, the geological data in black and the mineral resource information in shades of red.

Geological data The geological boundary lines are from an original survey on the one-inch scale by W. H. Penning and W. H. Dalton published (as part of Old Series Sheet 83) in 1886 with amendments from six-inch partial resurveys by P. E. Kent in 1937, W. D. Evans in 1941 and T. P. Fletcher in 1980. The geological boundaries represent the best interpretation of the information available at the time of the survey. However, it is inevitable, particularly with drift deposits, that local irregularities and discrepancies will be revealed as new evidence from boreholes and excavations becomes available.

Borehole data, which include the stratigraphical relations, thicknesses and mean particle-size analyses of the sand and gravel samples collected during the assessment, are also shown on the Map.

Mineral resource information For assessment purposes, the Map is divided into resource blocks (see Appendix A)

Table 2 Results of aggregate tests.

Sample	Mechanical properties			Physical properties		
	AIV	10% Fines (kN)	Water absorption (% of dry mass)	Relative density on an oven-dried basis	Relative density on a saturated and surface-dried basis	Apparent relative density
1	19	290	1.4	2.54	2.57	2.63
2	19	330	1.3	2.54	2.57	2.62
3	20	270	1.9	2.51	2.55	2.63
4	27	150	3.4	2.42	2.51	2.64
5	39	<100*	4.3	2.42	2.52	2.70

* Equipment not accurate below 100 kN.

Table 3 Mean composition of +8-16 mm gravel used in the aggregate tests.

Sample	Percentage by weight					
	Flint	Quartzite	Limestone	Quartz	Sandstone	Ironstone
1	12	49	14	15	7	3
2	16	51	5	18	9	1
3	16	48	4	18	14	trace
4	64	0	32	0	4	0
5	3	5	89	3	0	0

Table 4 List of boreholes supplying +10-14 mm gravel to produce Samples 1 to 5.

Sample	Deposit	Boreholes
1	River Gravel (Witham floodplain)	06 NE 17, 07 SW 34 and 07 SE 21 (8.5-12.4 m only)
2	River Gravel (Witham floodplain)	06 NE 29 and 06 SE 25 (9.6-13.4 m only)
3	Fluvio-glacial and Older River Sand and Gravel	06 NW 31 and 06 SE 24
4	River Gravel (Langworth river)	07 NE 14, 07 SE 14 and 07 SE 21 (4.3-8.5 m only)
5	River Gravel (Jurassic dip slope)	06 SE 22 (0.5-7.0 m only) and 06 SE 25 (1.1-9.6 m only)

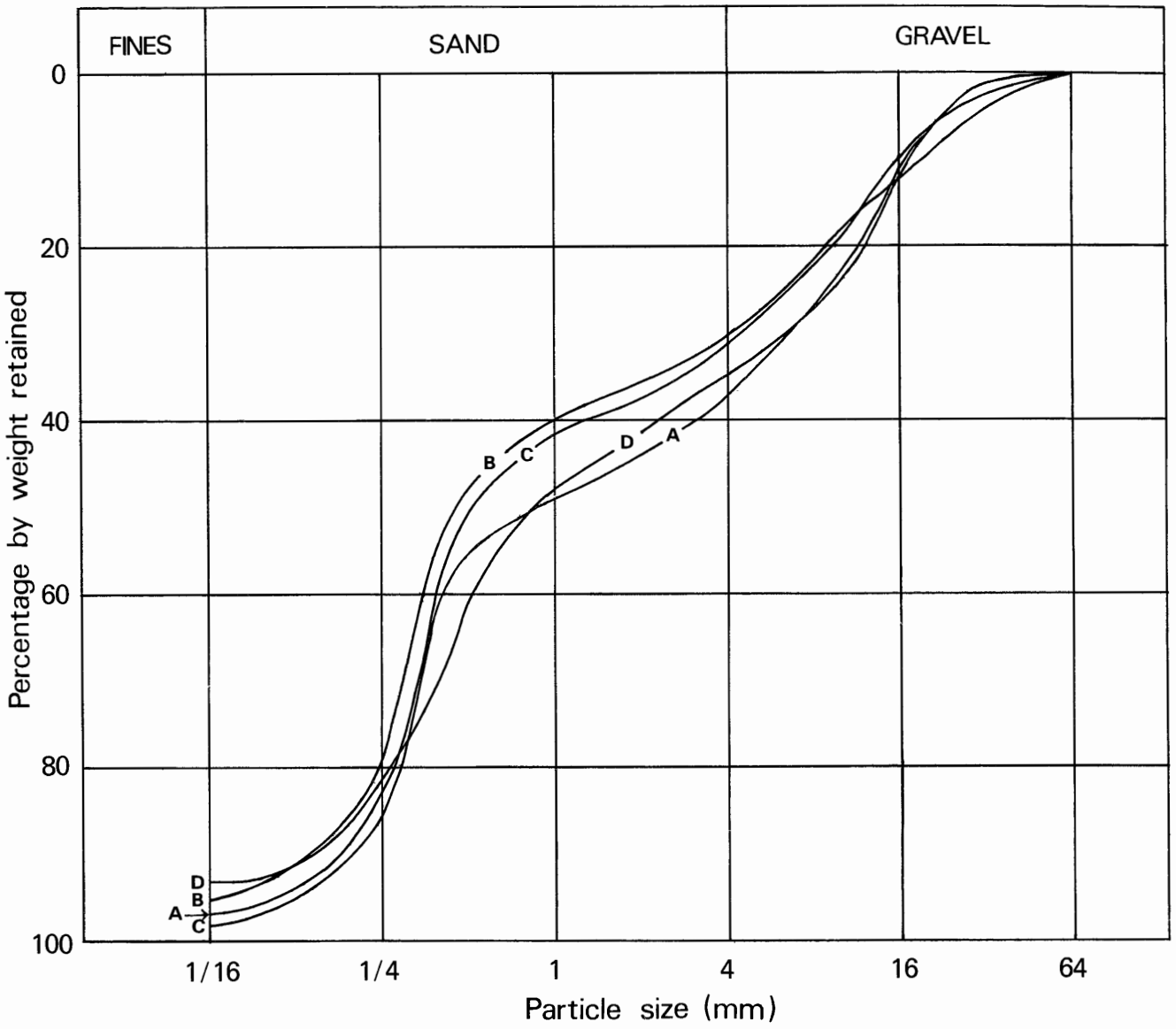
which may be subdivided into areas where mineral is 'exposed', where mineral is present beneath overburden, and where sand and gravel is absent or not potentially workable. The mineral is identified as 'exposed' where the overburden, commonly consisting only of soil and subsoil, averages less than 1.0 m in thickness. Areas where bedrock outcrops and where boreholes indicate absence of sand and gravel beneath cover are interpreted to be not potentially workable and are uncoloured on the Map. In such areas it has been assumed that mineral is absent except in infrequent and relatively minor patches which can neither be outlined nor assessed quantitatively in the context of this survey.

Where possible, the boundries between the different categories of deposits are based on the mapped geological lines. Where there is a transition from one category to another which is independent of the geological lines and which could not be accurately delineated during this survey, inferred boundaries have been inserted. Such boundaries are shown by a distinctive zigzag symbol which is intended to convey an approximate location within a likely zone of occurrence, rather than to represent the breadth of the zone, its width being limited only by cartographic considerations. For the purpose of measuring areas the centre line of the symbol is used.

RESULTS

The statistical results are summarised in Table 5. Fuller grading particulars are shown in Figures 6, 7, 8, 11 and 12 and Tables 6 to 9: the cumulative grading curves are based on up to 11 data points.

Accuracy of results For each of the blocks, the accuracy of the results at the 95 per cent probability level (that is, on average nineteen out of every twenty sets of limits constructed in this way contain the true value for the volume of mineral) varies between 12 per cent and 44 per cent (Appendix B). However, the true volumes are more likely to be nearer the figure estimated than either of the limits. Moreover, it is probable that roughly the same percentage limits would apply for the statistical estimate of mineral volume within a very much smaller parcel of ground (say 100 hectares) containing similar sand and gravel deposits, if the results from the same number of sample points (as provided by, say, ten boreholes) were used in the calculation. Thus, if closer limits are needed for quotation of reserves, data from more sample points would be required, even if the area were quite small. However, it must be emphasised that the quoted volume of mineral has no simple relationship with the amount that could be extracted in practice, as no allowance has



Block	Percentage by weight retained					
	$\frac{1}{16}$ mm	$\frac{1}{4}$ mm	1 mm	4 mm	16 mm	64 mm
A	97	83	49	37	10	0
B	96	78	40	30	11	0
C	98	85	42	31	9	0
D	94	81	48	35	11	0

Figure 6 Mean particle-size distribution for the mineral in resource blocks A to D, based on data from IMAU boreholes.

been made in the calculations for any restraints (such as existing buildings and roads) on the use of the land for mineral working.

NOTES ON THE RESOURCE BLOCKS

The resource block boundaries are drawn to take account of geological and geographical factors. The mineral in Blocks A and D is for the most part exposed; Block A consists of River Gravels with a small area of Fluvio-glacial and Older River Sand and Gravel around Stainton by Langworth whereas Block D contains Fluvio-glacial and Older River Sand and Gravel cropping out on the higher ground to the west of the Fenland.

By contrast, the potentially workable sand and gravel in Blocks B and C, consisting of River Gravels with some alluvial sand, is entirely concealed beneath the alluvial clays of the River Witham. In Block B the mineral is in most cases interrupted by waste partings whereas in Block C waste partings occur only sporadically.

Block A (Figure 7, Table 6)

This block extends from Fiskerton [050 723] and Short Ferry to the northern edge of the resource sheet area and contains River Gravels of the Langworth river and its tributaries, and Fluvio-glacial and Older River Sand and Gravel on the higher ground. Till covers much of the remaining area and bedrock is exposed around Scothern

Table 5 The sand and gravel resources of the district: statistical assessment.

Block	Area		Mean thickness			Volume of sand and gravel			Mean grading percentage		
	Block	Mineral	Over-burden	Mineral	Waste		Limits at the 95% probability level		Fines	Sand	Gravel
	km^2	km^2	m	m	m	$m^3 \times 10^6$	± %	± $m^3 \times 10^6$	$-\frac{1}{16}$ mm	$+\frac{1}{16}$ -4 mm	+4 mm
A	53.4	13.8	0.7	2.3	0	32	44	14	3	59	38
B	13.7	12.7	2.3	5.6	1.2	71	37	26	4	69	27
C	23.0	19.9	2.8	8.2	0	163	12	20	2	67	31
D	23.8	7.6	0.6	2.9	0	22	42	9	6	59	35
A to D	113.9	54.0	1.8	5.3	0.3	288	18	52	3	66	31

Table 6 Block A: data from IMAU boreholes.

Borehole	Recorded thickness (m)		Mean grading percentage					
	Mineral	Over-burden	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ -$\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 mm
07 NE 8	3.0	0.5	3	11	39	8	23	16
07 NE 10	5.1	0.4	2	9	36	11	28	14
07 NE 11	0.7	1.3	4	9	19	15	23	30
07 NE 14	2.8	1.0	3	6	27	16	33	15
07 NE 16	1.8	0.5	5	17	26	16	32	4
07 NE 17	1.8	0.2	2	14	33	19	27	5
07 NE 18	Nil							
07 NE 20	1.8	0.7	8	16	24	10	34	8
07 SE 13	3.6	0.5	2	10	31	18	31	8
07 SE 14	2.3	1.3	2	13	28	12	32	13
07 SE 16	Nil							
07 SE 17	2.9	0.5	7	31	56	2	4	trace

Table 7 Block B: data from IMAU boreholes.

Borehole	Recorded thickness (m)			Mean grading percentage					
	Mineral	Over-burden	Waste	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ -$\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse gravel +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm
07 SW 29	5.2	1.1	2.9	6	28	42	7	13	4
07 SW 30	3.4	5.5	0.2	3	6	46	13	24	8
07 SW 31	6.8	1.8	1.0	2	15	65	7	8	3
07 SW 32	Nil								
07 SW 34	9.1	0.6	1.1	4	42	34	6	10	4
07 SE 18	9.2	1.6	0.0	5	12	20	10	27	26
07 SE 22	9.0	1.8	1.2	4	27	33	7	20	9
07 SE 23	3.2	3.2	0.9	5	17	35	8	22	13
07 SE 24	8.4	1.2	1.0	6	25	40	7	15	7

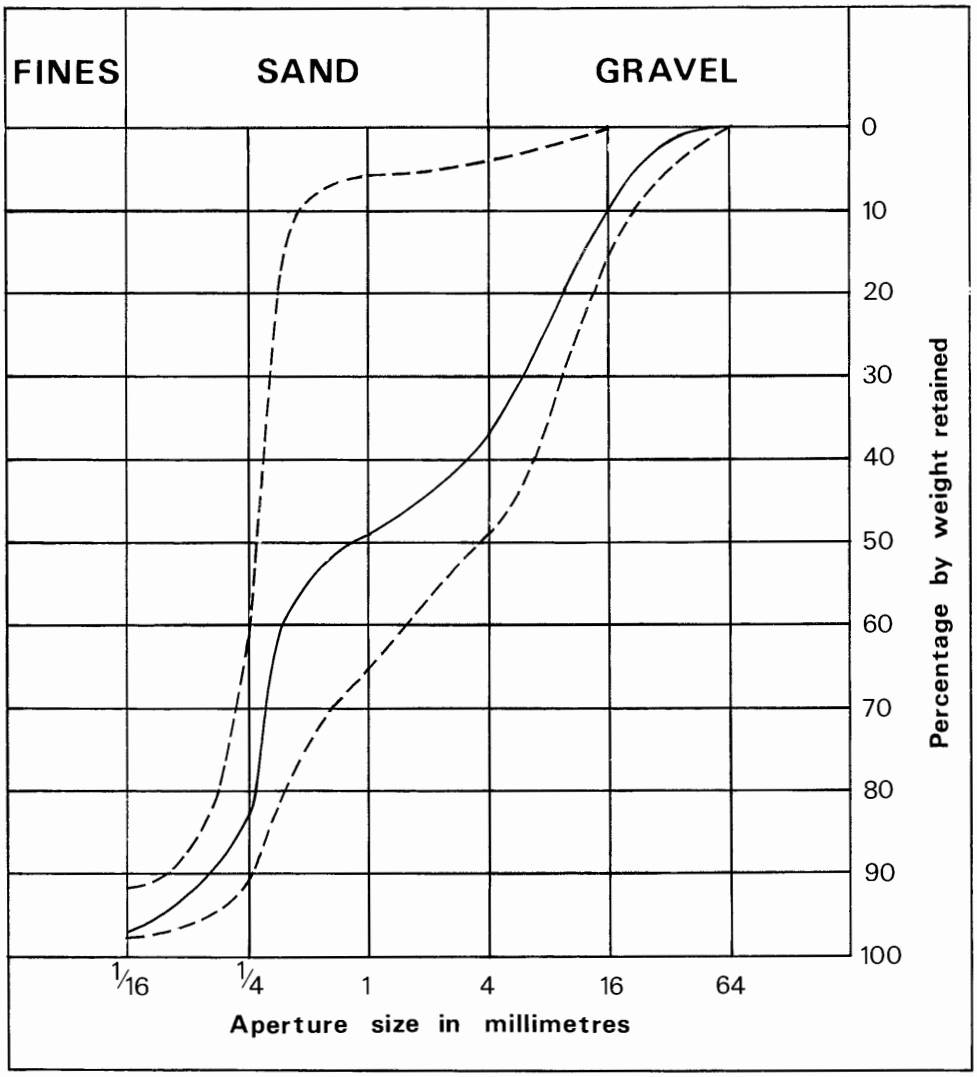


Figure 7 Grading characteristics of the mineral in Block A. The continuous line represents the mean grading of the block; the broken lines denote the envelope within which the mean grading curves for individual boreholes fall.

[035 775]. Of the 19 IMAU boreholes in Block A, seven located in till around Fiskerton and Bullington [092 780] proved to be barren. Of the twelve sited to investigate the fluvial deposits, two boreholes (07 NE 18 and 07 SE 16) failed to prove mineral; these have been entered in the resource block calculations as nil thicknesses. Supplementary data were derived from two other boreholes and others held in confidence by the Institute.

Except for borehole 07 SE 17, where the mineral graded as sand, all the IMAU boreholes confirming mineral proved gravel or sandy gravel. The proved mineral ranges in thickness from 0.7 m in borehole 07 NE 11 to 5.3 m in borehole 07 NE 3 (a non-IMAU borehole), giving a mean thickness of 2.3 m. the mean grading based on IMAU data is 3 per cent fines, 59 per cent sand and 38 per cent gravel and an estimated volume of mineral present is 32 million m^3 $\pm$14 million m^3 at the 95 per cent confidence level.

Overburden has a mean thickness of 0.7 m and is generally found to be a thin sandy soil between 0.2 and 0.7 m in thickness. However, close to the present course of the Langworth river, alluvial clays may cap the river gravels, as in borehole 07 SE 14 where the overburden is 1.3 m thick.

Block B (Figures 8, 9 and 10, Table 7)

Fluvial deposits of the River Witham between Greetwell and Branston Delph are assessed in this block. Data from 8 IMAU boreholes are supplemented by 3 non-confidential boreholes from other sources. They show a sequence of alluvial silts and clays with interdigitated sands and pebbly sands, which have been proven to be 'clayey' in places (for example, borehole 07 SE 23), overlying the River Gravels which are sandy gravels and pebbly sands. However, borehole 07 SE 18 proved uninterrupted sandy gravel, whereas in borehole 07 SE 32 only a thin peaty soil on till was recorded, showing that locally this sequence may vary. The latter borehole is included in the resource block calculations as a nil thickness since the area of non-mineral cannot be defined.

The sands within the Alluvium have a proven mean thickness of 0.6 m based on 11 data points. The IMAU boreholes give a mean grading of 10 per cent fines, 87 per cent sand and 3 per cent gravel to give an overall classification of 'clayey' sand.

By contrast, the River Gravels range in thickness from 1.9 m in borehole 07 SE 23 to 9.2 m in borehole 07 SE 18, have a mean thickness of 5.0 m and a mean grading of 3 per cent fines, 58 per cent sand and 39 per cent gravel, giving an overall classification of sandy gravel.

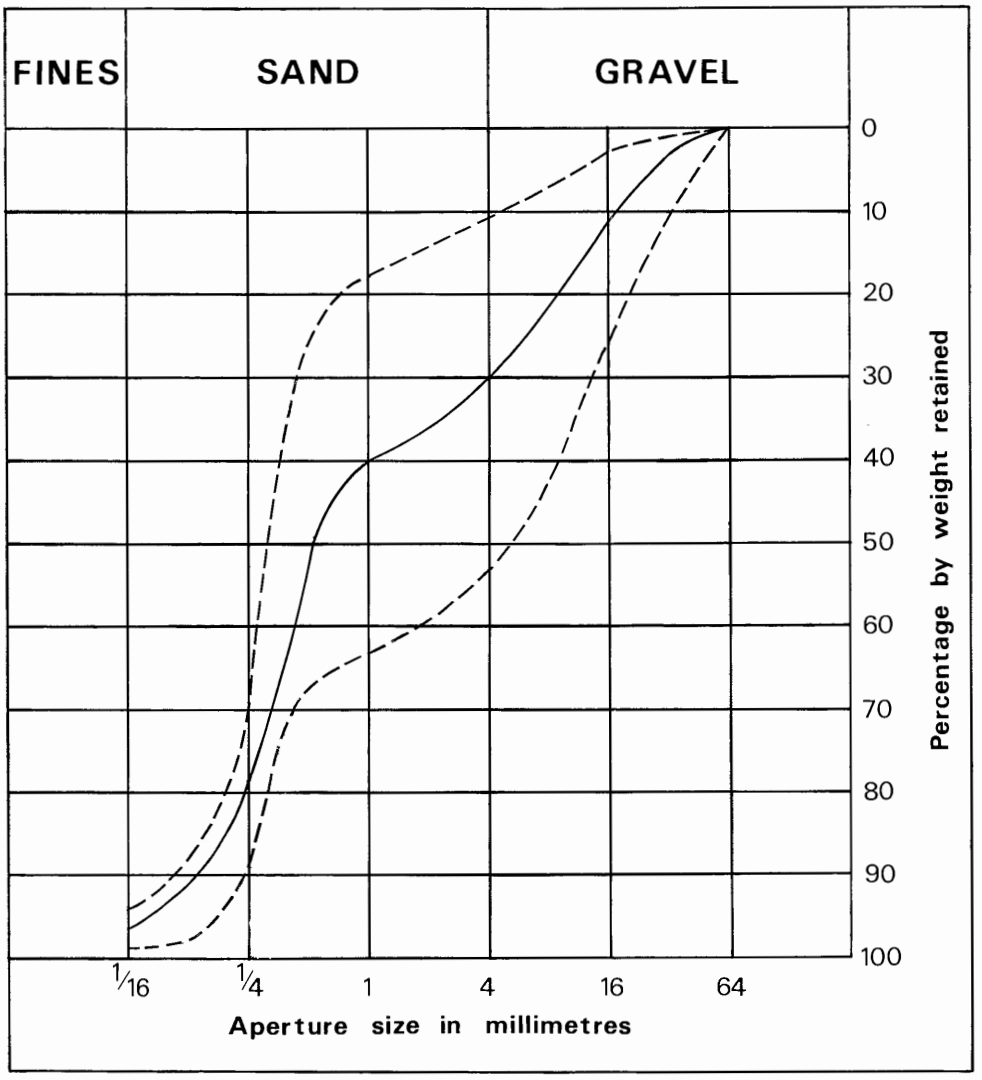


Figure 8 Grading characteristics of the mineral in Block B (for explanation see Figure 7).

The overall proven mean mineral thickness is 5.6 m with a mean grading of 4 per cent fines, 69 per cent sand and 27 per cent gravel. The estimated volume of mineral present is 71 million $m^3 \pm 26$ million m^3 at the 95 per cent confidence level.

The overburden consists of silts, clays and subordinate peats and ranges in thickness from 0.6 m in borehole 07 SW 34 to 6.7 m in borehole 07 SE 1 (a non-IMAU borehole. Waste partings are present in all those boreholes proving mineral except for 07 SE 18. These silts and clays range in thickness from 0.2 to 2.9 m with a mean thickness of 1.2 m.

Block C (Figures 9, 10 and 11, Table 8)
Mineral in this block is concealed beneath Alluvium/Marine or Estuarine Alluvium which covers the remaining area of the Witham floodplain south of Branston Delph. It consists chiefly of River Gravels although locally alluvial sands are present, as in borehole 06 NE 26. The assessment is based on 17 boreholes, 14 of which were drilled by IMAU. The mean gradings show the mineral to be dominantly sandy gravel but pebbly sands do occur, for example in borehole 06 NE 20. Proven mineral thicknesses range from 6.1 to 12.3 m with a mean thickness of 8.2 m. The IMAU boreholes alone give a mean grading of 2 per cent fines, 67 per cent sand and 31 per cent gravel. The volume is estimated at 163 million $m^3 \pm 20$ million m^3 at the 95 per cent confidence level.

Sand and gravel beneath the Alluvium, which extends into the valleys draining the Jurassic dip slope, is found to be absent or thin (see borehole 06 SE 27). These areas have therefore been assessed as not potentially workable.

Overburden generally consists of alluvial silts and clays with subordinate peats. Proven thicknesses range from 0.5 to 4.5 m with a mean thickness of 2.8 m. A waste parting of 0.8 m was recorded in borehole 06 SE 26.

Block D (Figure 12, Table 9)
Mineral in this block consists of Fluvio-glacial and Older River Sand and Gravel which caps the dissected bevelled till ridge to the west of the Witham floodplain between Heighington [035 695] and Blankney [072 601]. These deposits were investigated by 9 boreholes sunk by IMAU, one other borehole (06 NE 10) and several others held in confidence by the Institute. Of the IMAU boreholes, 06 NW 30 and 07 SW 33 proved sand and gravel to be thin or absent in the northern part of the block. Borehole 06 NE 22 also failed to prove sand and gravel but since the area of non-mineral cannot be delineated, this data point is included in the resource block calculation as a nil thickness. Three other IMAU boreholes (06 NE 19, 06 NE 27 and 06 SE 21) sited in the surrounding till were found to be barren.

Mineral thicknesses proved range from 1.0 to 4.1 m with a mean thickness of 2.9 m. A mean grading of 6 per cent fines, 59 per cent sand and 35 per cent gravel is

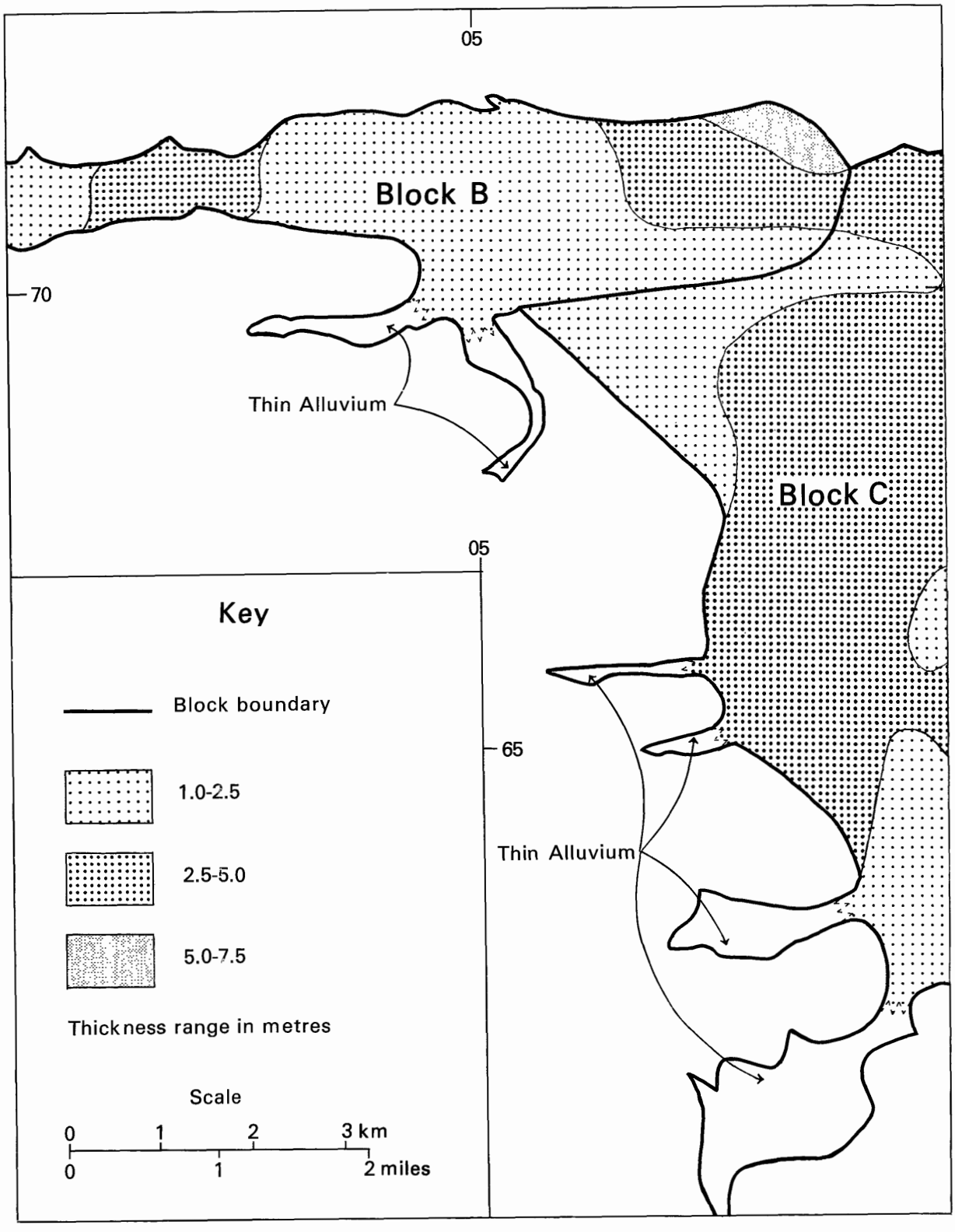


Figure 9 Isopachytes of the alluvial overburden in the Witham floodplain.

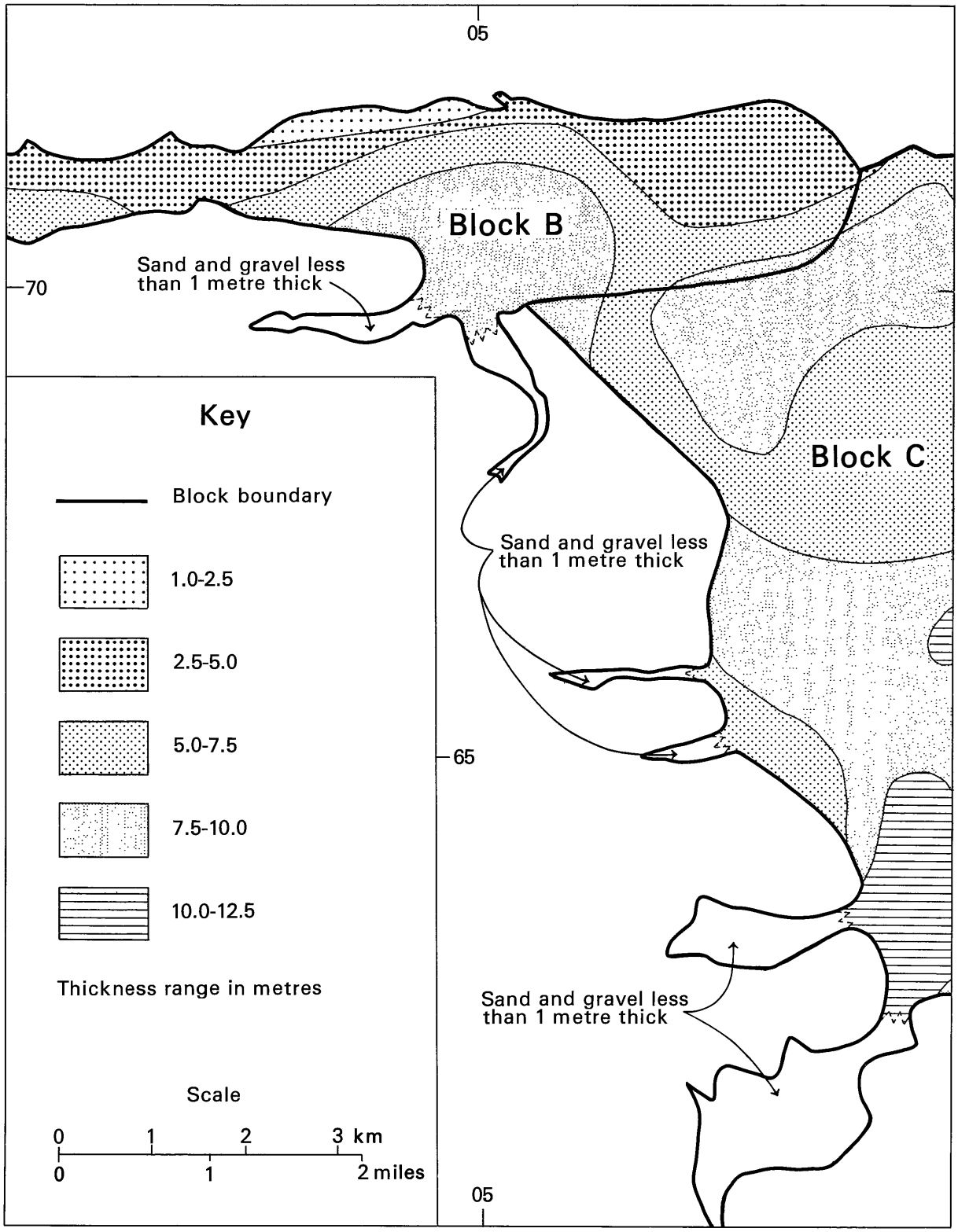


Figure 10 Isopachytes of sand and gravel in the Witham floodplain.

Table 8 Block C: data from IMAU boreholes

Borehole	Recorded thickness (m)		Mean grading percentage					
	Mineral	Over-burden	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 mm
06 NW 16	6.3	1.4	3	7	43	14	24	9
06 NE 17	7.9	2.8	4	20	43	12	16	5
06 NE 18	6.1	4.5	1	9	37	14	29	10
06 NE 20	6.8	2.5	2	18	62	4	10	4
06 NE 21	7.3	3.1	2	12	44	12	24	6
06 NE 23	7.1	3.5	2	14	56	7	15	6
06 NE 25	8.5	3.2	3	11	36	10	27	13
06 NE 26	8.5*	3.5	2	7	45	10	24	12
06 NE 29	9.5	3.6	4	15	43	8	20	10
06 NE 30	7.3	4.4	2	15	38	11	23	11
06 SE 22	12.0	0.5	2	16	35	13	26	8
06 SE 25	12.3	1.1	1	16	42	14	22	5
07 SE 21	8.1	4.3	1	6	46	13	23	11
07 SE 25	8.8	2.1	2	11	42	11	25	9

* Excluding a 0.8 m waste parting

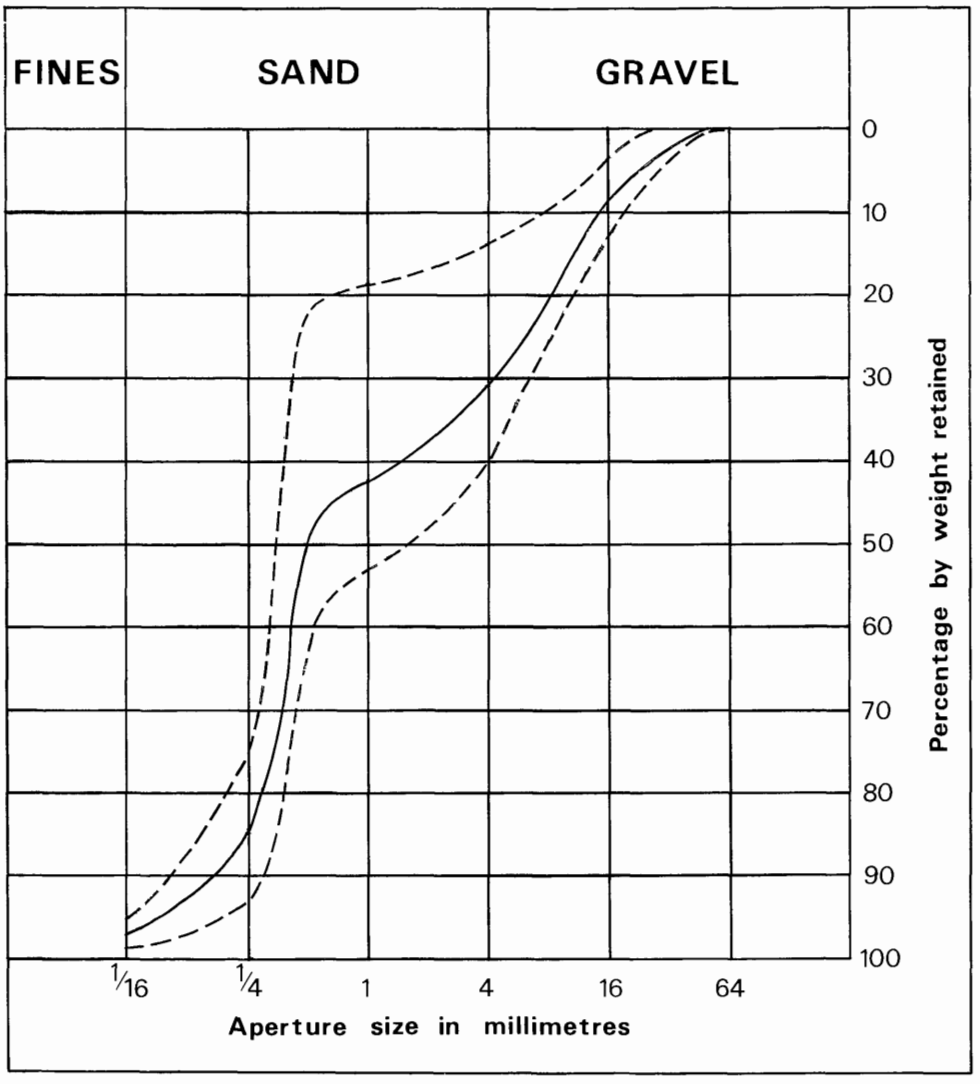


Figure 11 Grading characteristics of the mineral in Block C (for explanation see Figure 7).

Table 9 Block D: data from IMAU boreholes

Borehole	Recorded thickness (m)		Mean grading percentage					
	Mineral	Overburden	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 mm
06 NW 31	3.3	0.9	6	9	41	15	23	6
06 NE 22	Nil							
06 NE 24	3.3	0.5	6	14	40	15	22	3
06 NE 28	2.9	0.4	9	8	32	14	25	12
06 SE 23	1.0	0.4	6	9	23	9	18	35
06 SE 24	3.2	0.6	5	8	34	8	27	18
06 SE 26	4.1	0.6	3	9	43	12	23	10

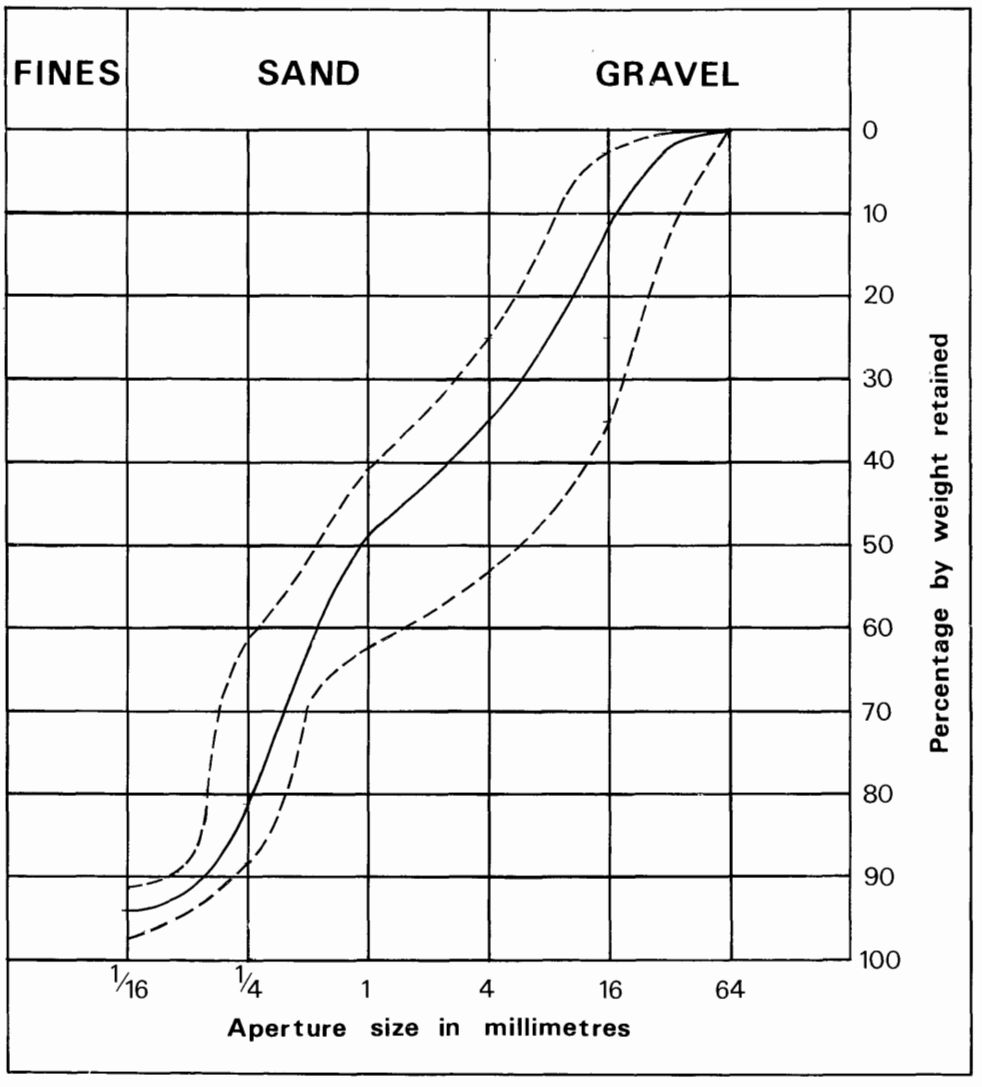


Figure 12 Grading characteristics of the mineral in Block D (for explanation see Figure 7).

based on 6 IMAU boreholes. The volume is estimated at 22 million $m^3 \pm 9$ million m^3 at the 95 per cent confidence level.

Overburden recorded from IMAU boreholes is a thin sandy soil which ranges in thickness from 0.4 to 0.9 m and has a mean thickness of 0.6 m.

LIST OF WORKINGS (all abandoned)

Location and grid reference	Deposit worked
Branston Moor [0490 6810]	Fluvioglacial and Older River Sand and Gravel
S. of Langworth [0730 7570]	River Gravels
S. of Langworth [0740 7530]	River Gravels

CONCLUSIONS

In Blocks B and C, sand and gravel mostly in the form of River Gravels covered by Alluvium, fills a flat-bottomed channel which traverses the district in an east-west direction. In the Lincoln Gap area the channel is about 1 km wide and filled with a 9-m thick succession consisting of a basal gravel overlain by interdigitated sands, silts and clays. Farther downstream the channel widens to about 5 km and sandy gravels, averaging 8.2 m in thickness, dominate the sequence. Generally, the sand and gravel is lithologically uniform although locally intermixing of River Gravels from different side valleys occurs in the main Witham valley.

Other River Gravels are deposited in a northerly-trending valley occupied by the Langworth river. These sands and gravels, which fill a shallow depression in the surrounding till, are very variable in composition, grading and thickness and are only concealed where modern Alluvium, up to 1.3 m thick, has been deposited. The surrounding Till, which covers much of this northern area (Block A), is barren.

On the western flank of the River Witham an area of higher ground, formed by till, is capped by Fluvio-glacial and Older River Sand and Gravel (Block D). Although variable in thickness, this sand and gravel is consistent in composition and notable for its lack of limestone. The till in this area is also barren.

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APPENDIX A

FIELD AND LABORATORY PROCEDURES

Trial and error during initial studies of the complex and variable glacial deposits of East Anglia and Essex showed that an absolute minimum of five sample points evenly distributed across the sand and gravel are needed to provide a worthwhile statistical assessment, but that, where possible, there should be not less than ten. Sample points are any points for which adequate information exists about the nature and thickness of the deposit and may include boreholes other than those drilled during the survey and exposures. In particular, the cooperation of sand and gravel operators ensures that boreholes are not drilled where reliable information is already available; although this may be used in the calculations, it is held confidentially by the Institute and cannot be disclosed.

The mineral shown on each 1:25 000 sheet is divided into resource blocks. The arbitrary size selected is a compromise to meet the aims of the survey by providing sufficient sample points in each block. As far as possible the block boundaries are determined by geological boundaries so that, for example, glacial and river terrace gravels are separated. Otherwise division is by arbitrary lines, which may bear no relationship to the geology. The blocks are drawn provisionally before drilling begins.

A reconnaissance of the ground is carried out to record any exposures and inquiries are made to ascertain what borehole information is available. Borehole sites are then selected to provide an even pattern of sample points at a density of approximately one per square kilometre. However, because broad trends are independently overlain by smaller-scale characteristically random variations, it is unnecessary to adhere to a square grid pattern. Thus such factors as ease of access and the need to minimise disturbance to land and the public are taken into account in siting the holes; at the same time it is necessary to guard against the possibility that ease of access (that is, the positions of roads and farms) may reflect particular geological conditions, which may bias the drilling results.

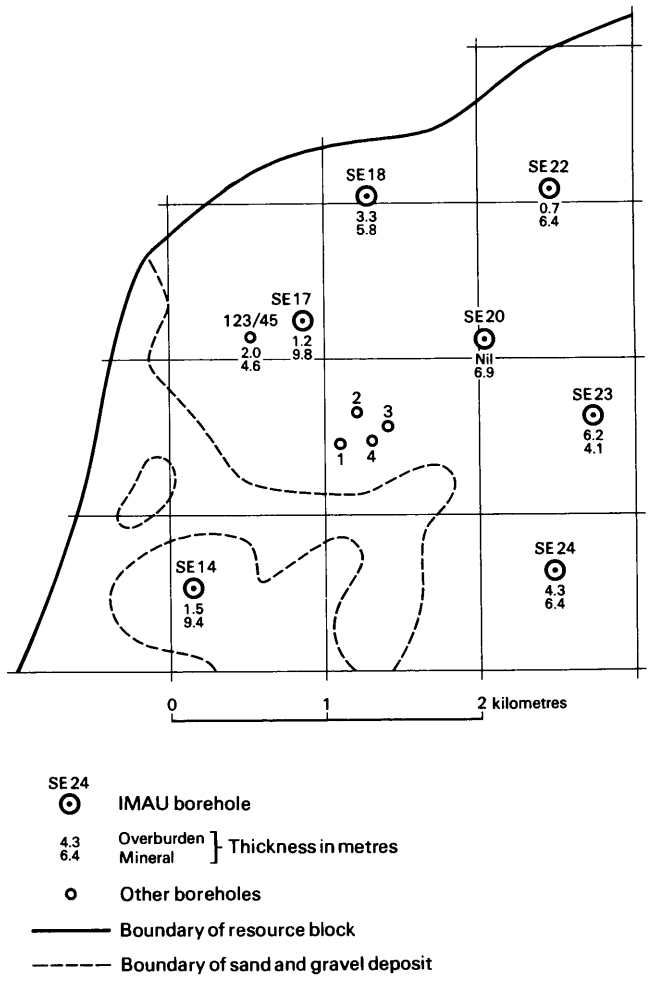
The drilling machine employed should be capable of providing a continuous sample representative of all unconsolidated deposits, so that the in-situ grading can be determined, if necessary, to a depth of 30 m (100 ft) at a diameter of about 200 mm (8 in), beneath different types of overburden. It should be reliable, quiet, mobile and relatively small (so that it can be moved to sites of difficult access). Shell and auger rigs have proved to be almost ideal.

The rigs are modified to enable deposits above the water table to be drilled 'dry', instead of with water added to facilitate the drilling, to minimise the amount of material drawn in from outside the limits of the hole. The samples thus obtained are representative of the in-situ grading, and satisfy one of the most important aims of the survey. Below the water table the rigs are used conventionally, although this may result in the loss of some of the fines fraction and the pumping action of the bailer tends to draw unwanted material into the hole from the sides or the bottom.

A continuous series of bulk samples is taken throughout the sand and gravel. Ideally samples are composed exclusively of the whole of the material encountered in the borehole between stated depths. However, care is taken to discard, as far as possible, material which has caved or has been pumped from the bottom of the hole. A new sample is commenced whenever there is an appreciable lithological change within the sand and gravel, or at every 1 m (3.3 ft) depth. The samples, each weighing between 25 and 45 kg (55 and 100 lb), are despatched in heavy-duty polythene bags to a laboratory for grading. The grading procedure is based on B.S. 1337 (British Standards Institution, 1967). Random checks of the accuracy of the grading are made in the Institute's laboratories.

All data, including mean grading analysis figures calculated for the total thickness of the mineral, are entered on standard record sheets, abbreviated copies of which are reproduced in Appendix E.

Detailed records may be consulted at the appropriate offices of the Institute, upon application to the Head, Industrial Minerals Assessment Unit.



Example of resource block assessment: map of a fictitious block

APPENDIX B

STATISTICAL PROCEDURE

Statistical assessment

1 A statistical assessment is made of an area of mineral greater than 2 km^2, if there are at least five evenly spaced boreholes in the resource block (for smaller areas, see Paragraph 12 below).

2 The simple methods used in the calculations are consistent with the amount of data provided by the survey (Hull, 1981). Conventional symmetrical confidence limits are calculated for the 95 per cent probability level, that is, on average nineteen out of every twenty sets of limits constructed in this way contain the true value for the volume of mineral.

3 The volume estimate (V) for the mineral in a given block is the product of two variables, the sampled areas (A) and the mean thickness ($\bar{l}_m$) calculated from the individual thicknesses at the sample points. The standard deviations for these variables are related such that

$$S_V = \sqrt{(S_A^2 + S_{\bar{l}_m}^2)} \qquad [1]$$

4 The above relationship may be transposed such that

$$S_V = S_{\bar{l}_m} \sqrt{(1 + S_A^2 / S_{\bar{l}_m}^2)} \qquad [2]$$

From this it can be seen that as $S_A^2 / S_{\bar{l}_m}^2$ tends to 0, S_V tends to $S_{\bar{l}_m}$.

If, therefore, the standard deviation for area is small with respect to that for thickness, the standard deviation for volume approximates to that for mean thickness.

5 Given that the number of approximately evenly spaced sample points in the sampled area is n with mineral thickness measurements $l_{m_1}, l_{m_2}, \ldots l_{m_n}$, then the best estimate of mean thickness, $\bar{l}_m$, is given by

$$\Sigma\ (l_{m_1} + l_{m_2} \ldots l_{m_n}) / n .$$

For groups of closely spaced boreholes a discretionary weighting factor may be applied to avoid bias (see note on weighting below). The standard deviation for mean thickness $S_{\bar{l}_m}$, expressed as a proportion of the mean thickness, is given by

$$S_{\bar{l}_m} = (1/\bar{l}_m) \sqrt{\ [\Sigma (l_m - \bar{l}_m)^2/(n-1)]}$$

where l_m is any value in the series l_{m_1} to l_{m_n}.

6 The sampled area in each resource block is coloured pink on the map. Wherever possible, calculations relate to the mineral within mapped geological boundaries (which may not necessarily correspond to the limits of a deposit). Where the area is not defined by a mapped boundary, that is, where the boundary is inferred, a distinctive symbol is used. Experience suggests that the errors in determining area are small relative to those in thickness. The relationship $S_A / S_{\bar{l}_m} \leqq 0.\dot{3}$ is assumed in all cases. It follows from Equation [2] that

$$S_{\bar{l}_m} \leqq S_V \leqq 1.05\, S_{\bar{l}_m} \qquad [3]$$

7 The limits on the estimate of mean thickness of mineral, $L_{\bar{l}_m}$, may be expressed in absolute units $\pm (t/\sqrt{n}) \times S_{\bar{l}_m}$ or as a percentage $\pm (t/\sqrt{n}) \times S_{\bar{l}_m} \times (100/\bar{l}_m)$ per cent, where t is Student's t at the 95 per cent probability level for $(n-1)$ degrees of freedom, evaluated by reference to statistical tables. (In applying Student's t it is assumed that the measurements are distributed normally).

8 Values of t at the 95 per cent probability level for values of n up to 20 are as follows:

n	t	n	t
1	infinity	11	2.228
2	12.706	12	2.201
3	4.303	13	2.179
4	3.182	14	2.160
5	2.776	15	2.145
6	2.571	16	2.131
7	2.447	17	2.120
8	2.365	18	2.110
9	2.306	19	2.101
10	2.262	20	2.093

(from Table 12 in *Biometrika Tables for Statisticians*, Volume 1, Second Edition, Cambridge University Press, 1962). When n is greater than 20, 1.96 is used (the value of t when n is infinity).

9 In calculating confidence limits for volume, L_V, the following inequality, corresponding to Equation [3], is applied:

$$L_{\bar{l}_m} \leqq L_V \leqq 1.05\, L_{\bar{l}_m}.$$

10 In summary, for values of n between 5 and 20, L_V is calculated as

$$[(1.05 \times t)/\bar{l}_m] \times [\sqrt{\Sigma}(l_m - \bar{l}_m)^2/n\ (n-1)] \times 100$$

per cent,

and when n is greater than 20, as

$$[(1.05 \times 1.96)/\bar{l}_m] \times [\sqrt{\Sigma}(l_m - \bar{l}_m)^2/n\ (n-1)] \times 100$$

per cent.

11 The application of this procedure to a fictitious area is illustrated in the accompanying Figure and example of a block calculation.

Inferred assessment

12 If the sampled area of mineral in a resource block is between 0.25 km^2 and 2 km^2, an assessment is inferred on the basis of geological and topographical information, usually supported by the data from one or two boreholes. The volume of mineral is calculated as the product of the area, measured from field data, and the estimated thickness. Confidence limits are not calculated.

13 In some cases a resource block may include an area left uncoloured on the map, within which mineral (as defined) is interpreted to be generally absent. If there is reason to believe that some mineral may be present, an inferred assessment may be made.

14 No assessment is attempted for an isolated area of mineral less than 0.25 km^2.

15 Note on weighting The thickness of a deposit at any point may be governed solely by the position of the point in relation to a broad trend. However, most sand and gravel deposits also exhibit a random pattern of local, and sometimes considerable, variation in thickness. Thus the distribution of sample points needs to be only approximately regular and in estimating the mean thickness only simple weighting is necessary. In practice, equal weighting can often be applied to thicknesses at all sample points. If, however, there is a distinctly unequal distribution of points, bias is avoided by dividing the sampled area into broad zones, to each of which a value roughly proportional to its area is assigned. This value is then shared between the data points with the zone as the weighting factor.

Block calculation

Scale: 1:25 000
Block: Fictitious

Area
Block: 11.08 km²
Mineral: 8.32 km²

Mean thickness
Overburden: 2.5 m
Mineral: 6.5 m

Volume
Overburden: 21 million m³
Mineral: 54 million m³

Confidence limits of the estimate of mineral volume at the 95 per cent probability level: ± 20 per cent
That is, the volume of mineral (with 95 per cent probability): 54 ± 11 million m³

Thickness estimate (measurements in metres)
l_o= overburden thickness l_m = mineral thickness

Sample point	Weighting w	Overburden l_o	Overburden wl_o	Mineral l_m	Mineral wl_m	Remarks
SE 14	1	1.5	1.5	9.4	9.4	IMAU boreholes
SE 18	1	3.3	3.3	5.8	5.8	
SE 20	1	nil	-	6.9	6.9	
SE 22	1	0.7	0.7	6.4	6.4	
SE 23	1	6.2	6.2	4.1	4.1	
SE 24	1	4.3	4.3	6.4	6.4	
SE 17	½	1.2	1.6	9.8	7.2	Hydrogeology Unit record
123/45	½	2.0		4.6		
1	¼	2.7	2.6	7.3	5.8	Close group of four boreholes (commercial)
2	¼	4.5		3.2		
3	¼	0.4		6.8		
4	¼	2.8		5.9		
Totals	$\Sigma w = 8$	$\Sigma wl_o = 20.2$		$\Sigma wl_m = 52.0$		
Means		$\overline{wl}_o = 2.5$		$\overline{wl}_m = 6.5$		

Calculation of confidence limits

wl_m	$\lvert(wl_m - \overline{wl}_m)\rvert$	$(wl_m - \overline{wl}_m)^2$
9.4	2.9	8.41
5.8	0.7	0.49
6.9	0.4	0.16
6.4	0.1	0.01
4.1	2.4	5.76
6.4	0.1	0.01
7.2	0.7	0.49
5.8	0.7	0.49

$\Sigma(wl_m - \overline{wl}_m)^2 = 15.82$

$n = 8$

$t = 2.365$

L_V is calculated as

$1.05\ (t/\overline{wl}_m)\ \sqrt{[\Sigma(wl_m - \overline{wl}_m)^2 / n(n-1)]} \times 100$

$= 1.05 \times (2.365/6.5)\ \sqrt{[15.82/(8 \times 7)]} \times 100$

$= 20.3$

$\simeq 20$ per cent.

APPENDIX C

CLASSIFICATION AND DESCRIPTION OF SAND AND GRAVEL

For the purposes of assessing resources of sand and gravel a classification should take account of economically important characteristics of the deposit, in particular the absolute content of fines and the ratio of sand to gravel.

The terminology commonly used by geologists when describing sedimentary rocks (Wentworth, 1922) is not entirely satisfactory for this purpose. For example, Wentworth proposed that a deposit should be described as a 'gravelly sand' when it contains more sand than gravel and there is at least 10 per cent of gravel, provided that there is less than 10 per cent of material finer than sand (< $\frac{1}{16}$ mm) and coarser than pebbles (> 64 mm in diameter). Because deposits containing more than 10 per cent fines are not embraced by this system, a modified binary classification based on Willman (1942) has been adopted.

When the fines content exceeds 40 per cent the material is considered to be not potentially workable and falls outside the definition of mineral. Deposits which contain 40 per cent fines or less are classified primarily on the ratio of sand to gravel but qualified in the light of the fines content, as follows: less than 10 per cent fines - no qualification; 10 per cent or more but less than 20 per cent fines - 'clayey'; 20 to 40 per cent fines - 'very clayey'.

The term 'clay' (as written, with single quote marks) is used to describe all material passing $\frac{1}{16}$ mm. Thus it has no mineralogical significance and includes particles falling within the size range of silt. The normal meaning applies to the term clay where it does not appear in single quotation marks.

The ratio of sand to gravel defines the boundaries between sand, pebbly sand, sandy gravel and gravel (at 19:1, 3:1 and 1:1).

Thus it is possible to classify the mineral into one of twelve descriptive categories (see the accompanying Figure). The procedure is as follows:

1 Classify according to the ratio of sand to gravel.
2 Describe the fines.

For example, a deposit grading 11 per cent gravel, 70 per cent sand and 19 per cent fines is classified as 'clayey' pebbly sand. This short description is included in the borehole log (see Appendix D)

Many differing proposals have been made for the classification of the grain size of sediments (Atterberg, 1905; Udden, 1914; Wentworth, 1922; Wentworth, 1935; Allen, 1936; Twenhofel, 1937; Lane and others, 1947). As Archer (1970a, b) has emphasised, there is a pressing need for a simple metric scale acceptable to both scientific and engineering interests, for which the class limit sizes correspond closely with certain marked changes in the natural properties of mineral particles. For example, there is an important change in the degree of cohesion between particles at about the $\frac{1}{16}$-mm size, which approximates to the generally accepted boundary between silt and sand. These and other requirements are met by a system based on Udden's geometric scale and a simplified form of Wentworth's terminology (see the accompanying table), which is used in the Report.

The fairly wide intervals in the scale are consistent with the general level of accuracy of the qualitative assessments of the resource blocks. Three sizes of sand are recognised, fine (+$\frac{1}{16}$ -$\frac{1}{4}$ mm), medium (+$\frac{1}{4}$ -1 mm) and coarse (+1 -4 mm). The boundary at 16 mm distinguishes a range of finer gravel (+4 -16 mm), often characterised by abundance of worn tough pebbles of vein quartz, from larger pebbles, often of notably different materials. The boundary at 64 mm distinguishes pebbles from cobbles. The term 'gravel' is used loosely to denote both pebble-sized and cobble-sized material.

The size distribution of borehole samples is determined by sieve analysis, which is presented by the laboratory as logarithmic cumulative curves (see, for example, British Standards Institution, 1967). In this report the grading is tabulated on the borehole record sheets (Appendix E), the intercepts corresponding with the simple geometric scale $\frac{1}{16}$ mm, $\frac{1}{4}$ mm, 1 mm, 4 mm, 16 mm and so on as required. Original sample grading curves are available for reference at the appropriate office of the Institute.

Each bulk sample is described, subjectively, by a geologist at the borehole site. Being based on visual examination, the description of the grading is inexact, the accuracy depending on the experience of the observer. The descriptions recorded are modified, as necessary, when the laboratory results become available.

The relative proportions of the rock types present in the gravel fraction are indicated by the use of the words 'and' or 'with'. For example, 'flint and quartz' indicates roughly equal proportions with neither constituent accounting for less than about 25 per cent of the whole; 'flint with quartz' indicates that flint is dominant and quartz, the principal accessory rock type, comprises 5 to 25 per cent of the whole. Where the accessory material accounts for less than 5 per cent of the whole, but is still readily apparent, the phrase 'with some' has been used. Rare constitutents are referred to as 'trace'.

The terms used in the field to describe the degree of rounding of particles, which is concerned with the sharpness of the edges and corners of a clastic fragment and not the shape (after Pettijohn, 1957), are as follows.

Angular: showing little or no evidence of wear; sharp edges and corners.

Subangular: showing definite effects of wear. Fragments still have their original form but edges and corners begin to be rounded off.

Subrounded: showing considerable wear. The edges and corners are rounded off to smooth curves. Orignial grain shape is still distinct.

Rounded: original faces almost completely destroyed, but some comparatively flat surfaces may still remain. All original edges and corners have been smoothed off to rather broad curves. Original shape is still apparent.

Well rounded: not original faces, edges or corners left. The entire surface consists of broad curves; flat areas are absent. The original shape is suggested by the present form of the grain.

Classification of gravel, sand and fines

Size limits	Grain-size description	Qualification	Primary classification
	Cobble		
64 mm			
		Coarse	Gravel
16 mm	Pebble		
		Fine	
4 mm			
		Coarse	
1 mm			
	Sand	Medium	Sand
$\frac{1}{4}$ mm			
		Fine	
$\frac{1}{16}$ mm			
	Fines (silt and clay)		Fines

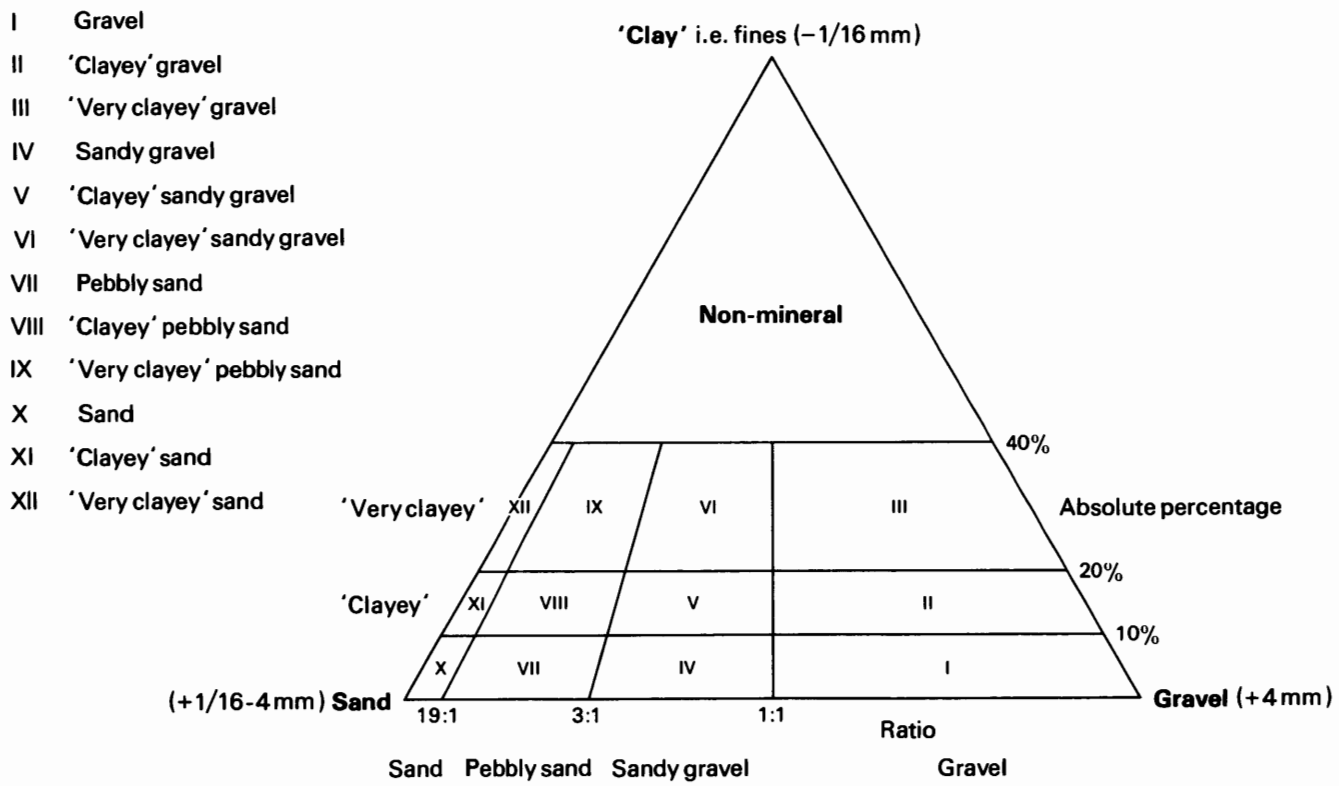


Diagram showing the descriptive categories used in the classification of sand and gravel

APPENDIX D

EXPLANATION OF THE BOREHOLE RECORDS

Annotated fictitious example

CK 66 NW 5 **6191 6962** **Northfields**[1] **Block B**

Surface level (+49.7 m) +163 ft[2]
Water struck at +45.9 m[3]
October 1972[4]

Overburden 2.8 m
Mineral 5.4 m
Bedrock 0.7 m+[5]

LOG

Geological classification	Lithology[6]	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Clay, silty, dark brown	2.6	2.8
River Terrace Deposits	**a** Gravel Gravel: fine to coarse, with cobbles towards base, angular to rounded flint and limestone with ironstone and some quartz and chalk Sand: medium with coarse and some fine, quartz and limestone	5.4	8.2
Boulder Clay	Clay, sandy and pebbly, red-brown	1.1	9.3
Glacial Sand and Gravel	**b** Sand, 'clayey' in part: fine, subangular to rounded, quartz with some coal	1.4	10.7
Lias	Mudstone, blue-grey, fossiliferous	0.7+	11.4

GRADING[7]

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	5	46	49	2.8-3.8	20	14	62	2	2		
				3.8-4.8	2	2	12	18	42	24	
				4.8-5.8	1	3	24	13	35	24	
				5.8-6.8	0	4	21	20	26	29	
				6.8-8.2	4	3	23	10	23	30	7
				Mean	5	5	28	13	25	22	2
b	5	95	0	9.3-10.3	3	73	23	1			
				10.3-10.7	9	85	5	1			
				Mean	5	77	17	1			
a+b	5	56	39	Mean	5	20	26	10	20	17	2

COMPOSITION[8]

percentages by weight in gravel fraction

Depth below surface (m)	Flint	Quartz	Limestone	Chalk	Ironstone
3.8-4.8	41	5	50	1	3
4.8-5.8	39	3	45	5	8
5.8-6.8	45	2	42	5	6
6.8-8.2	19	6	61	3	11
Mean	35	4	51	3	7

The numbered paragraphs below correspond with the annotations given on the specimen record opposite.

1 Location
The position of the borehole is generally referred to the nearest named locality on the 1:25 000 base map and the resource block in which the borehole lies is stated.

2 Surface level
The surface level at the borehole site is given in metres and feet above Ordnance Datum. All measurements were made in feet; approximate conversions to metres are given in brackets.

3 Groundwater conditions
If groundwater was present, the level at which it was encountered or the level at which it stood on completion of drilling is normally given (in metres relative to Ordnance Datum).

4 Type of drill and date of drilling
Unless otherwise stated the borehole was drilled by a shell and auger rig using 152 mm diameter casing. The month and year of completion of drilling are stated.

5 The plus sign (+) indicates that the base of the deposit was not reached during drilling.

6 Lithological description
When sand and gravel is recorded a general description based on the grading characteristics (for details see Appendix C) is followed by more detailed particulars of the gravel and/or sand fractions. Where more than one bed of mineral is recognised each is designated by a letter, e.g. **a, b,** etc. The description of other deposits is based on visual examination in the field.

7 Grading data
A continuous series of bulk samples is taken throughout the thickness of sand and gravel. A new sample is commenced whenever there is appreciable lithological change or at every 1 m of depth.

For each bulk sample the percentages of fines ($-\frac{1}{16}$ mm), fine sand ($+\frac{1}{16}$-$\frac{1}{4}$ mm), medium sand ($+\frac{1}{4}$-1 mm), coarse sand (+1-4 mm), fine gravel (+1-4 mm), fine gravel (+4-16 m) and coarse and cobble gravel (+16 mm) are stated.

The mean grading of groups of samples making up an identified bed of mineral are also given in detail and in summary. Where more than one bed is recognised the mean grading for the whole of the mineral in the borehole may be given. Where necessary, in calculating mean gradings, data for individual samples are weighted by the thickness represented. If, exceptionally, grading results are not available for a sample, an attempt may be made to estimate the grading by comparing the grading and field descriptions of adjacent samples with the sample in question. Such estimates are shown in square brackets.

Fully representative sampling of sand and gravel is difficult to achieve, particularly where groundwater levels are high. Comparison between boreholes and adjacent exposures commonly suggests that in borehole samples the proportion of sand may be higher and the proportion of fines and coarse gravel may be lower.

8 Composition
Details of the composition of selected samples or groups of samples may be given. Where appropriate the calculated weighted mean composition of groups of samples may be quoted.

APPENDIX E

INDUSTRIAL MINERALS ASSESSMENT UNIT BOREHOLE RECORDS

TF 06 NW 30 **0416 6896** **Heighinton** **Block D**

Surface level +78 ft (+23.8 m)
Water struck at +19.9 m
May 1979

Waste 2.5 m
Bedrock 4.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.9	0.9
Fluvio-glacial and Older River Sand and Gravel	Clay, silty, greyish brown with orange-brown mottling	0.2	1.1
	Clay, reddish brown with pebbles of chalk	1.4	2.5
Great Oolite Limestone	Sandy, silty, clay, grey-brown, fossiliferous	4.3+	6.8

TF 06 NW 31 **0477 6833** **North of Branston Moor** **Block D**

Surface level (+19.5 m) +64 ft
Water not encountered
May 1979

Overburden 0.9 m
Mineral 3.3 m
?Bedrock

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.9	0.9
Fluvio-glacial and Older River Sand and Gravel	Sandy gravel Gravel: fine, subrounded quartzite with quartz, sandstone and angular flint Sand: medium, quartz and dark rock fragments	3.3	4.2
?Bedrock	Borehole abandoned at 4.2 m; no progress and no sample recovered		

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
6	65	29	0.9-2.1	8	9	38	15	24	6	0
			2.1-3.1	5	10	37	15	25	8	0
			3.1-4.2	4	7	48	16	21	4	0
			Mean	6	9	41	15	23	6	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
0.9-2.1	14	55	-	14	16	-	1	-
2.1-3.1	14	58	-	14	13	-	1	-
3.1-4.2	14	54	1	11	20	-	-	-
Mean	14	56	-	13	16	-	1	-

TF 06 NE 16 **0673 6942** **Branston Booths** **Block C**

Surface level (+1.8 m) +6 ft
Water struck at +0.8 m
May 1979

Overburden 1.4 m
Mineral 6.3 m
Bedrock 1.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.7	0.7
Marine or Estuarine Alluvium	Sandy clay, yellowish brown	0.7	1.4
River Gravels	**a** Pebbly sand Gravel: fine subangular to subrounded quartzite Sand: medium quartz and dark rock fragments	1.1	2.5
	b Gravel Gravel: fine with coarse, subangular to subrounded quartzite with some quartz and angular to subangular flint Sand: medium and coarse, quartz with some quartzite and dark rock fragments	2.9	5.4
	c Pebbly sand, 'clayey' from 6.4 to 7.2 m Gravel: fine, subrounded quartz with angular flint Sand: medium, subrounded quartz with some rock fragments including flint	2.3	7.7
Ancholme Clay Group	Silty clay, greenish grey, fossiliferous	1.3+	9.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	4	81	15	1.4-2.5	4	7	65	9	10	5	0
b	1	44	55	2.5-3.4	1	4	30	11	34	20	0
				3.4-4.4	1	8	22	11	42	16	0
				4.4-5.4	1	5	23	17	38	16	0
				Mean	1	6	25	13	38	17	0
c	6	80	14	5.4-6.4	2	8	45	23	21	1	0
				6.4-7.2	13	7	57	14	9	0	0
				7.2-7.7	2	7	75	11	5	0	0
				Mean	6	8	55	17	13	1	0
a+b+c	3	64	33	1.4-7.7	3	7	43	14	24	9	0

TF 06 NE 17 **0781 6888** **Branston Fen** **Block C**

Surface level (+1.5 m) +5 ft
Water struck at -1.5 m
May 1979

Overburden 2.8 m
Mineral 7.9 m
Bedrock 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Peaty soil and fill	1.4	1.4
Marine or Estuarine Alluvium	Clay, greenish grey with plant debris	1.4	2.8
River Gravels	**a** Sand, 'clayey' at top, 'clayey' and pebbly at base Gravel: fine, subrounded limestone with some rounded quartz, sandstone and subangular flint Sand: fine and medium, quartz with some limestone and dark rock fragments	3.2	6.0
	b Sandy Gravel Gravel: fine, rounded to subrounded quartzite with limestone, quartz, sandstone, flint and some ironstone	4.7	10.7
	Sand: medium, quartz with some dark rock fragments	1.1+	11.8
Ancholme Clay Group	Clay, greenish grey		

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	8	88	4	2.8-4.0	11	48	41	trace	0	0	0
				4.0-5.0	3	53	42	2	0	0	0
				5.0-6.0	10	20	54	5	11	trace	0
				Mean	8	41	45	2	4	trace	0
b	1	66	33	6.0-7.0	1	4	41	15	27	12	0
				7.0-8.0	1	4	39	21	26	9	0
				8.0-9.0	1	13	47	22	16	1	0
				9.0-10.0	0	6	36	22	28	8	0
				10.0-10.7	0	7	42	15	26	10	0
				Mean	1	6	41	19	25	8	0
a+b	4	75	21	2.8-10.7	4	20	43	12	16	5	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
6.0-7.0	12	45	24	10	6	-	3	-
7.0-8.0	6	46	19	16	10	-	3	-
8.0-10.7	12	49	16	12	7	-	4	-
Mean	11	48	18	12	7	-	4	-

TF 06 NE 18 **0908 6936** **Branston Fen** **Block C**

Surface level (+1.2 m) +4 ft
Water struck at -2.8 m
May 1979

Overburden 4.5 m
Mineral 6.1 m
Bedrock 1.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Fill and peaty soil	1.6	1.6
Marine or Estuarine Alluvium	Silty clay, greyish brown and brown clay at base	2.9	4.5
River Gravels	**a** Sandy gravel Gravel: fine, angular to subangular flint with some subangular to subrounded quartzite, quartz and limestone Sand: medium, quartz with dark rock fragments	3.1	7.6
	b Gravel Gravel: fine with coarse, subangular to subrounded quartzite with some sandstone, quartz and angular flint Sand: medium to coarse, quartz with dark rock fragments	3.0	10.6
Ancholme Clay Group	Silty clay, greenish grey, laminated	1.3+	11.9

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	1	71	28	4.5-5.5	2	18	37	13	27	3	0
				5.5-6.5	1	12	53	14	16	4	0
				6.5-7.6	1	10	45	12	25	7	0
				Mean	1	13	45	13	23	5	0
b	2	47	51	7.6-8.8	2	6	35	18	31	8	0
				8.8-9.8	0	3	33	12	31	21	0
				9.8-10.6	3	3	13	16	45	20	0
				Mean	2	4	28	15	35	16	0
a+b	1	60	39	4.5-10.6	1	9	37	14	29	10	0

TF 06 NE 19 **0579 6878** **Branston Lodge Farm** **Block D**

Surface level (+13.1 m) +43 ft
Water not encountered
May 1979

Waste 5.9 m
Bedrock 1.1+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Sandy clay, orange-brown with grey mottling	1.3	1.4
	Clay, grey with pebbles of chalk	4.5	5.9
Kellaways Beds	Silty clay, greenish grey, fossiliferous	1.1+	7.0

TF 06 NE 20 **0771 6802** **Willow Farm** **Block C**

Surface level (+0.9 m) +3 ft
Water struck at -1.6 m
May 1979

Overburden 2.5 m
Mineral 6.8 m
Bedrock 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.3	0.3
Marine or Estuarine Alluvium	Silty clay, greenish grey, peaty below 2.1 m	2.2	2.5
River Gravels	**a** Sandy gravel Gravel: fine, subangular to subrounded quartzite and limestone with quartz and sandstone Sand: medium, quartz and limestone with dark rock fragments	3.0	5.5
	b Sand, medium with fine, quartz	3.8	9.3
Ancholme Clay Group	Silty clay, greenish grey	1.1+	10.4

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	3	67	30	2.5-3.5	2	7	38	12	30	11	0
				3.5-4.5	2	8	62	8	13	7	0
				4.5-5.5	3	12	47	9	23	6	0
				Mean	2	9	49	10	22	8	0
b	2	97	1	5.5-6.7	2	31	63	2	2	0	0
				6.7-7.5	1	26	73	trace	trace	0	0
				7.5-8.5	1	15	84	trace	0	0	0
				8.5-9.3	2	24	71	1	2	trace	0
				Mean	2	24	72	1	1	trace	0
a+b	2	84	14	2.5-9.3	2	18	62	4	10	4	0

TF 06 NE 21 **0992 6871** **Branston Causeway** **Block C**

Surface level (+0.9 m) +3 ft
Water struck at -0.6 m
May 1979

Overburden 3.1 m
Mineral 7.3 m
Bedrock 0.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.4	0.4
Marine or Estuarine Alluvium	Clay, brownish grey with some plant debris	0.6	1.0
	Peat, olive-grey at top to yellowish brown at base; sandy below 1.6 m	1.5	2.5
	Clay, pale brown with bluish grey veins and plant debris	0.6	3.1

River Gravels	**a** Sandy gravel Gravel: fine, subrounded limestone with angular flint Sand: medium quartz with some limestone	4.0	7.1
	b Sandy gravel Gravel: fine with coarse, subrounded quartzite and limestone with some sandstone, quartz and angular flint Sand: medium quartz with some limestone	3.3	10.4
Ancholme Clay Group	Clay, greenish grey	0.6+	11.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	2	70	28	3.1-4.1	3	21	38	14	24	0	0
				4.1-5.1	1	13	36	15	28	7	0
				5.1-6.1	1	14	42	15	25	3	0
				6.1-7.1	3	11	50	12	22	2	0
				Mean	2	15	41	14	25	3	0
b	2	65	33	7.1-8.1	3	11	61	10	12	3	0
				8.1-9.1	2	9	40	9	28	12	0
				9.1-10.4	0	9	42	7	28	14	0
				Mean	2	9	47	9	23	10	0
a+b	2	68	30	3.1-10.4	2	12	44	12	24	6	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
3.1-4.1	75	2	23	-				
4.1-5.1	70	7	23	-				
5.1-6.1	58	3	37	2				
6.1-7.1	41	12	41	6				
Mean	60	6	32	2				
7.1-8.1	9	53	4	24	9	-	1	
8.1-9.1	12	57	8	18	5	-	-	
9.1-10.4	15	58	4	14	9	-	-	
Mean	13	57	6	17	7	-	trace	
Mean	36	32	20	9	3	-	trace	

TF 06 NE 22 **0679 6767** **Mere Oaks Farm** **Block D**

Surface level (+21.9 m) +72 ft
Water not encountered
May 1979

Waste 19.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.7	0.7
Fluvio-glacial and Older River Sand and Gravel	'Clayey' sand, yellowish orange	0.2	0.9

Till	Clay, grey with orange-brown mottling and pebbles of chalk	1.6	2.5
	Silty clay, dark grey with brown mottling, laminated in parts	0.7	3.2
	Clay, dark greyish brown with pebbles of chalk, flint, red marl and black mudstone: mudstone dominant erratic below 10.0 m	16.2+	19.4

TF 06 NE 23 **0906 6759** **Potter Hanworth Fen** **Block C**

Surface level (+2.7 m) +9 ft
Water struck at -0.6 m
April 1979

Overburden 3.5 m
Mineral 7.1 m
Bedrock 0.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Fill	1.2	1.2
Marine or Estuarine Alluvium	Clay, yellowish brown, silty; peat at top	0.4	1.6
	Clay, olive-grey, silty with plant debris	1.4	3.0
	Peat, brown with clay	0.2	3.2
	Clay, olive-grey, silty	0.3	3.5
River Gravels	**a** Sand, medium, quartz	3.0	6.5
	b Sandy gravel Gravel: fine and coarse, subrounded quartzite with limestone, well rounded quartz and some angular flint Sand: medium, quartz with some dark rock fragments	4.1	10.6
Ancholme Clay Group	Clay, greenish grey	0.7+	11.3

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	4	94	2	3.5-4.5	3	25	71	1	trace	0	0
				4.5-5.5	4	23	72	1	trace	0	0
				5.5-6.5	4	24	62	6	4	0	0
				Mean	4	24	68	2	2	0	0
b	1	64	35	6.5-7.5	3	8	49	11	20	9	0
				7.5-8.5	0	7	61	9	17	6	0
				8.5-9.5	0	4	31	10	44	11	0
				9.5-10.6	1	8	49	9	18	15	0
				Mean	1	6	48	10	24	11	0
a+b	2	77	21	3.5-10.6	2	14	56	7	15	6	0

TF 06 NE 24 **0579 6688** **Moor Lane** **Block D**

Surface level (+19.8 m) +65 ft
Water struck at +16.0 m
May 1979

Overburden 0.5 m
Mineral 3.3 m
Bedrock 5.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy with pebbles	0.5	0.5
Fluvio-glacial and Older River Sand and Gravel	Sandy gravel Gravel: fine, subrounded quartzite with quartz, sandstone and angular flint Sand: medium, subrounded quartz with flint	3.3	3.8
Kellaways Beds	Sandy silt, olive-grey to greenish grey, micaceous	5.9+	9.7

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
6	69	25	0.5-1.5	5	12	48	12	20	3	0
			1.5-2.5	7	18	51	12	12	0	0
			2.5-3.8	5	12	24	21	33	5	0
			Mean	6	14	40	15	22	3	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
0.5-3.8	17	60	-	9	14	-	-	-

TF 06 NE 25 **0766 6699** **Potter Hanworth Fen** **Block C**

Surface level (+2.1 m) +7 ft
Water struck at -1.1 m
May 1979

Overburden 3.2 m
Mineral 8.5 m
Bedrock 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Marine or Estuarine Alluvium	Clay, olive-grey and brown, sandy at base; peaty between 0.5 and 1.6 m	2.9	3.2
River Gravels	**a** 'Clayey' pebbly sand Gravel: fine and coarse, subrounded quartzite with limestone Sand: fine and medium, quartz	1.0	4.2
	b Sandy gravel Gravel: fine, subrounded to rounded quartzite with limestone, well rounded quartz, angular flint and some subrounded sandstone Sand: fine to coarse, quartz with some limestone and flint	2.0	6.2

	c Sandy gravel Gravel: fine with coarse subrounded to rounded quartzite with quartz, sandstone, angular flint and some limestone Sand: medium with coarse, quartz with some dark rock fragments	5.5	11.7
Ancholme Clay Group	Clay, greenish grey	1.1+	12.8

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	11	80	9	3.2-4.2	11	40	38	2	5	4	0
b	2	62	36	4.2-5.2	2	14	34	10	30	10	0
				5.2-6.2	2	12	40	14	26	6	0
				Mean	2	13	37	12	28	8	0
c	2	52	46	6.2-7.2	2	9	36	10	30	13	0
				7.2-8.2	1	4	33	8	32	22	0
				8.2-9.2	1	7	52	6	23	11	0
				9.2-10.2	3	3	36	17	31	10	0
				10.2-11.2	0	2	23	10	36	29	0
				11.2-11.7	2	2	25	26	31	14	0
				Mean	2	5	35	12	30	16	0
a+b+c	3	57	40	3.2-11.7	3	11	36	10	27	13	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
4.2-5.2	13	42	18	19	7	-	1	-
5.2-6.2	13	34	23	22	6	-	2	-
Mean	13	38	21	20	7	-	1	-
6.2-7.2	16	48	7	18	10	-	1	-
7.2-8.2	15	49	3	23	9	-	1	-
8.2-9.2	16	54	4	15	10	-	1	-
9.2-10.2	18	49	3	18	12	-	-	-
10.2-11.2	15	53	3	18	11	-	-	-
11.2-11.7	9	50	3	31	7	-	-	-
Mean	15	51	4	19	10	-	1	-
4.2-11.7	14	46	10	20	9	-	1	-

TF 06 NE 26 **0859 6656** **South-west of Glebe Farm** **Block C**

Surface level (+1.5 m) +5 ft
Water struck at -2.0 m
April 1979

Overburden 3.5 m
Mineral 1.1 m
Waste 0.8 m
Mineral 7.4 m
Bedrock 0.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Fill	1.2	1.2
Marine or Estuarine Alluvium	Clayey silt, yellowish brown and peaty at top, olive-grey below 2.6 m with plant debris	2.0	3.2

	Peat, yellowish brown but olive-grey where more silty	0.3	3.5
	a Sand, medium subrounded quartz	1.1	4.6
	Clayey silt, pale brown with bands of fine quartz sand	0.8	5.4
River Gravels	**b** Sandy gravel Gravel: fine, subangular limestone with subrounded to rounded quartzite, angular flint and rounded to well rounded quartz Sand: fine to coarse, subrounded quartz with some limestone	3.0	8.4
	c Gravel, sandy to 9.4 m Gravel: fine and coarse, subrounded quartzite with rounded to well rounded quartz, angular flint and some sandstone and limestone Sand: medium quartz	4.4	12.8
Ancholme Clay Group	Clay, greenish grey	0.8+	13.6

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	8	92	0	3.5-4.6	8	7	84	1	0	0	0
b	2	62	36	5.4-6.4	3	14	35	14	31	3	0
				6.4-7.4	1	10	34	13	34	8	0
				7.4-8.4	0	8	49	16	23	4	0
				Mean	2	11	37	14	31	5	0
c	1	54	45	8.4-9.4	0	7	65	14	13	1	0
				9.4-10.4	0	3	29	10	29	29	0
				10.4-11.5	0	3	32	8	36	21	0
				11.5-12.8	1	2	38	9	26	24	0
				Mean	1	4	40	10	26	19	0
a+b+c	2	62	36	Mean	2	7	45	10	24	12	0

TF 06 NE 27 **0525 6563** **Rectory, Potter Hanworth** **Block D**

Surface level (+16.2 m) +53 ft
Water not encountered
May 1979

Waste 1.2 m
Bedrock 0.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Fill	0.1	0.1
Till	Clay, olive-grey to brown at top yellowish orange at base with small pebbles of limestone; limestone rubble between 0.4 and 0.8 m	1.1	1.2
Great Oolite Limestone	Limestone, pale orange	0.8+	2.0

TF 06 NE 28 **0673 6548** **Nocton Fen Lane** **Block D**

Surface level (+18.3 m) +60 ft
Water struck at +16.5 m
May 1979

Overburden 0.4 m
Mineral 2.9 m
Waste 10.7 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.4	0.4
Fluvio-glacial and Older River Sand and Gravel	Sandy gravel, 'clayey' to 1.8 m Gravel: fine with coarse, subrounded quartzite with well rounded quartz, angular flint and some subrounded sandstone Sand: medium with coarse, quartz with some flint and quartzite	2.9	3.3
Till	Clay, olive-grey with pebbles of limestone, flint and black mudstone	10.7	14.0
Ancholme Clay Group	Clay, olive-grey, fossiliferous	1.0+	15.0

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
9	54	37	0.4-1.8	11	11	36	12	19	11	0
			1.8-3.3	7	5	29	17	30	12	0
			Mean	9	8	32	14	25	12	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
1.4-1.8	13	51	2	24	8	-	2	-
1.8-3.3	16	58	-	17	9	-	-	-
Mean	15	55	1	19	9	-	1	-

TF 06 NE 29 **0905 6578** **Nocton Fen** **Block C**

Surface level (+1.8 m) +6 ft
Water struck at -1.6 m
April 1979

Overburden 3.6 m
Mineral 9.5 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and fill	0.7	0.7
Marine or Estuarine Alluvium	Clay, olive-grey but yellowish brown to 1.2 m with plant debris; thin peat bands at 0.7 m and 3.1 m	2.9	3.6
River Gravels	a 'Clayey' sand Sand: fine and medium quartz Fines: olive-grey silt	1.0	4.6

	b Pebbly sand, sand at base Gravel: fine, subrounded quartzite with limestone angular flint, rounded quartz, and sandstone Sand: medium, quartz with dark angular rock fragments	5.1	9.7
	c Gravel Gravel: fine and coarse, subrounded quartzite with rounded quartz, angular flint, subrounded sandstone and some limestone Sand: medium with coarse, quartz with some dark angular rock fragments	3.4	13.1
Ancholme Clay Group	Clay, greenish grey	0.9+	14.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	13	87	0	3.6-4.6	13	46	40	1	0	0	0
b	4	75	21	4.6-6.5	6	22	49	6	16	1	0
				6.5-7.5	1	11	36	6	28	18	0
				7.5-8.5	5	17	44	7	17	10	0
				8.5-9.7	4	14	76	3	2	1	0
				Mean	4	17	52	6	15	6	0
c	1	47	52	9.7-10.7	1	5	28	6	24	36	0
				10.7-11.7	2	2	27	15	37	17	0
				11.7-12.7	0	2	32	17	36	13	0
				12.7-13.1	2	3	36	20	29	9	1
				Mean	1	3	30	14	32	20	0
a+b+c	4	66	30	3.6-13.1	4	15	43	8	20	10	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
4.6-6.5	22	58	10	7	3	-	-	-
6.5-7.5	9	56	9	15	9	-	1	1
7.5-8.5	15	58	7	12	6	-	2	-
Mean	13	57	9	13	7	-	1	-
9.7-10.7	14	56	3	15	8	-	3	1
10.7-11.7	19	43	3	21	14	-	-	-
11.7-12.7	18	49	2	21	10	-	-	-
12.7-13.1	17	51	6	19	7	-	-	-
Mean	17	49	3	19	11	-	1	-
Mean	16	52	5	17	9	-	1	-

TF 06 NE 30 **0860 6514** **Wasps Nest** **Block C**

Surface level (+2.4 m) +8 ft
Water struck at -1.8 m
April 1979

Overburden 4.4 m
Mineral 7.3 m
Bedrock 1.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and fill	0.6	0.6
Marine or Estuarine Alluvium	Clay, olive-grey with plant debris and 0.1 m of peat at base	1.3	1.9

	Gravel Gravel: fine subangular to subrounded limestone with some quartzite and flint Sand: fine quartz and coarse limestone	0.8	2.7
	Clay, brown with bluish grey mottling; sandy at base	1.7	4.4
River Gravels	**a** Pebbly sand Gravel: fine subrounded limestone Sand: fine and medium, quartz	1.0	5.4
	b Sandy gravel Gravel: fine, subangular to subrounded quartzite with limestone and angular flint Sand: medium, quartz	2.1	7.5
	c Sandy gravel Gravel: fine and coarse, subrounded quartzite with rounded to well rounded quartz, angular flint, subangular to subrounded sandstone and some limestone Sand: medium, quartz with some flint and limestone	4.2	11.7
Ancholme Clay Group	Clay, olive-grey, fossiliferous	1.3+	13.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	9	84	7	4.4-5.4	9	41	35	8	7	0	0
b	1	72	27	5.4-5.8	5	20	39	12	22	2	0
				5.8-7.5	1	13	43	15	24	4	0
				Mean	1	14	43	15	24	3	0
c	0	56	44	7.5-8.5	trace	8	35	11	33	13	0
				8.5-9.5	trace	5	40	12	23	20	0
				9.5-10.5	trace	4	31	11	32	20	2
				10.5-11.7	trace	15	39	9	20	17	0
				Mean	0	8	37	11	27	17	trace
a+b+c	2	64	34	4.4-11.7	2	15	38	11	23	11	0

TF 06 SE 21 **0701 6455** **Stockdove Holt** **Block D**

Surface level (+16.2 m) +53 ft
Water not encountered
May 1979

Waste 11.8 m
Bedrock 0.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and fill	0.9	0.9
Till	Clay, yellowish brown with small pebbles of limestone and chalk to 5.0 m then greyish brown to olive-brown with olive-black mudstone and traces of red mudstone and chalk	10.9	11.8
Ancholme Clay Group	Clay, olive-grey, silty, well-bedded, fossiliferous	0.7+	12.5

TF 06 SE 22 **0953 6420** **Willow Farm** **Block C**

Surface level (+2.1 m) +7 ft
Water level not recorded
April 1979

Overburden 0.5 m
Mineral 12.0 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
River Gravels	**a** Sandy gravel Gravel: fine, subangular to subrounded limestone with some subrounded to rounded quartz and quartzite Sand: fine to coarse quartz with coarse subangular to subrounded limestone	6.5	7.0
	b Sandy gravel Gravel: fine with coarse, rounded to subrounded quartzite with rounded quartz, angular flint, subrounded sandstone and some limestone Sand: medium with coarse, quartz with some dark rock fragments	5.5	12.5
Ancholme Clay Group	Clay, greenish grey	1.0+	13.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
a	2	72	26	0.5-2.0	4	31	27	15	22	1	0
				2.0-3.0	3	27	32	9	25	4	0
				3.0-4.0	1	25	37	10	22	5	0
				4.0-5.0	0	18	32	25	23	2	0
				5.0-6.0	3	17	37	16	24	3	0
				6.0-7.0	1	18	42	11	22	6	0
				Mean	2	24	34	14	23	3	0
b	1	56	43	7.0-7.7	2	13	34	14	33	4	0
				7.7-8.7	1	7	30	13	33	16	0
				8.7-9.7	1	10	36	15	29	9	0
				9.7-10.7	3	8	42	12	24	11	0
				10.7-11.7	0	6	40	8	23	23	0
				11.7-12.5	0	5	30	13	31	21	0
				Mean	1	8	36	12	29	14	0
a+b	2	64	34	0.5-12.5	2	16	35	13	26	8	0

TF 06 SE 23 **0827 6371** **Nocton Wood** **Block D**

Surface level (+11.6 m) +38 ft
Water not encountered
April 1979

Overburden 0.4 m
Mineral 1.0 m
Waste 7.5 m
Bedrock 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.4	0.4
Fluvio-glacial and Older River Sand and Gravel	Gravel Gravel: coarse with fine subrounded quartzite with some quartz and angular flint Sand: fine and medium subangular quartz with coarse and medium subangular to subrounded lithic grains Fines: yellowish brown	1.0	1.4
Till	Clay, yellowish brown at top, olive-grey below with pebbles of flint and olive-grey mudstone	5.7	7.1
	Clayey silt, yellowish brown with grey mottling	0.4	7.5
	Clay, reddish brown at top, olive-grey below with small pebbles of chalk and black mudstone with some sandstone and limestone	1.4	8.9
Ancholme Clay Group	Clay, greenish grey, silty, fossiliferous	1.1+	10.0

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$ mm
6	41	53	0.4-1.4	6	9	23	9	18	35	0

TF 06 SE 24 **0850 6251** **Metheringham Barff** **Block D**

Surface level (+17.4 m) +57 ft
Water struck at +13.9 m
April 1979

Overburden 0.6 m
Mineral 3.2 m
Waste 12.6 m
Bedrock 0.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.6	0.6
Fluvio-glacial and Older River Sand and Gravel	Sandy gravel Gravel: fine and coarse, subrounded quartzite with rounded quartz, subangular to subrounded sandstone and angular flint Sand: medium, subrounded quartz with angular dark rock fragments	3.2	3.8
Till	Clay, olive-grey with pebbles of limestone, sandstone, quartzite and mudstone; laminated from 14.2 to 14.5 m	12.6	16.4
Ancholme Clay Group	Clay, olive-grey, fossiliferous	0.7+	17.1

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
5	50	45	0.6-1.6	5	8	30	6	29	22	0
			1.6-2.6	6	8	39	8	24	15	0
			2.6-3.8	2	5	36	13	30	14	0
			Mean	5	8	34	8	27	18	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
0.6-1.6	16	40	1	26	15	-	2	-
1.6-2.6	15	50	-	21	13	-	1	-
2.6-3.8	16	48	-	18	17	-	1	-
Mean	16	45	1	22	14	-	2	-

TF 06 SE 25 **0964 6314** **East of Fen Side Farms** **Block C**

Surface level (+3.7 m) +12 ft
Water struck at +1.2 m
April 1979

Overburden 1.1 m
Mineral 12.3 m
Bedrock 0.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy with limestone pebbles	1.1	1.1
River Gravels	**a** Pebbly sand Gravel: fine, subangular to subrounded limestone with some quartzite, angular flint and trace of rounded quartz Sand: medium, quartz with some subrounded limestone	8.5	9.6
	b Sandy gravel Gravel: fine, subrounded quartzite with sandstone, rounded quartz, subangular limestone and angular flint Sand: medium with coarse, subrounded quartz with dark rock fragments	3.8	13.4
Ancholme Clay Group	Clay, greenish grey	0.8+	14.2

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	2	75	23	1.1-2.6	4	39	34	8	15	0	0
				2.6-3.6	trace	18	45	13	22	2	0
				3.6-4.6	1	16	36	18	24	5	0
				4.6-5.6	1	10	35	19	31	4	0
				5.6-6.6	1	9	40	18	27	5	0
				6.6-7.6	2	19	45	14	20	0	0
				7.6-8.6	3	29	43	8	13	4	0
				8.6-9.6	2	24	50	9	12	3	0
				Mean	2	21	41	13	20	3	0
b	trace	64	36	9.6-10.6	trace	4	38	21	29	8	0
				10.6-11.6	1	3	56	14	22	4	0
				11.6-12.6	trace	2	43	16	28	11	0
				12.6-13.4	trace	4	42	13	23	18	0
				Mean	trace	3	45	16	26	10	0
a+b	1	72	27	1.1-13.4	1	16	42	14	22	5	0

TF 06 SE 26 **0960 6132** **Barff Farm** **Block D**

Surface level (+18.0 m) +59 ft
Water struck at +15.6 m
April 1979

Overburden 0.6 m
Mineral 4.1 m
Waste 13.4 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy and pebbly	0.6	0.6
Fluvio-glacial and Older River Sand and Gravel	Sandy gravel Gravel: fine with coarse, subrounded quartzite with sandstone, rounded quartz and angular flint Sand: medium, subrounded quartz with some angular dark rock fragments	4.1	4.7
Till	Clay, olive-grey with pebbles of chalk and black mudstone; laminated from 14.5 to 15.2 m	13.4	18.1
Ancholme Clay Group	Clay, olive-grey, silty, fossiliferous	0.9+	19.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
	3	64	33	0.6-1.7	6	10	51	12	10	11	0
				1.7-2.7	3	9	38	15	22	13	0
				2.7-4.7	2	8	40	11	31	8	0
				Mean	3	9	43	12	23	10	0

TF 06 SE 27 **0857 6146** **Moor Lane** **Block C**

Surface level (+6.8 m) +22 ft
Water not encountered
October 1979

Waste 2.5 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Marine or Estuarine Alluvium	Sandy gravel Gravel: fine, subangular to subrounded limestone Sand: medium quartz with limestone	0.8	1.3
Till	Clay, bluish grey, stoney	1.2	2.5
Kellaways Beds	Clay, greenish grey	0.3+	2.8

TF 07 NE 7 **0516 7938** **East of Mickleholme** **Block A**

Surface level (+8.2 m) +27 ft
Water not encountered
May 1979

Waste 0.7 m
Bedrock 3.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Alluvium	Clay, dark yellowish brown with reddish brown mottling and small quartz pebbles	0.2	0.7
Ancholme Clay Group	Clay, greenish grey, fossiliferous	3.9+	4.6

TF 07 NE 8 **0665 7930** **Reasby** **Block A**

Surface level (+15.5 m) +51 ft
Water not encountered
May 1979

Overburden 0.5 m
Mineral 3.0 m
Waste 0.2 m
Bedrock 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Fluvio-glacial and Older River Sand and Gravel	Sandy gravel Gravel: fine with coarse, angular to subangular flint with some subrounded to rounded quartz and quartzite Sand: medium with fine, quartz	3.0	3.5
Till	Clay, dark grey with pebbles of chalk and flint	0.2	3.7
Ancholme Clay Group	Clay, dark grey, silty	1.1+	4.8

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
3	58	39	0.5-1.5	3	15	48	5	16	13	0
			1.5-2.5	6	12	41	9	24	8	0
			2.5-3.5	1	4	27	9	31	28	0
			Mean	3	11	39	8	23	16	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
0.5-1.5	92	3	-	2	3	-	-	-
1.5-2.5	93	3	-	-	4	-	-	-
2.5-3.5	93	3	-	3	1	-	-	-
Mean	93	3	-	2	2	-	-	-

TF 07 NE 9 **0515 7871** **Scothern Grange** **Block A**

Surface level (+8.2 m) +27 ft
Water not encountered
May 1979

Waste 2.1 m
Bedrock 1.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Alluvium on Till	Clay, sandy, yellowish brown with yellowish orange and grey-green sandy partings and pebbles of flint and limestone	1.6	2.1
Ancholme Clay Group	Clay, silty, greyish green	1.4+	3.5

TF 07 NE 10 **0632 7828** **Stainton Level Crossing** **Block A**

Surface level (+14.6 m) +48 ft
Water struck at +10.4 m
May 1979

Overburden 0.4 m
Mineral 5.1 m
Bedrock 0.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.4	0.4
Fluvio-glacial and Older River Sand and Gravel	Sandy gravel, sandy from 3.1 to 4.1 m Gravel: fine with coarse, angular flint with some subrounded sandstone Sand: medium, quartz with some angular flint	5.1	5.5
Ancholme Clay Group	Clay, greenish grey	0.7+	6.2

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
2	56	42	0.4-1.4	4	8	23	16	34	15	0
			1.4-3.1	2	10	32	13	33	10	0
			3.1-4.1	4	16	64	4	8	4	0
			4.1-5.5	1	3	31	8	32	25	0
			Mean	2	9	36	11	28	14	0

TF 07 NE 11 **0717 7885** **Stainton Wood** **Block A**

Surface level (+9.8 m) +32 ft
Water not encountered
May 1979

Overburden 1.3 m
Mineral 0.7 m
Bedrock 1.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.4	0.4
?Alluvium	Clay, olive-grey and brown with pebbles of flint, silty and sandy in parts	0.9	1.3
River Gravels	Gravel Gravel: fine and coarse angular flint Sand: coarse and medium, quartz with angular flint	0.7	2.0
Ancholme Clay Group	Clay, greenish grey, well laminated	1.7+	3.7

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
4	43	53	1.3-2.0	4	9	19	15	23	30	0

TF 07 NE 12 **0888 7803** **Bullington** **Block A**

Surface level (+14.0 m) +46 ft
Water not encountered
May 1979

Waste 3.5 m
Bedrock 0.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil,	0.7	0.7
Till	Clay, olive-grey with rust brown mottling with pebbles of chalk and flint and a trace of shell fragments	2.8	3.5
Ancholme Clay Group	Silty clay, olive-black, well-bedded, fossiliferous	0.7+	4.2

TF 07 NE 13 **0534 7699** **Sudbrooke Grange** **Block A**

Surface level (+12.2 m) +40 ft
Water not encountered
May 1979

Waste 2.9 m
Bedrock 1.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Fill	0.4	0.4
Till	Clay, brown with partings of orange-brown sand	1.1	1.5
	Clay, olive-brown, mottled, with pebbles of chalk	1.4	2.9
Ancholme Clay Group	Silty clay, greenish grey, fossiliferous	1.3+	4.2

TF 07 NE 14 **0757 7748** **Newball Grange** **Block A**

Surface level (+8.8 m) +29 ft
Water struck at +5.5 m
May 1979

Overburden 1.0 m
Mineral 2.8 m
Bedrock 0.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
?Alluvium	Clay, dark yellowish orange, sandy with pebbles of flint	0.6	1.0
River Gravels	Gravel Gravel: fine with coarse, angular flint with subrounded limestone Sand: medium with coarse, quartz with some flint and limestone	2.8	3.8
Ancholme Clay Group	Clay, greenish grey	0.7+	4.5

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
3	49	48	1.0-2.0	5	9	26	10	32	18	0
			2.0-3.0	3	5	28	21	34	9	0
			3.0-3.8	1	2	25	16	35	21	0
			Mean	3	6	27	16	33	15	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
1.0-2.0	77	-	20	1	1	-	1	-
2.0-3.0	65	1	28	1	3	-	2	-
3.0-3.8	60	1	35	-	3	-	1	-
Mean	67	1	28	1	2	-	1	-

TF 07 NE 15 **0917 7706** **East of Newball Wood** **Block A**

Surface level (+18.6 m) +61 ft
Water not encountered
May 1979

Waste 9.7 m
Bedrock 0.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Fill	0.4	0.4
Till	Silty, clay, reddish brown with grey mottling	1.1	1.5
	Clay, olive-brown at top, grey below 2.3 m; with pebbles of chalk and some black mudstone, red marl and flint	8.2	9.7
Ancholme Clay Group	Silty clay, greenish grey, friable	0.7+	10.4

TF 07 NE 16 **0589 7629** **Langworth** **Block A**

Surface level (+7.0 m) +23 ft
Water not encountered
May 1979

Overburden 0.5 m
Mineral 1.8 m
Bedrock 1.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
River Gravels	Sandy gravel Gravel: fine, angular flint with subangular to subrounded limestone Sand: fine to coarse, quartz with some limestone and flint	1.8	2.3
Ancholme Clay Group	Clay, greenish grey	1.4+	3.7

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
5	59	36	0.5-2.3	5	17	26	16	32	4	0

TF 07 NE 17 **0705 7574** **Manor Farm** **Block A**

Surface level (+6.4 m) +21 ft
Water not encountered
May 1979

Overburden 0.2 m
Mineral 1.8 m
Bedrock 1.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.2	0.2
River Gravels	Sandy gravel Gravel: fine, subangular limestone with angular flint Sand: fine to coarse, quartz with dark rock fragments	1.8	2.0
Ancholme Clay Group	Silty, clay, dark grey, friable	1.3+	3.3

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
2	66	32	0.2-1.2	2	14	31	20	28	5	0
			1.2-2.0	2	15	36	17	26	4	0
			Mean	2	14	33	19	27	5	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
0.2-1.2	24	-	75	trace	trace	-	1	-
1.2-2.0	24	-	71	2	3	-	-	-
Mean	24	-	73	1	1	-	1	-

TF 07 NE 18 **0794 7574** **West of Newball Wood House** **Block A**

Surface level (+5.2 m) +17 ft
Water struck at +2.9 m
May 1979

Waste 2.8 m
Bedrock 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil on silty clay	1.4	1.4
Alluvium	Clay, dark grey, sandy in parts	0.9	2.3
Till	Clay, grey with pebbles of angular flint	0.5	2.8
Ancholme Clay Group	Silty clay, greenish grey, friable	1.1+	3.9

TF 07 NE 20 **0645 7675** **North of Langworth Bridge** **Block A**

Surface level (+6.7 m) +22 ft
Water struck at +4.6 m
October 1979
Minuteman

Overburden 0.7 m
Mineral 1.8 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Silty clay, sandy	0.5	0.7
River Gravels	Sandy gravel Gravel: fine, angular flint with subangular limestone Sand: fine to coarse, quartz with flint and limestone	1.8	2.5
Ancholme Clay Group	Clay, grey, silty	1.0+	3.5

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
8	50	42	0.7-2.5	8	16	24	10	34	8	0

TF 07 SW 28 **0479 7355** **Moor Lane** **Block A**

Surface level (+12.2 m) +40 ft
Water not encountered
May 1979

Waste 3.3 m
Bedrock 1.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Clay, brown and grey with pebbles of chalk and some flint	3.2	3.3
Ancholme Clay Group	Silty clay, dark grey, friable	1.2+	4.5

TF 07 SW 29 **0069 7090** **South-west of Greetwell** **Block B**

Surface level (+3.7 m) +12 ft
Water struck at +1.2 m
May 1979

Overburden 1.1 m
Mineral 1.9 m
Waste 2.6 m
Mineral 1.6 m
Waste 0.3 m
Mineral 1.7 m
Bedrock 0.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	1.1	1.1
Alluvium	**a** Sand, fine and medium, quartz	1.9	3.0
	Sandy silt, greyish brown	2.6	5.6
River Gravels	**b** Pebbly sand Gravel: fine, angular flint with some subangular limestone Sand: fine and medium, quartz with some dark rock fragments	1.6	7.2
	Silty clay, reddish brown with grey mottling, laminated	0.3	7.5
	c Sandy gravel Gravel: fine with coarse, subangular to subrounded quartzite with some quartz and angular flint Sand: medium, quartz with dark lithic grains	1.7	9.2
Lias, undivided	Siltstone, dark grey, finely laminated	0.8+	10.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$ mm
a	7	92	1	1.1-3.0	7	40	49	3	1	0	0
b	9	63	18	5.6-7.2	9	35	29	9	16	2	0
c	2	62	36	7.5-8.5	3	8	42	9	25	13	0
				8.5-9.2	1	9	50	10	23	7	0
				Mean	2	8	45	9	25	11	0
a+b+c	6	77	17	Mean	6	28	42	7	13	4	0

TF 07 SW 30 **0152 7107** **North-west of Washingborough** **Block B**

Surface level (+2.7 m) +9 ft
Water struck at +0.7 m
May 1979

Overburden 5.5 m
Mineral 1.2 m
Waste 0.2 m
Mineral 2.2 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	2.2	2.2
Alluvium	Silty peat, dark brown, bluish grey below 4.0 m wood fragments in peat; sandy at base	3.3	5.5
River Gravels	**a** Sand, medium, subrounded quartz with some limestone and dark rock fragments	1.2	6.7
	Sandy clay, reddish brown	0.2	6.9
	b Sandy gravel Gravel: fine with coarse, subangular to subrounded quartzite with quartz, limestone and angular flint Sand: medium with coarse, quartz and dark rock fragments	2.2	9.1
Lias, undivided	Silty clay, greenish grey	0.9+	10.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	4	94	2	5.5-6.7	4	9	78	7	2	0	0
b	2	50	48	6.9-7.9	2	4	29	22	35	8	0
				7.9-9.1	2	4	29	12	37	16	0
				Mean	2	4	29	17	36	12	0
a+b	3	65	32	Mean	3	6	46	13	24	8	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
6.9-7.9	16	48	8	20	6	-	2	-
7.9-9.1	8	58	2	22	8	-	2	-
Mean	12	54	4	21	7	-	2	-

TF 07 SW 31 **0337 7116** **Washingborough Fen** **Block B**

Surface level (+1.5 m) +5 ft
Water struck at -4.6 m
May 1979

Overburden 1.8 m
Mineral 3.3 m
Waste 1.0 m
Mineral 3.5 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.4	0.4
Alluvium	Peat, sandy	1.4	1.8
River Gravels	**a** Sand, medium with fine, quartz with dark rock fragments	3.3	5.1
	Clay, olive-grey with pale brown sandy partings	1.0	6.1
	b Pebbly sand Gravel: fine with coarse, subrounded to rounded quartzite with rounded to well rounded quartz, subrounded limestone and angular flint Sand: medium, subrounded quartz with some dark rock fragements	3.5	9.6
Upper Estuarine Beds	Sandstone, greenish grey	0.2+	9.8

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	2	96	2	1.8-3.5	1	24	70	2	3	0	0
				3.5-5.1	3	27	67	1	2	0	0
				Mean	2	26	69	1	2	0	0
b	2	79	19	6.1-7.2	1	4	56	15	18	6	0
				7.2-8.2	2	6	65	12	11	4	0
				8.2-9.6	2	3	67	8	12	8	0
				Mean	2	4	63	12	13	6	0
a+b	2	87	11	Mean	2	15	65	7	8	3	0

TF 07 SW 32 **0448 7173** **Fiskerton** **Block B**

Surface level (+2.7 m) + 9 ft
Water struck at +0.6 m
May 1979

Waste 2.8 m
Bedrock 1.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Soil, peaty	1.1	1.1
Till	Clay, brownish yellow with pebbles of limestone	1.7	2.8
Blisworth Clay	Silty clay, dark grey, fossiliferous	1.7+	4.5

TF 07 SW 33 **0371 7011** **North of Heighington** **Block D**

Surface level (+19.8 m) +65 ft
Water struck at +16.4 m
May 1979

Waste 4.3 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.7	0.7
Fluvio-glacial and Older River Sand and Gravel	Clay, dark brown; sandy with pebbles of purple quartzite and quartzitic sandstone	2.8	3.5
	Sandy silt, yellowish brown	0.8	4.3
Great Oolite Limestone	Silty clay, dark greyish brown with limestone horizon at top; fossiliferous	1.0+	5.3

TF 07 SW 34 **0444 7079** **Washingborough Fen** **Block B**

Surface level (+3.4 m) +11 ft
Water struck at -1.2 m
May 1979

Overburden 0.6 m
Mineral 5.9 m
Waste 1.1 m
Mineral 3.2 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.6	0.6
River Gravels	**a** Sand, fine with medium, quartz with some limestone and dark rock fragments	5.9	6.5
	Silty clay, brown	1.1	7.6
	b Sandy gravel Gravel: fine with coarse, subrounded to rounded quartzite with rounded to well rounded quartz, angular flint and some limestone Sand: fine to coarse, quartz with some dark rock fragments	3.2	10.8
Great Oolite Limestone	Clay, greenish grey, fossiliferous	0.5+	11.3

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	6	92	2	0.6-1.6	3	39	55	1	1	1	0
				1.6-2.6	4	59	34	1	2	0	0
				2.6-3.6	7	69	24	trace	trace	0	0
				3.6-4.6	7	53	32	3	5	0	0
				4.6-5.6	10	73	15	1	1	0	0
				5.6-6.5	6	63	29	1	1	0	0
				Mean	6	59	32	1	2	0	0
b	1	64	35	7.6-8.6	2	16	37	13	23	9	0
				8.6-9.6	trace	11	42	12	22	13	0
				9.6-10.8	trace	6	36	18	28	12	0
				Mean	1	11	38	15	24	11	0
a+b	4	82	14	Mean	4	42	34	6	10	4	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
7.6-8.6	17	54	5	20	3	-	1	-
8.6-9.6	7	52	4	26	9	-	2	-
9.6-10.8	7	59	2	20	10	-	2	-
Mean	10	54	4	22	8	-	2	-

TF 07 SE 13 **0828 7408** **Barlings House** **Block A**

Surface level (+4.3 m) +14 ft
Water struck at +1.3 m
May 1979

Overburden 0.5 m
Mineral 3.6 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
River Gravels	Sandy gravel Gravel: fine with coarse, angular flint with subrounded limestone Sand: fine to coarse, quartz with flint	3.6	4.1
Ancholme Clay Group	Clay, greenish grey, silty	0.9+	5.0

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
2	59	39	0.5-1.5	7	23	30	11	28	1	0
			1.5-2.5	1	9	38	25	25	2	0
			2.5-3.5	0	4	28	21	30	17	0
			3.5-4.1	1	1	25	16	46	11	0
			Mean	2	10	31	18	31	8	0

TF 07 SE 14 **0940 7435** **Newball Common** **Block A**

Surface level (+4.9 m) +16 ft
Water not encountered
May 1979

Overburden 1.3 m
Mineral 2.3 m
Bedrock 2.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and fill	1.3	1.3
River Gravels	Sandy gravel Gravel: fine with coarse, angular to subangular flint and subrounded limestone with trace of sandstone Sand: fine to coarse, subrounded quartz with angular dark rock fragments including flint	2.3	3.6
Ancholme Clay Group	Silty clay, dark grey	2.5+	6.1

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
2	53	45	1.3-2.2	4	12	26	12	33	13	0
			2.2-3.6	2	13	30	11	32	12	0
			Mean	2	13	28	12	32	13	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
1.3-2.2	76	-	22	-	1	-	1	-
2.2-3.6	57	-	41	-	2	-	-	-
Mean	65	-	33	-	2	-	-	-

TF 07 SE 15 **0635 7246** **Hall Farm** **Block A**

Surface level (+12.2 m) +40 ft
Water not encountered
May 1979

Waste 9.3 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Fill	0.8	0.8
Till	Clay, dark grey with pebbles of chalk and trace of flint and red marl	8.5	9.3
Ancholme Clay Group	Silty clay, greenish grey, fossiliferous	0.9+	10.2

TF 07 SE 16 **0866 7279** **Fiskerton Fen** **Block A**

Surface level (+4.0 m) +13 ft
Water not encountered
May 1979

Waste 3.5 m
Bedrock 1.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
River Gravels	Silty clay, olive-brown with grey and orange mottling	3.1	3.5
Ancholme Clay Group	Silty clay, grey	1.6+	5.1

TF 07 SE 17 **0951 7204** **Stainfield Fen** **Block A**

Surface level (+3.4 m) +11 ft
Water not encountered
May 1979

Overburden 0.5 m
Mineral 2.9 m
Waste 1.1 m
Bedrock 1.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Fill	0.5	0.5
Alluvium	Sand, medium with fine, subangular to subrounded quartz with some dark rock fragments	2.9	3.4
Till	Sandy clay, dark grey with small chalk pebbles	1.1	4.5
Ancholme Clay Group	Silty clay, greenish grey	1.7+	6.2

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
7	89	4	0.5-1.5	6	31	57	2	3	1	0
			1.5-3.4	8	31	55	2	4	0	0
			Mean	7	31	56	2	4	trace	0

TF 07 SE 18 **0585 7112** **Washingborough Fen** **Block B**

Surface level (+1.9 m) +6 ft
Water struck at -0.1 m
May 1979

Overburden 1.6 m
Mineral 9.2 m
Bedrock 0.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Soil on Alluvium	Soil, peaty	1.6	1.6
River Gravels	Gravel, sandy gravel to 3.6 m Gravel: fine and coarse subangular to subrounded quartzite with rounded quartz, angular flint and trace limestone Sand: fine to coarse, subrounded quartz with some limestone and dark rock fragments	9.2	10.8
Kellaways Beds	Sandy silt, greenish grey	0.4+	11.2

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
5	42	53	1.6-2.6	3	12	32	14	26	13	0
			2.6-3.6	9	18	28	12	18	15	0
			3.6-4.6	2	5	20	9	34	30	0
			4.6-5.6	trace	2	31	9	24	34	0
			5.6-6.6	2	4	24	11	30	27	2
			6.6-7.6	5	9	17	11	33	25	0
			7.6-8.6	10	23	19	11	19	18	0
			8.6-10.8	7	16	7	7	29	34	0
			Mean	5	12	20	10	27	26	0

TF 07 SE 19 **0762 7191** **Long Wood** **Block A**

Surface level (+4.3 m) +14 ft
Water not encountered
May 1979

Waste 3.4 m
Bedrock 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, pebbly	0.2	0.2
Till	Clay, dark grey with small pebbles of chalk, sandstone and red marl	3.2	3.4
Ancholme Clay Group	Silty clay, olive-brown to 3.6 m, greenish grey below	1.1+	4.5

TF 07 SE 20 **0888 7139** **Short Ferry** **Block A**

Surface level (+6.7 m) +22 ft
Water not encountered
May 1979

Waste 5.1 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, dark grey with small pebbles of fine chalk	4.8	5.1
Ancholme Clay Group	Silty clay, dark greenish grey	0.9+	6.0

TF 07 SE 21 **0976 7103** **Branston Island** **Block C**

Surface level (+1.5 m) +5 ft
Water struck at -2.8 m
May 1979

Overburden 4.3 m
Mineral 8.1 m
Bedrock 0.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Alluvium	Peat, brown	2.8	3.2
	Clay, greenish grey, peaty	1.1	4.3
River Gravels	**a** Sandy gravel Gravel: fine with coarse, angular to subangular flint with subrounded limestone and some sandstone Sand: medium with coarse, quartz with some limestone and dark rock fragments	4.2	8.5
	b Sandy gravel Gravel: fine with coarse, subrounded to rounded quartzite with well rounded quartz, angular to subangular flint and some limestone Sand: medium, quartz and some dark rock fragments	3.9	12.4
Ancholme Clay Group	Clay, greenish grey	0.6+	13.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	1	59	40	4.3-5.4	2	3	32	22	36	5	0
				5.4-6.4	1	5	42	17	25	10	0
				6.4-7.4	trace	2	36	15	27	20	0
				7.4-8.5	0	3	42	18	25	12	0
				Mean	1	3	38	18	28	12	0
b	1	72	27	8.5-9.5	1	9	44	10	22	14	0
				9.5-10.5	trace	13	58	6	13	10	0
				10.5-12.4	1	6	60	9	17	7	0
				Mean	1	9	55	8	17	10	0
a+b	1	65	34	4.3-12.4	1	6	46	13	23	11	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
4.3-6.4	68	-	26	1	5	-	-	-
6.4-8.5	56	-	41	-	3	-	-	-
Mean	62	-	34	trace	4	-	-	-
8.5-12.4	16	42	10	21	9	-	1	1
Mean	46	14	26	7	6	-	trace	1

TF 07 SE 22 **0599 7032** **Middle Fen Lane** **Block B**

Surface level (+2.4 m) +8 ft
Water struck at +0.4 m
May 1979

Overburden 1.8 m
Mineral 4.0 m
Waste 1.2 m
Mineral 5.0 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and fill	0.5	0.5
Alluvium	Peaty silt	1.3	1.8
	a 'Clayey' sand, fine, quartz	2.0	3.8
River Gravels	**b** Pebbly sand Gravel: fine, subangular to subrounded limestone with some rounded quartzite and quartz Sand: fine and medium, quartz with some limestone	2.0	5.8
	Clay, olive-grey; sandy in parts	1.2	7.0
River Gravels	**c** Sandy gravel Gravel: fine with coarse, subrounded to rounded quartzite with angular flint, limestone and well rounded quartz Sand: medium, quartz with some dark rock fragments	5.0	12.0
Kellaways Beds	Sandstone, greenish grey, fine grained	0.9+	12.9

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	11	88	1	1.8-2.8	13	66	17	2	2	0	0
				2.8-3.8	9	79	12	trace	trace	0	0
				Mean	11	72	15	1	1	0	0
b	6	71	23	3.8-4.8	9	34	30	3	24	0	0
				4.8-5.8	4	28	44	4	15	5	0
				Mean	6	31	37	3	20	3	0
c	1	57	42	7.0-8.3	trace	15	54	7	12	12	0
				8.3-9.3	trace	8	58	11	17	6	0
				9.3-10.3	0	3	9	14	51	23	0
				10.3-11.3	1	3	25	15	35	21	0
				11.3-12.0	1	10	41	11	25	12	0
				Mean	1	8	38	11	27	15	0
a+b+c	4	67	29	Mean	4	27	33	7	20	9	0

TF 07 SE 23 **0698 7094** **Middle Fen Lane** **Block B**

Surface level (+2.1 m) +7 ft
Water struck at +0.1 m
May 1979

Overburden 3.2 m
Mineral 1.3 m
Waste 0.9 m
Mineral 1.9 m
Bedrock 1.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.2	0.2
?Alluvium	Peat, silty at top	1.7	1.9
	Clay, olive-grey with plant debris	1.3	3.2
	a 'Clayey' pebbly sand, gravel from 4.2 to 4.5 m Gravel: fine and coarse, subrounded to rounded quartzite with quartz, sandstone angular flint and some subrounded limestone Sand: fine and medium, quartz	1.3	4.5
	Clay, dark brown; sandy and pebbly	0.9	5.4
River Gravels	**b** Sandy gravel Gravel: fine with coarse, subrounded to rounded quartzite with well rounded quartz, angular flint and subrounded sandstone Sand: medium, quartz with some dark rock fragments	1.9	7.3
Ancholme Clay Group	Clay, greenish grey, fossiliferous	1.3+	8.6

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	11	68	21	3.2-4.2	13	31	39	5	9	3	0
				4.2-4.5	4	20	19	8	17	30	2
				Mean	11	28	34	6	11	9	1
b	1	54	45	5.4-6.4	1	12	42	7	23	15	0
				6.4-7.3	1	6	29	11	35	18	0
				Mean	1	9	36	9	29	16	0
a+b	5	60	35	Mean	5	17	35	8	22	13	0

COMPOSITION

Depth below surface (m)	percentages by weight in gravel fraction							
	Flint	Quartzite	Limestone	Quartz	Sandstone	Mudstone	Ironstone	Others
3.2-4.5	13	47	5	26	9	-	-	-
5.4-6.4	16	47	2	19	14	-	1	1
6.4-7.3	14	56	-	17	12	-	1	-
Mean	15	52	1	18	13	-	1	-
Mean	14	49	3	22	11	-	1	-

TF 07 SE 24 **0793 7022** **Branston Delph** **Block B**

Surface level (+1.8 m) +6 ft
Water struck at -0.2 m
June 1979

Overburden 1.2 m
Mineral 1.7 m
Waste 1.0 m
Mineral 6.7 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.7	0.7
Alluvium	Clay, olive-grey, sandy towards base	0.5	1.2
	a 'Clayey' sand, fine with medium, quartz	1.7	2.9
	Clay olive-grey but dark brown where sandy and pebbly	1.0	3.9
River Gravels	**b** Sandy gravel, 'clayey' and sandy to 5.0 m Gravel: fine, subrounded limestone with angular flint and some subrounded to rounded quartzite and quartz Sand: fine and medium, quartz with some dark rock fragments	3.1	7.0
	c Sandy gravel, sandy at base Gravel: fine and coarse, subrounded to rounded quartzite with well rounded quartz, angular flint with some subrounded sandstone and limestone Sand: medium, quartz and dark rock fragments	3.6	10.6
Ancholme Clay Group	Clay, greenish grey	1.0+	11.6

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	11	88	1	1.2-2.9	11	60	26	2	1	0	0
b	9	68	23	3.9-5.0	19	29	26	6	13	7	0
				5.0-6.0	2	18	33	14	27	6	0
				6.0-7.0	6	26	47	5	12	4	0
				Mean	9	25	35	8	17	6	0
c	1	67	32	7.0-8.0	1	11	46	10	22	10	0
				8.0-9.0	0	8	38	12	28	14	0
				9.0-10.6	2	7	60	8	13	10	0
				Mean	1	8	50	9	20	12	0
a+b+c	6	72	22	Mean	6	25	40	7	15	7	0

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Dd 696817 K8

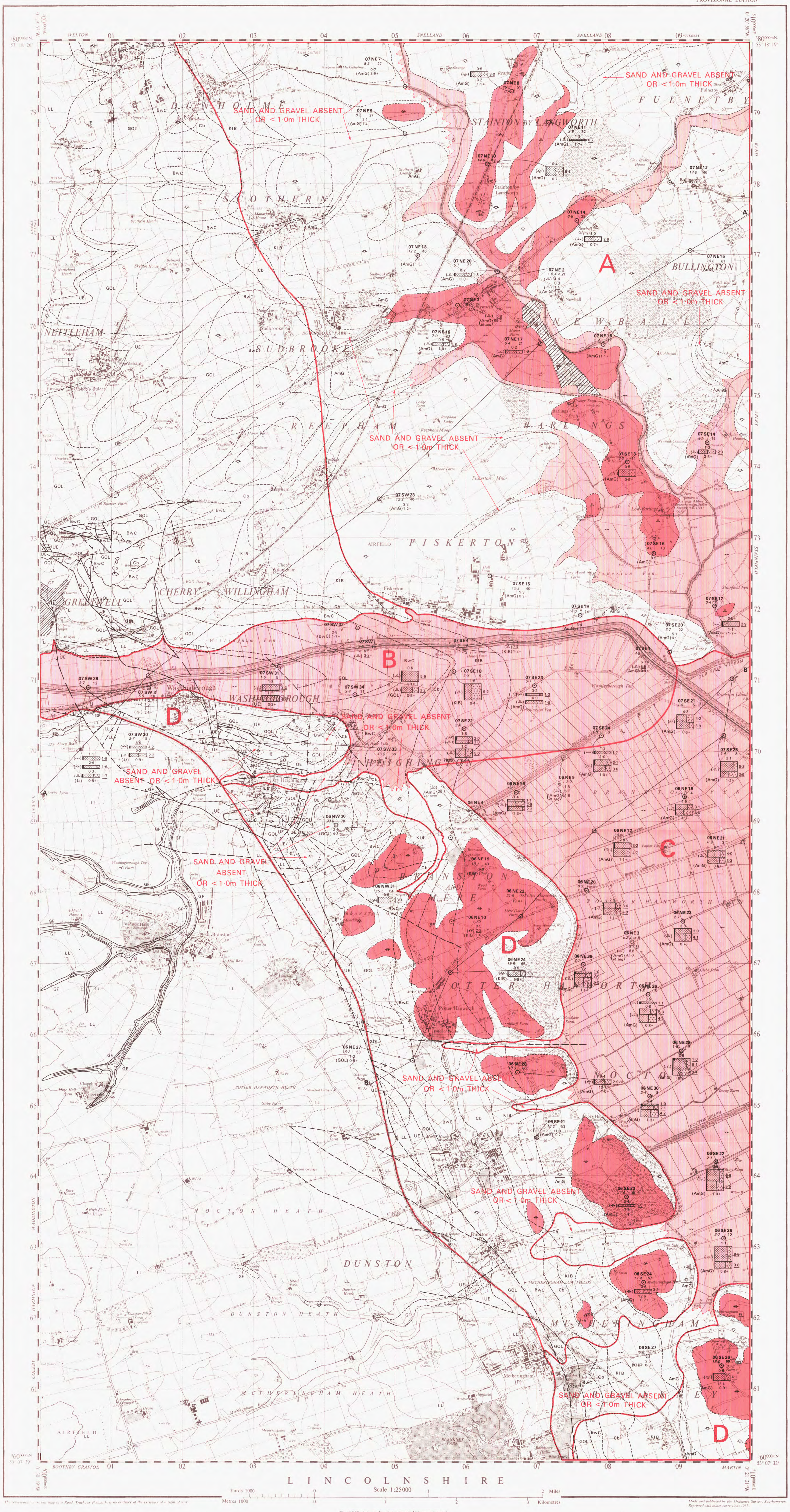
INSTITUTE OF GEOLOGICAL SCIENCES

INDUSTRIAL MINERALS ASSESSMENT UNIT

THE SAND AND GRAVEL RESOURCES OF POTTER HANWORTH AND REEPHAM, LINCOLNSHIRE

Scale 1:25,000 or about 2½ Inches to 1 Mile

ORDNANCE SURVEY
SHEETS TF 06 & 07
PROVISIONAL EDITION



The representation on this map of a Road, Track, or Footpath, is no evidence of the existence of a right of way.

The GRID lines on this sheet are at 1 Kilometre interval.
Heights are in feet above Mean Sea Level at Newlyn.
Contours values are in feet.
1 square inch on this map represents 99 639 acres on the ground.

Compiled from 6" sheets last fully revised 1904-38. Other partial systematic revision 1946-53 has been incorporated.

Made and published by the Ordnance Survey, Southampton. Reprinted with minor corrections 1957.

Geological lines from an original geological survey on the one-inch scale by W. H. Penning and W. H. Dalton, published (as part of Old Series Sheet 83) in 1886, with amendments from six-inch partial resurveys by P. E. Kent in 1937, W. D. Evans in 1941 and T. P. Fletcher in 1980 and 1:50 000 compilation by P. M. Allen (New Series Sheet 114) published in 1973.

Sand and Gravel survey by I. Jackson and J. B. L. Wild in 1979.
R. G. Thurrell, Head, Industrial Minerals Assessment Unit.

1:25 000 Sand and Gravel Resource Sheet published 1981.
G. M. Brown, D.Sc., F.R.S., Director, Institute of Geological Sciences.
1100/82

Data quoted for an individual borehole refer strictly to that site; reliable conclusions cannot be drawn about the thickness and grading elsewhere in the deposit, particularly in material as variable as sand and gravel. However, estimates of the volume and mean grading of the mineral as a whole in each Resource Block are given in the Report.

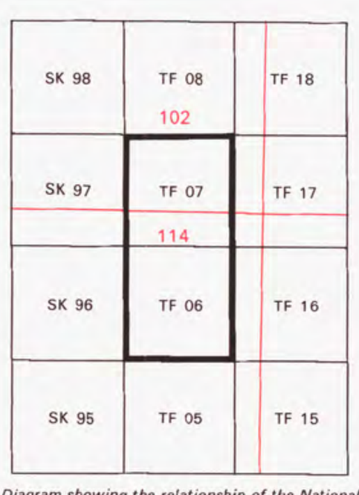


Diagram showing the relationship of the National Grid 1:25 000 sheets with the One-Inch Geological Sheet 102 and the 1:50 000 Geological Sheet 114.

THE SAND AND GRAVEL RESOURCES OF POTTER HANWORTH AND REEPHAM, LINCOLNSHIRE

96

This map should be read in conjunction with the accompanying Report which contains details of the assessment of resources.

EXPLANATION OF SYMBOLS AND ABBREVIATIONS

DRIFT (QUATERNARY — Recent and Pleistocene)

- **Blown Sand** - fine quartz sand — BS-11
- **Alluvium** - clay, silt and sand with subordinate peat — A-61
- **Marine or Estuarine Alluvium** - silt and clay with lenses of sand and peat — ME-10
- **Head including downwash** — H-38
- **River Gravels, undifferentiated** - gravel with some sand — RG-4
- **Fluvio-glacial and Older River Sand and Gravel** - gravel with some silty clay — FL-17
- **Till** - dark grey stony clay with laminated clay — TL-12

SOLID (JURASSIC)

Upper
- AmG **Ancholme Clay Group** - mudstones and shales
- KIB **Kellaways Beds** - sandstone, sand, silt and mudstone

Middle
- Cb **Cornbrash** - limestone, fossiliferous
- BwC **Blisworth Clay** - mudstone with bands of limestone and sand
- GOL **Great Oolite Limestone** - limestone with mudstone bands
- UE **Upper Estuarine Beds** - sandy mudstone, sand and lignite
- LL **Lincolnshire Limestone, undivided** - limestone with mudstone
- GF **Grantham Formation and Northampton Sand Ironstone** - ferruginous clay and sand

Lower
- Li **Lias, undivided** - mudstones and shales

- **Worked-out areas of sand and gravel.** — WO-9
- **Worked-out opencast ironstone area.** — WO-10

BOUNDARY LINES

- Geological boundary, Drift.
- Geological boundary, Solid.
- Line of fault; crossmark indicates downthrow side.
- Inferred boundary between recognised categories of deposits.
- Resource Block boundary.

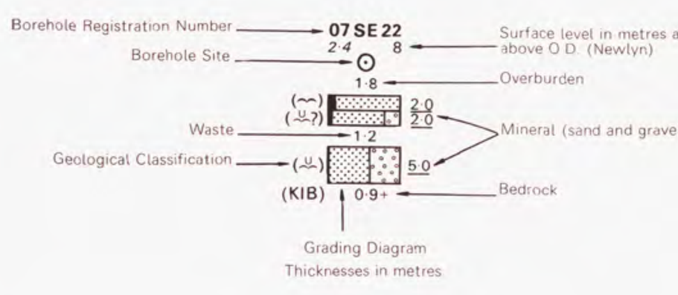
Broken lines denote uncertainty.

BOREHOLE DATA

SITE LOCATIONS

- Industrial Minerals Assessment Unit (I.M.A.U.) Boreholes.
- Other Boreholes.

I.M.A.U. BOREHOLES



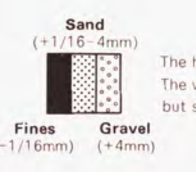
Note:
(i) Figures underlined denote thicknesses used in the assessment of resources.
(ii) The + sign indicates that the base of the deposit was not reached.
(iii) The figures in *italics* are the metric conversions of the measurements recorded in feet.
(iv) The Geological Classification is given only for mineral and bedrock.

Borehole Registration Number

Each I.M.A.U. borehole is defined by a Registration Number, e.g. **07 SE 22**. The initial numbers and letters refer to the quarter sheet and the final figures to the I.G.S. serial numbers for that quarter sheet. The unique designation for borehole **07 SE 22** is **TF 07 SE 22**.

Grading Diagrams

Each grading diagram shows the mean particle size distribution of a distinct deposit of mineral.



The height of the diagram is proportional to the mineral thickness. The widths of the divisions show the proportions of **Fines, Sand** and **Gravel** but small amounts of gravel may be omitted or exaggerated.

OTHER BOREHOLES

The layout of information is the same as for I.M.A.U. boreholes, although the data available may not be as comprehensive. They are registered in the same series.

CATEGORIES OF DEPOSITS

- **Exposed mineral, assessed.** — CAT-E2
- **Continuous or almost continuous spreads of mineral beneath overburden.** — CAT-C1
- **Sand and gravel either not potentially workable (see Report) or absent.** — CAT-A2

Where appropriate on other sheets the categories 'sand and gravel not assessed', and 'Discontinuous spreads of mineral beneath overburden' are recognised.

RESOURCE BLOCKS

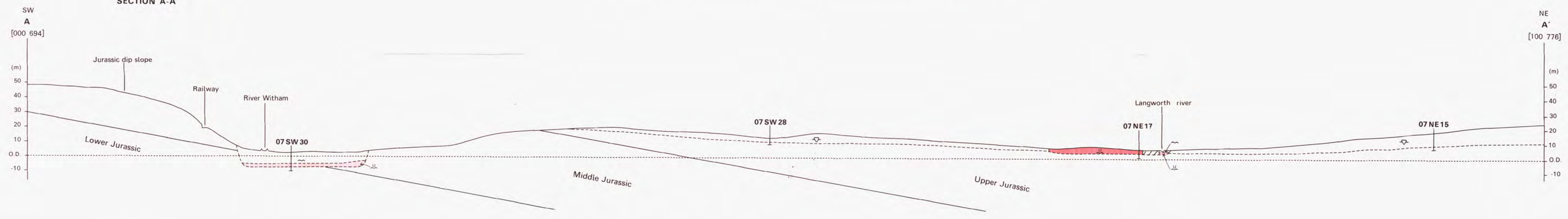
For the purpose of assessment, the mineral is divided into Resource Blocks (see Report). Each is designated by a letter.

Detailed records may be consulted on application to the Head, Industrial Minerals Assessment Unit, Institute of Geological Sciences, Keyworth, Nottingham. NG12 5GG.

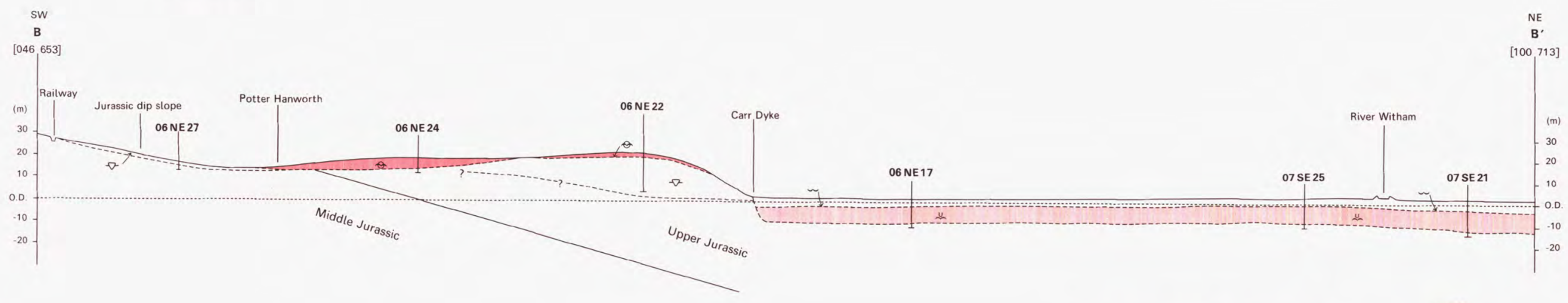
Made and published by the Ordnance Survey, Southampton, for the Institute of Geological Sciences, Natural Environment Research Council.

GENERALIZED HORIZONTAL SECTIONS (the lines of the sections are shown on the map)

SECTION A-A'



SECTION B-B'



Horizontal scale 1:25 000; vertical exaggeration x 25