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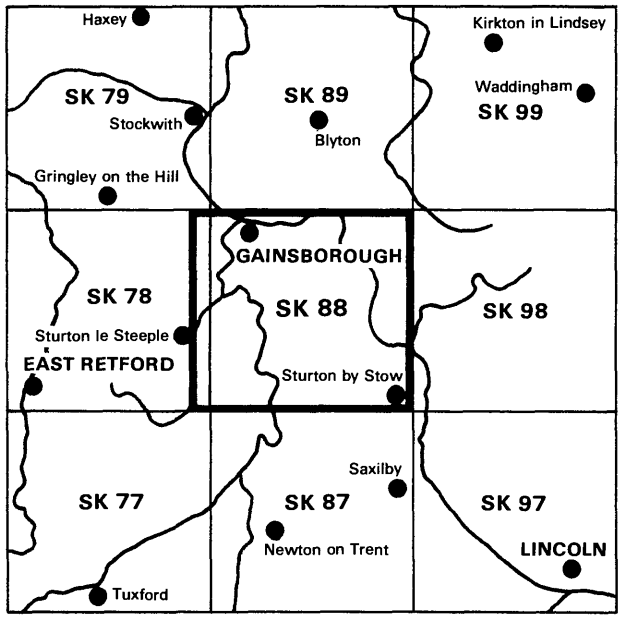
Mineral Assessment Report 19



The sand and gravel resources of the country south of Gainsborough, Lincolnshire

Description of 1:25 000 resource sheet SK 88 and part of SK 78

J. H. Lovell, BSc

London Her Majesty's Stationery Office 1976

The Institute of Geological Sciences was formed by the incorporation of the Geological Survey of Great Britain and the Museum of Practical Geology with Overseas Geological Surveys and is a constituent body of the Natural Environment Research Council.

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 onward will appear in the Mineral Assessment Report Series 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 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.

The survey was conducted, under the supervision of Mr D. Price, by Mr J. H. Lovell, assisted in the drilling and sampling programme by Mr J. R. Gozzard. The work, which was controlled from the sub-unit in Leeds (J. H. Hull, Officer-in-Charge), is based on one-inch scale geological surveys published in 1886 on Old Series Sheet 83 (Lincoln) and on six-inch geological mapping by Mr G. H. Rhys and Mr E. G. Smith in 1957-61, published on New Series One-Inch Sheet 101 (East Retford). The geological lines, now presented at the 1:25 000 scale, incorporate minor amendments resulting from the present work.

Mr J. W. Gardner, CBE (Land Agent) has been responsible for negotiating access to land for drilling. The ready cooperation of land owners and tenants in this work is gratefully acknowledged.

Kingsley Dunham
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1 June 1975

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Dr A. W. Woodland succeeded Sir Kingsley Dunham as Director on 1 January 1976.

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The geological maps of the Institute of Geological Sciences, pre-existing borehole information, and 43 boreholes drilled for the Mineral Assessment Unit form the basis of the assessment of sand and gravel resources in the Gainsborough area.

All deposits in the area which 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 confidence level.

The 1:25 000 map is divided into eight resource blocks containing between 0.3 and 10.9 km^2 of sand and gravel. For the blocks assessed statistically the geology of the deposits is described and the mineral-bearing area, the mean thickness of overburden and mineral, and the mean grading of the mineral are stated. Detailed borehole data are given. The geology, the position of the boreholes and the outlines of the resource blocks are shown on the accompanying map.

Sommaire

Les sources des renseignements qui constituent les bases de l'évaluation des ressources en sable et en gravier dans la région de Gainsborough, comprennent les cartes géologiques de l'Institute of Geological Sciences, des données obtenues des trous de sonde déjà en existence, et de 43 trous de sonde forés pour le Mineral Assessment Unit.

Dans la région tous les dépôts qui pourraient être exploités pour le sable et le gravier ont été étudiés et on s'est servi d'une méthode statistique simple pour en évaluer le volume. Les évaluations de volume sont tenues d'être symétriquement à 95 pour cent exactes.

La carte 1:25 000 est divisée en huit blocs de ressource avec d'entre 0.3 à 10.9 km^2 de sable et de gravier. Pour les blocs évalués statistiquement on décrit la géologie des dépôts et on donne l'étendue du terrain minéralisé, l'épaisseur moyenne de recouvrement et de minéral, et le triage moyen de minéral. On présente des données détaillées des trous de sonde. La situation des trous de sonde, la géologie et les profils des blocs de ressource sont montrés sur la carte.

Zusammenfassung

Die geologischen Karten vom Institute of Geological Sciences, vorherexistierende Information über Bohrlöcher, und 43 für die Mineral Assessment Unit gebohrten Bohrlöcher, bilden den Grund für die Einschätzung der Sand- und Schottermittel im Gainsborough Gebeit.

Alle Ablagerungen im Gebeit, die möglich bearbeitbar für Sand und Schotter sind, wurden untersucht, und eine einfache statistische Methode wurde benutzt, um das Volumen zu schätzen. Man gibt die Zuverlässigkeit der Volumenschatzungen mit symmetrischen 95 Prozent Vertrauensgrenzen.

Man teilt die 1:25 000 Karte in 8 Mittelsblöcke, die zwischen 0.3 und 10.9 km^2 von Sand und Schotter umfassen. Man beschreibt die Geologie der Ablagerungen für die statistisch bewerteten Blöcke. Das mineralhaltige Gebeit, die mittlere Dicke von Überlastung und Mineral, und die mittlere Klassifizierung von Mineral werden bestimmt Ausführliche Bohrlöcherdaten werden auch gegeben. Die Geologie, die Lage der Bohrlöcher und die Skizzen der Blöcke werden auf der Begleitkarte gezeigt.

The sand and gravel resources of the country south of Gainsborough, Lincolnshire

Description of 1:25 000 resource sheet SK 88 and part of SK 78

J. H. LOVELL, BSc[1]

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, both the economic and the social factors used to decide whether a deposit may be workable in the future cannot 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).

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 geological evidence. The sites available for inspection, measurement, and sampling are too widely spaced to permit the mineral bodies to be outlined completely or the grade established throughout". (Anon., 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 BS sieve, about 1/16 mm) should not exceed 40 per cent.
d. The deposit must 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.

If a deposit of sand and gravel broadly meets these criteria, it 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.

For the particular needs of assessing sand and gravel resources, a grain-size classification based on the geometric scale 1/16 mm, 1/4 mm, 1 mm, 4mm, 16 mm has been adopted. The boundaries between fines (that is, the clay and silt fractions) and sand, and between sand and gravel grade 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 approximately 10 km^2 of sand and gravel. No account is taken of any factors, for example, roads, villages and 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 the mineral in parts of a block, except in the immediate vicinity of the sample points.

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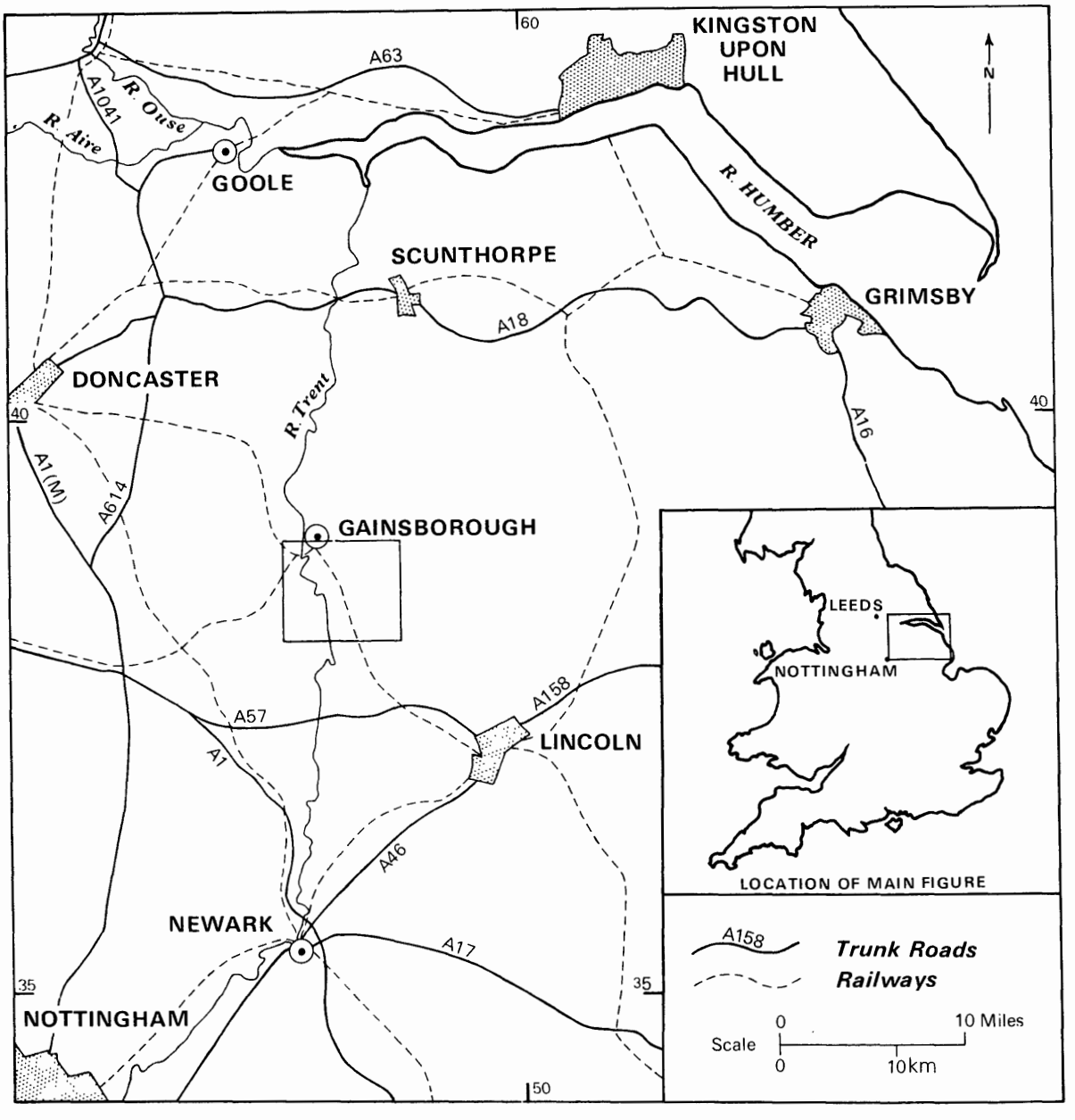


Fig. 1. Sketch map showing the location of sheet SK 88 and part of SK 78

Description of 1:25 000 Resource Sheet SK 88 and Part of SK 78

The area occupies 110 km^2 (42.5 square miles) along the Nottinghamshire-Lincolnshire border and is largely agricultural. Gainsborough (Fig. 1) is the main centre of population, industry and communication, lying as it does around one of the few bridges over the River Trent. The river, which is tidal, flows northwards across the western part of the area and its floodplain, which is up to 2 miles wide, forms a major topographic feature.

East of the Trent, Keuper, Rhaetic and Lower Lias rocks form west-facing scarps which rise to about 100 ft above OD. Farther east a plateau falls gently eastwards to about 25 ft above OD and is dissected by the southward-flowing River Till.

GEOLOGY

A classification of deposits which outcrop in the area is shown in Table 1. The relationship between these deposits is illustrated in the schematic cross-section Fig. 2. A further description of deposits in the west of the area will be found in the descriptive memoir (Smith and others, 1973).

Table 1. Classification and geological sequence.

DRIFT	
Recent and Pleistocene	Blown sand
	Peat
	Alluvium
	First Terrace of the R. Trent
	Head
	Older River Deposits
	Glacial Sand and Gravel
	Boulder Clay
SOLID	
Jurassic	Lower Lias
Permo-Triassic	Rhaetic
	Keuper Marl

Keuper Marl

The uppermost 400 ft (122 m) of the Keuper Marl formation are exposed in the area. The beds consist of red and greenish-grey unfossiliferous clays and laminated mudstones which dip gently eastwards. Gypsum occurs locally in thin seams and nodules, while small topographic features are formed by bands of hard, white and pale green dolomitic sandstones and siltstones called 'skerries'.

Rhaetic

This formation forms a prominent north-south scarp between Lea and Brampton, but the rocks are poorly exposed because of extensive drift cover. The beds consist of dark, pyritic, fossiliferous, papery shales and subordinate limestones, sandstones and pale-weathering clays. The thickness ranges from 40 to 70 ft (12 to 21 m).

Lower Lias

The Lower Lias outcrop occupies the eastern half of the sheet area and is largely drift covered. Nevertheless a prominent scarp is formed by a limestone at the base, though to the east, succeeding dip-slope and scarp-slope features are not well developed. The beds, which dip eastward, consist of dark grey clays and shales, with bands of cream to dark grey argillaceous limestone and dark sandstones. The clays contain septarian nodules and are locally pyritic. The limestones are fissile, rarely massive and, together with the sandstones, often ferruginous. The beds commonly contain abundant bivalves, brachiopods and cephalopods.

Boulder Clay

West of the River Trent, two small patches of boulder clay occur near West Burton; both are thin and consist of reddish-brown clay with pockets of sand and quartzite pebbles.

East of the river, a dissected sheet of boulder clay up to 45 ft (13.7 m) thick near Heapham Cliff [899 883], infills a shallow depression in Lower Lias rocks and small patches, concealed beneath Glacial Sand and Gravel, cap parts of the Keuper Marl and Rhaetic scarps. In these areas the boulder clay is grey and reddish-brown, with limestone, flint, chalk, vein quartz and quartzite pebbles; locally its composition reflects the underlying geology.

Glacial Sand and Gravel

These deposits occur mainly east of the River Trent, between Gainsborough and Brampton, and reach a maximum proved thickness of 7.2 m (23.6 ft). They generally overlie Keuper, Rhaetic or Lower Lias rocks, but may be associated with boulder clay. They consist of fine and medium grained sands with sporadic vein quartz and quartzite pebbles, a small percentage of reddish-brown silt and red clay bands.

Elsewhere, only isolated deposits of Glacial Sand and Gravel have been recognised. Near West Burton the deposit [800 847] consists of brownish pebbly sand, and around Kexby [874 860] at least 4 m (13 ft) of yellow fine and medium grained silty sand are found. Other patches, for example, near Stow [883 824], Gate Burton [837 829] and Somerby Grove

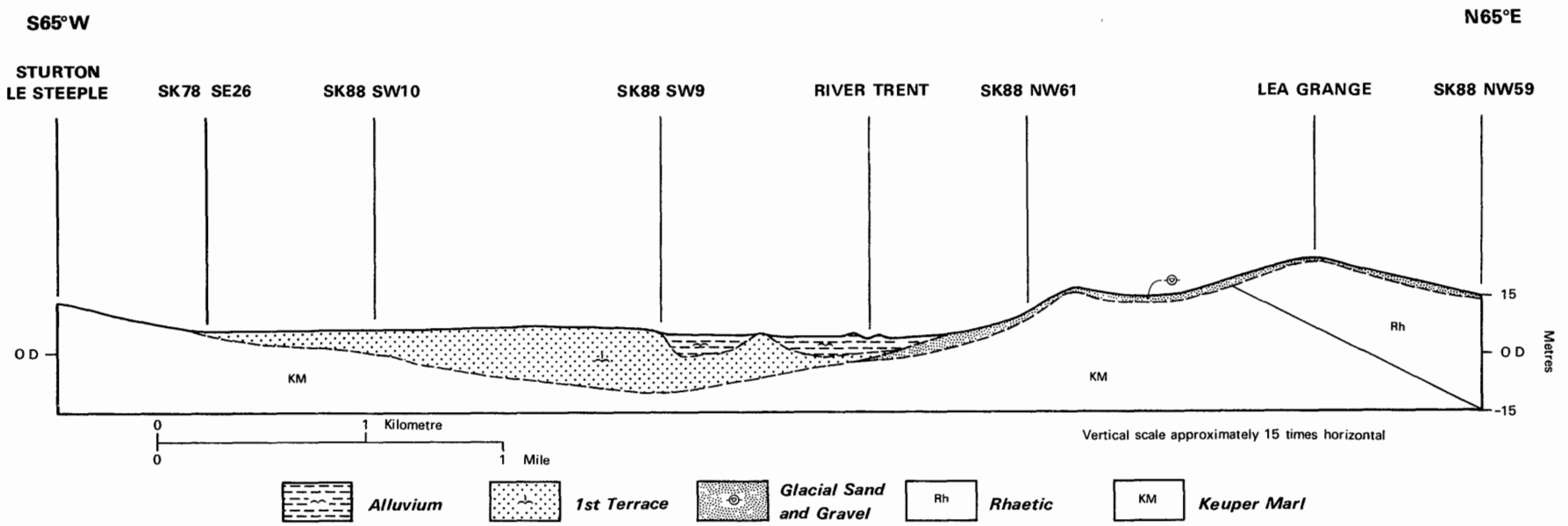


Fig. 2. Schematic section across the Trent Valley showing the general relationships between deposits

[851 889] although mapped as Glacial Sand and Gravel, consist mainly of stiff, reddish- brown and grey clays with sand pockets and pebbles of flint, limestone, vein quartz and sandstone, frequently beneath a thin veneer of pebbly sand.

Older River Deposits

These deposits occupy a restricted area of low ground east of Marton and Brampton. Although they are the northward extension of a significant, mineral-bearing deposit found on sheet SK 87 Newton-on-Trent, Lincolnshire (Price, 1975), here they consist only of brown and grey laminated clays and silts with sand pockets and small pebbles.

Head

This is a thin, soliflucted deposit whose composition reflects the underlying geology. It occurs in a dry valley east of Gainsborough and along streams [792 802; 791 817] near Habblesthorpe, and consists of sand, silt and clay with small pebbles.

First Terrace

The First Terrace of the River Trent is the major mineral-bearing deposit in the area. It outcrops extensively in the south-west, around Littleborough, Cottam and Habblesthorpe, but apart from small patches, for example, on Lea Marsh [813 866] (Fig. 2), and in the outskirts of Gainsborough, the deposit elsewhere lies beneath the alluvium of the River Trent.

The maximum proved thickness is 12.3 m (40.5 ft), which was recorded in a site investigation borehole [8066 8755] on Bole Ings. The top of the First Terrace lies between 12 and 17 ft (3.7 and 5.2 m) above OD, while its base descends to about 40 ft (12.2 m) below OD in a deep valley which follows approximately the present course of the River Trent.

The deposit consists of sands and gravels in varying proportions, together with a small percentage of fines, but grades laterally into silts and clays along its western boundary. A basal facies containing a greater percentage of gravel has been recognised in some boreholes; the terrace in general is more sandy towards the top.

Alluvium

The alluvium forming the floodplain of the River Trent reaches a maximum width of nearly two miles near West Burton. Its top lies between 6 and 14 ft (1.8 and 4.3 m) above OD and a maximum proved thickness of 9.0 m (29.5 ft) is attained in borehole SK 88 NW 55. The deposit consists of brown and grey clays and sandy, micaceous silts with sand pockets and peat beds; other organic remains include logs and leaves, and small gastropods which frequently show their original colouration. Locally, as for example near Bole and West Burton, meanders infilled with silt and peat represent former courses of the River Trent.

Small patches of thin alluvium occur in the eastern half of the area and consist of locally derived clays and silts.

Peat

Sporadic patches of peat overlie Glacial Sand and Gravel deposits near Brampton and Knaith, but elsewhere peat is intimately associated with the Trent alluvium.

Blown Sand

Near Brampton, a small patch [843 807] of blown sand consists of well rounded fine and medium grained quartz with a small percentage of fines. Elsewhere much of the land is covered with a veneer of blown sand which is too thin to map. Locally this deposit has accumulated against the Keuper Marl and Rhaetic scarps, and has apparently been derived from the inliers of First Terrace standing slightly above the alluvium.

COMPOSITION OF THE SAND AND GRAVEL

The two potentially workable sand and gravel horizons on this sheet are the Glacial Sand and Gravel and the First Terrace of the Trent.

Glacial Sand and Gravel

These deposits have a mean grading of fines 6 per cent, sand 92 per cent and gravel 2 per cent but show considerable variation about the means. The fines content ranges between 1 and 22 per cent, the higher values generally being found towards the south of the main outcrop. The gravel content ranges from 0 to 9 per cent.

Typically, the sand consists of subrounded to well rounded, medium grained quartz with some rounded rock fragments, and the gravel of well rounded vein quartz, quartzite and flint pebbles, chiefly of the fine gravel size.

First Terrace

These deposits show considerable lateral and vertical variation in composition. In the south-west (block A) sands predominate, but where the deposits are concealed beneath the Trent alluvium, pebbly sands, sandy gravels and gravels are common. The mean grading of all the samples taken from the First Terrace is fines 3 per cent, sand 77 per cent, gravel 20 per cent, but allowing for errors in sampling

from below the water table, in situ fines and sand percentages may be somewhat higher.

The gravel fractions consist mainly of subrounded to well rounded fine and coarse grained pebbles, but some boreholes contain a basal layer of cobbles. The results of pebble counts on selected samples are shown in Table 2. Well-rounded, hard, brown and purple quartzites, probably derived from Permo-Triassic and Carboniferous formations, and vein quartz are the major constituents. Flint and chert, probably of Cretaceous and Carboniferous age, and red and brown sandstone are next in abundance. Locally derived siltstone and mudstone, and Carboniferous and Jurassic limestones, usually contribute only a few per cent, mainly in the fine gravel fraction. Exceptionally, as in borehole SK 88 NW 47 (see Table 2) mudstone and siltstone pebbles from the Keuper Marl are present in more significant proportion and may be regarded as deleterious. Other less common constituents include conglomeratic, metamorphic and dark, fine grained igneous rocks.

The sand fractions range from fine to coarse grained with the medium grade usually dominant. They consist of subrounded to well rounded quartz grains, with subordinate subangular to rounded rock fragments which are generally coarser than the quartz grains. The fines consist mainly of reddish-brown silt.

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 in green, the geological data in black and the mineral resource information in shades of red.

Geological Data

The geological boundary lines, symbols, etc., shown are taken from the sources shown at the foot of the map. Borehole data, which include the stratigraphic relations and mean particle size distribution of the sand and gravel samples collected during the assessment survey, are also shown.

The geological boundaries are regarded as the best interpretation of the information available at the time of survey. However it is inevitable, particularly with glacial deposits (such as those included in this area) which change rapidly vertically and laterally, that local irregularities or discrepancies will be revealed by some boreholes (as, for example, at borehole SK 88 NW 56). These are taken into account in the assessment of resources.

			Constituent rock types (Percentages)							
Borehole No. &block letter	Sample depth(m)	Method of calculation	Quartzite	Quartz	Flint& chert	Sandstone	Mudstone & siltstone	Limestone	Igneous	Other
SK 88 NW 47 B	5.0-6.0	by number	23	19	12	19	26	1		
		by weight	38	17	23	12	9	trace	1	
SK 88 NW 47 B	8.0-9.0	by number	32	24	18	18	4	2	2	
		by weight	40	26	15	7	7	4	1	
SK 88 NW 52 B	8.5-9.5	by number	26	24	20	24	4	1	1	
		by weight	33	27	23	15	1	trace	1	
SK 88 SW 3 C	9.0-10.0	by number	32	24	18	22	3	trace	trace	1
		by weight	41	25	16	15	1	1	trace	1
SK 88 SW 7 C	11.3-12.3	by number	23	23	21	21	7	4	1	
		by weight	43	24	12	13	3	3	2	
SK 88 SW 13 A	5.8-6.8	by number	35	25	15	21	2	2		
		by weight	42	35	9	12	1	1		

Table 2. Pebble counts, by weight and number, for the gravel fractions (+4 mm) of selected samples from the First Terrace of the River Trent.

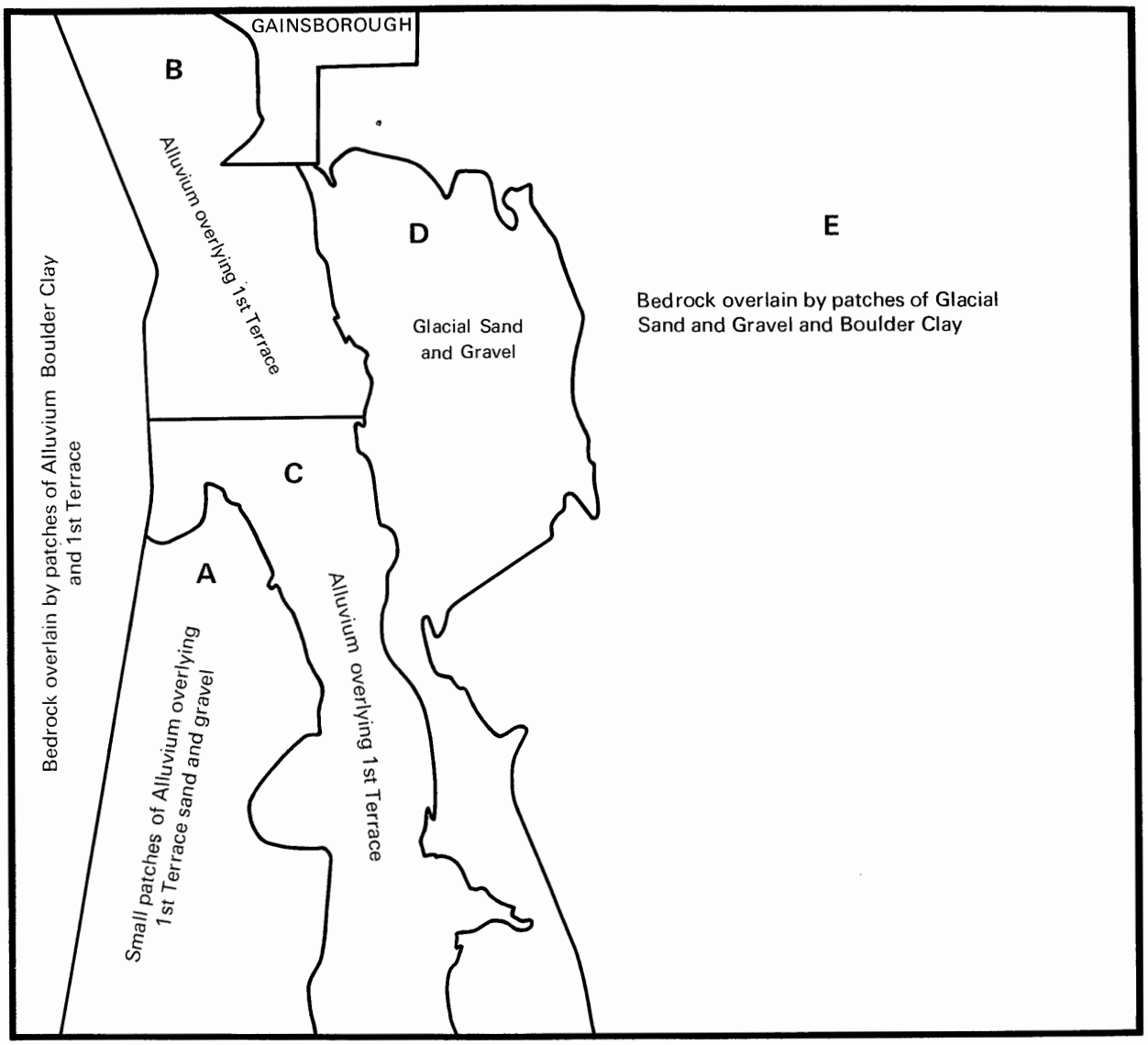


Fig. 3. The drift geology of SK 88 and part of SK 78 summarised in relation to the resource block boundaries

Mineral Resource Information

For assessment purposes the map is divided into areas of mineral and areas where sand and gravel is either not potentially workable or absent (for definition of 'mineral' and 'potentially workable' see p. 1).

On this sheet the mineral is subdivided into areas where it outcrops and areas where it is present in continuous spreads beneath overburden. However, within these areas there may be small patches where sand and gravel is absent or not potentially workable, for example, around borehole SK 88 NW 56. Areas where bedrock outcrops, where superficial deposits are classified as non-mineral, and those where sand and gravel is deemed to be not potentially workable are shown uncoloured. Two isolated deposits of mineral with an area of less than 0.25 km^2 have not been assessed.

For the most part the depicted distribution of the various categories of deposits is based on the mapped geological boundaries. Where there is a transition from one category to another which cannot be related to the geological map and which cannot be delineated accurately, inferred boundaries, shown by a distinctive symbol, have been inserted. The symbol is intended to signify an approximate location within a likely zone of occurrence rather than to represent the breadth of the zone, its size 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 3. Fuller grading particulars are shown in Fig. 4. Up to 11 data points have been used in plotting each grading curve.

Accuracy of Results

For the four statistically assessed resource blocks on this resource sheet the accuracy of the results at the 95 per cent probability level varies between 25 and 45 per cent (that is, it is probable that 19 times out of 20 the true volumes present lie between these limits). However, the true values are more likely to be nearer the figures estimated than the limits. Moreover, it is probable that in each block roughly the same percentage limits would apply for the estimate of volume of a very much smaller parcel of ground (say 1 km^2) 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 the quotation of reserves of part of a block, it can be expected that data from more than ten sample points will be required, even if the area is quite small. This point can be illustrated by considering the whole of the potentially workable sand and gravel in resource blocks A to D on this sheet. The volume (159 million m^3) can be estimated to limits of $\pm$20 per cent at the 95 per cent confidence level by a calculation based on data from 40 sample points spread across the four resource blocks. However, it must again be emphasised that the quoted volume of sand and gravel has no simple relationship with the amount which could be extracted in practice, as no allowance has 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 RESOURCE BLOCKS

Block A

This block contains 9.6 km^2 of mineral-bearing First Terrace, overlain in some places by thin alluvium (Fig. 3). The western margin of the block coincides with an inferred boundary which has been inserted to indicate approximately where the proportion of fines in the deposit exceeds the criterion adopted for 'mineral'.

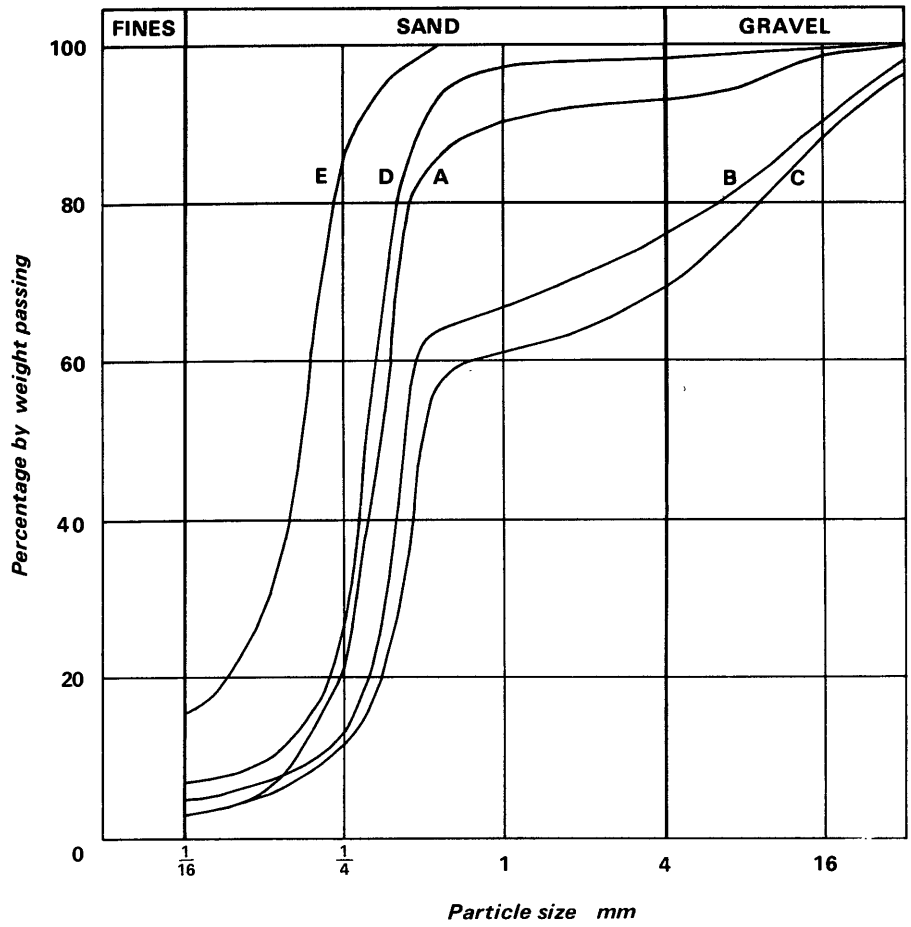
The mineral attains a maximum proved thickness of 8.3 m (27.0 ft) in borehole SK 88 SW 13, and has a mean thickness, based on eight data points, of 6.1 m (20 ft). Borehole SK 88 SW 13 is exceptional in that the lower part of the mineral contains 29 per cent gravel (sandy gravel) whereas there is no more than 5 per cent elsewhere in the deposit. The mean grading for the block is fines 3 per cent, sand 90 per cent, gravel 7 per cent and the estimated volume of mineral is 58 million^3 $\pm$15 million m^3.

The overburden consists of topsoil and clay, and its mean thickness is 0.6 m (2.0 ft).

Block B

This block encloses 7.1 km^2 of mineral-bearing First Terrace, overlain, except for minor outcrops, by alluvial clays, silts and peat. The western margin of the block coincides with an inferred boundary where mineral is thought to pass westwards into non-mineral; data from site-investigation boreholes for the West Burton power station assisted the location of this boundary.

Borehole SK 88 NW 46 was probably sited on a relatively recently abandoned river channel and proved 10 m (33 ft) of partly peaty silt and clay with pebbles at the base, on bedrock. The precise area around this hole from which mineral is absent is not known, but the available evidence suggests that it is small. The mineral, which attains a maximum proved



BLOCK	Percentage by weight passing				
	1/16 mm	1/4 mm	1 mm	4 mm	16 mm
A	3	22	90	93	99
B	5	13	67	75	92
C	3	12	61	69	88
D	6	25	97	98	99
E	16	86	100	100	100

Fig. 4. Mean particle size distribution for the assessed thickness of sand and gravel in resource blocks A to E

thickness of 12.3 m (40.5 ft) in a site-investigation borehole, SK 88 NW 33, [8066 8745] has a mean thickness of 5.3 m (17.5 ft) based on 15 sample points. Borehole SK 88 NW 50 proved only sand, but elsewhere the gravel content ranged from 14 per cent (borehole SK 88 NW 54) to 41 per cent (borehole SK 88 NW 52). The fines content is generally low, but reaches 12 and 13 per cent in boreholes SK 88 NW 49 and NW 54 respectively. The mean grading of the mineral is fines 5 per cent, sand 70 per cent and gravel 25 per cent, and its estimated volume 38 million m^3 $\pm$17 million m^3.

Excluding borehole SK 88 NW 46, which proved 10.0 m (33.0 ft) of waste on bedrock, the overburden thickness ranges up to 7.9 m (26.0 ft), with a mean for the block of 5.1 m (16.5 ft).

Block C

Block C is the upstream continuation of block B, and is geologically similar. It has an area of 8.6 km^2, and data from nine Mineral Assessment Unit boreholes and one site investigation borehole have been used to calculate the resources.

The mineral varies in thickness from 3.0 m (10.0 ft) to 9.3 m (30.5 ft) in boreholes SK 88 SW 4 and SW 8 respectively, with a mean for the block of 5.3 m (17.5 ft). Except for boreholes SK 88 NW 53 and SW 6 (which showed gravel percentages of 4 and 3 per cent respectively) near the edges of the block, the gravel content varies generally between 23 per cent in borehole SK 88 SW 4 and 52 per cent in SK 88 NW 55. The fines content is generally low, but reaches 9 per cent in SK 88 SW 4. The mean grading for the block is fines 3 per cent, sand 66 per cent and gravel 31 per cent, and the estimated volume of mineral is 46 million m^3 $\pm$14 million m^3.

The overburden thickness varies from 1.4 m (4.5 ft) in SK 88 SW 6 to 9.0 m (29.5 ft) in SK 88 NW 55, with a mean of 5.2 m (17.0 ft).

Block D

Block D has a total area of 11.9 km^2, of which 10.9 km^2 are mineral bearing; the remaining 1 km^2 consists of small outcrops of bedrock. Except near Knaith, where an inferred boundary has been drawn to exclude an area in which field and borehole evidence suggests that mineral is absent, the block boundary coincides with the maximum extent of the main Glacial Sand and Gravel deposit south of Gainsborough.

The mineral-bearing deposits in this block show considerable variations in lithology and thickness. In boreholes SK 88 NW 57, SW 18 and SW 22 sand and gravel is too thin to be potentially workable and in borehole SK 88 NW 56 only pebbly clay, possibly boulder clay, was encountered above bedrock. Because the true extent of non-mineral cannot be defined the volume of mineral has been calculated from the total area of sand and gravel as mapped

Statistical assessment blocks A to D

Block	AREA		MEAN THICKNESS				VOLUME OF MINERAL				MEAN GRADING PERCENTAGE		
	Block	Mineral	Overburden		Mineral		million m^3	million yd^3	95% confidence limits		Fines	Sand	Gravel
									$\pm$ %	$\pm$ Vol. million m^3	-1/16 mm	+1/16 -4 mm	+4-64 mm
	km^2	km^2	m	ft	m	ft							
A	9.6	9.6	0.6	2.0	6.1	20.0	58	77	25	15	3	90	7
B	7.1	7.1	5.1	16.5	5.3	17.5	38	50	45	17	5	70	25
C	8.6	8.6	5.2	17.0	5.3	17.5	46	60	31	14	3	66	31
D	11.9	10.9	0.5	1.5	1.6	5.0	17	22	44	7	6	92	2
	1.6	Gainsborough area not assessed											
	10.0	Barren area											
Total	48.8	36.2	1.9	6.0	4.4	14.5	159	209	20	32	4	77	19

Inferred assessment, block E, not included above

E	61.2	0.3	0.9	3.0	3.0	10.0	1	1	Speculative		16	84	0

Table 3. The sand and gravel resources of sheet SK 88 and part of SK 78.

and the mean thickness of the deposit, including 'nil values'. The mineral reaches a maximum proved thickness of 3.7 m (12.0 ft) in SK 88 NW 61, with a mean for the block, based on 11 sample points, of 1.6 m (5.0 ft). The proportion of gravel in the samples does not exceed 9 per cent, while the fines vary from 1 per cent to 22 per cent. The mean grading for the block is fines 6 per cent, sand 92 per cent, gravel 2 per cent, and the estimated volume of mineral is 17 million $m^3 \pm 7$ million m^3.

Overburden, mainly topsoil, reaches a maximum thickness of 1.0 m (3.5 ft) in SK 88 NW 58 and has a mean thickness of 0.5 m (1.5 ft).

Block E

This block has an area of 61.2 km^2, and contains a large area of solid rock and a variety of drift deposits which have been investigated with two boreholes and a number of hand-auger holes. Boreholes SK 88 SE 6 and SW 19 in the Glacial Sand and Gravel around Stow and Knaith, respectively, and hand-auger holes in other similar but smaller deposits proved only clay beneath a thin veneer of sand. Sands were proved in the Older River Deposits east of Brampton but they are too thin to be potentially workable. The only potentially workable mineral deposit is the Glacial Sand and Gravel around Kexby, and data from the hand-auger hole SK 88 NE 6 has been used to make an inferred assessment. The deposit has an area of 0.3 km^2 and a grading of fines 16 per cent and sand 84 per cent. The average thickness is about 3.0 m (10.0 ft) and an inferred assessment (Appendix B, p. 25) suggests a mineral volume of about 1 million m^3.

LIST OF WORKINGS

Commercial operators have not been active in the area, but numerous old pits in the deposits of the First Terrace and Glacial Sand and Gravel mark former small-scale working.

Appendix A: Field Procedure

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, 10 km^2, 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 British Standard 1377 (1967). Random checks on 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 F.

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

Appendix B: Statistical Procedure

Statistical Assessment

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

2. The simple methods used in the calculations are consistent with the amount of data provided by the survey. Conventional symmetrical confidence limits are calculated for the 95 per cent probability level. That is there is a 5 per cent or one in twenty

chance of a result falling outside the stated limits.

3. The volume estimate (V) for the mineral in a given block is the product of the 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

$$S_V = \sqrt{S_A^2 + S_{\bar{l}_m}^2} \quad \ldots\ldots(1)$$

4. The above relationship may be transposed such that

$$S_V = S_{\bar{l}_m} \sqrt{1 + \frac{S_A^2}{S_{\bar{l}_m}^2}} \quad \ldots\ldots(2)$$

From this it can be seen that as $\frac{S_A^2}{S_{\bar{l}_m}^2}$ 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 mean 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}, ... l_{m_n}, then the best estimate of mean thickness, $\bar{l}_m = \frac{\sum (l_{m_1} + l_{m_2} \ldots\ldots l_{m_n})}{n}$

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, $S_{\bar{l}}$ expressed as a proportion of the mean thickness is given by

$$S_{\bar{l}} = \frac{1}{\bar{l}_m} \sqrt{\frac{(l_m - \bar{l}_m)^2}{(n - 1)}}$$

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

$\frac{S_A}{S_{\bar{l}_m}} \leqslant 1/3$ is assumed in all cases

It follows from equation (2) that

$$S_{\bar{l}_m} \leqslant S_V \leqslant 1.05\ S_{\bar{l}_m} \quad \ldots\ldots(3)$$

7. The limits on the estimate of mean thickness of mineral, $L_{\bar{l}_m}$, may be expressed in absolute units

$$\pm \frac{t}{\sqrt{n}} \times S_{\bar{l}_m}$$

or as a percentage

$$\pm \frac{t}{\sqrt{n}} \times S_{\bar{l}_m} \times \frac{100}{\bar{l}_m} \text{ per cent}$$

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	∞	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, Biometrika Tables for Statisticians, Volume 1, Second Ed. 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:

$$L_{\bar{l}_m} \leqslant L_V \leqslant 1.05\ L_{\bar{l}_m}$$

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

$$\frac{1.05 \times t}{\bar{l}_m} \times \sqrt{\frac{\sum(l_m - \bar{l}_m)^2}{n(n-1)}} \times 100 \text{ per cent}$$

and when n is greater than 20, as

$$\frac{1.05 \times 1.96}{\bar{l}_m} \times \sqrt{\frac{\sum(l_m - \bar{l}_m)^2}{n(n-1)}} \times 100 \text{ per cent}$$

11. The application of this procedure to a fictitious area is illustrated in Figs. 5 and 6.

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, based on 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 need 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 within the zone as the weighting factor.

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 (less than 1/16 mm) and coarser than pebbles (more than 64 mm 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 not considered to be 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 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 Fig. 7). The procedure is as follows:

1. Classify according to ratio of sand to gravel;
2. Describe 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 Note 11, p. 19).

Many differing proposals exist 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 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 (Table 4), which is used in this 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 ($-\frac{1}{4}$ +1/16 mm), medium (-1 $+\frac{1}{4}$ mm) and coarse (-4 +1 mm). The boundary at 16 mm distinguishes a range of finer gravel (-16 +4 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 (see British Standard 1377, 1967). In this report the grading is tabulated on the borehole record sheets (Appendix F), the intercepts corresponding with the simple geometric scale 1/16 mm, $\frac{1}{4}$ mm, 1 mm, 4 mm, 16 mm and 64 mm. The sample grading results 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 very approximate 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 constituents 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. Original 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: no 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.

Table 4. Classification of gravel, sand and fines

Size limits	Grain size description	Qualification	Primary classification
64 mm	Cobble		Gravel
16 mm	Pebble	Coarse	
		Fine	
4 mm	Sand	Coarse	Sand
1 mm		Medium	
¼ mm		Fine	
1/16 mm			
	Fines (silt and clay)		Fines

Block Calculation — 1:25 000 Block — Fictitious

Area
- Block: 11.08 km^2
- Mineral: 8.32 km^2

Volume
- Overburden: 21 million m^3
- Mineral: 54 million m^3

Mean Thickness
- Overburden: 2.5 m
- Mineral: 6.5 m

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 m^3

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	MAU 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	Hydrogeological Dept record
123/45	½	2.0		4.6		
1	¼	2.7	2.5	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	$\Sigma w = 8$	$\Sigma wl_o = 20.1$		$\Sigma wl_m = 52.0$		
Means		$\bar{l}_o = 2.5$		$\bar{l}_m = 6.5$		

Calculation of confidence limits

l_m	$(l_m - \bar{l}_m)$	$(l_m - \bar{l}_m)^2$
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

$\Sigma(l_m - \bar{l}_m)^2 = 15.82$

$n = 8$

$t = 2.365$

L_V is calculated as

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

$$= 1.05 \times \frac{2.365}{6.5} \sqrt{\frac{15.82}{8 \times 7}} \times 100$$

$= 20.3$

$\simeq 20$ per cent

Fig. 5. Example of resource block assessment: calculation and results

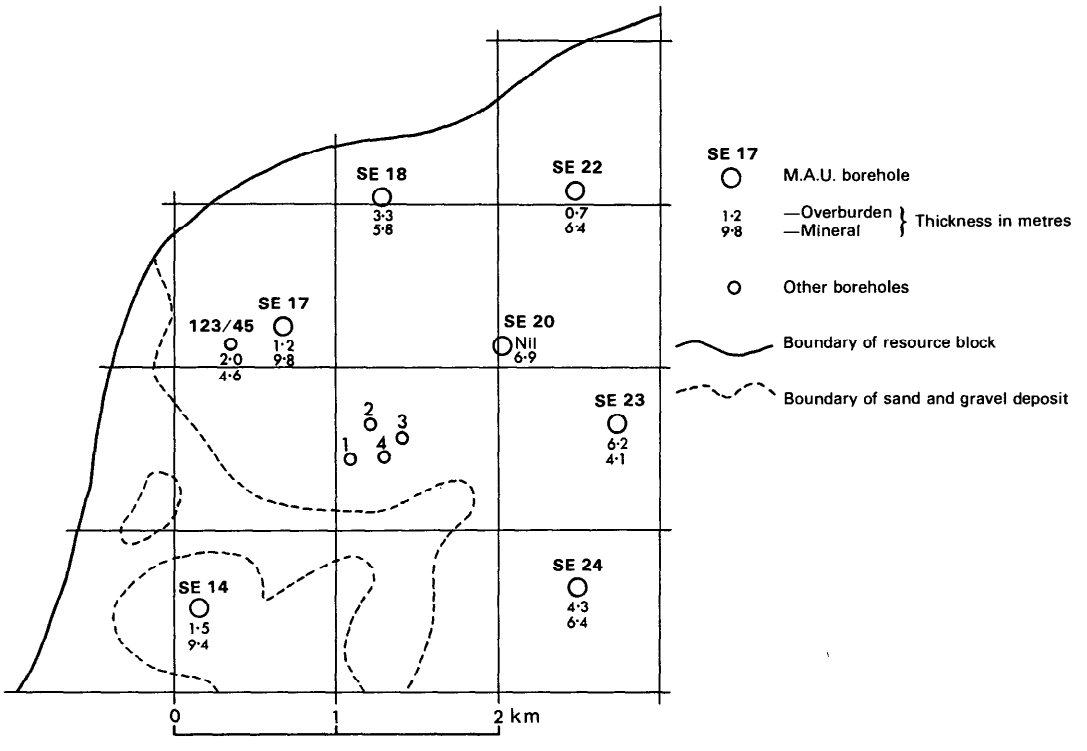
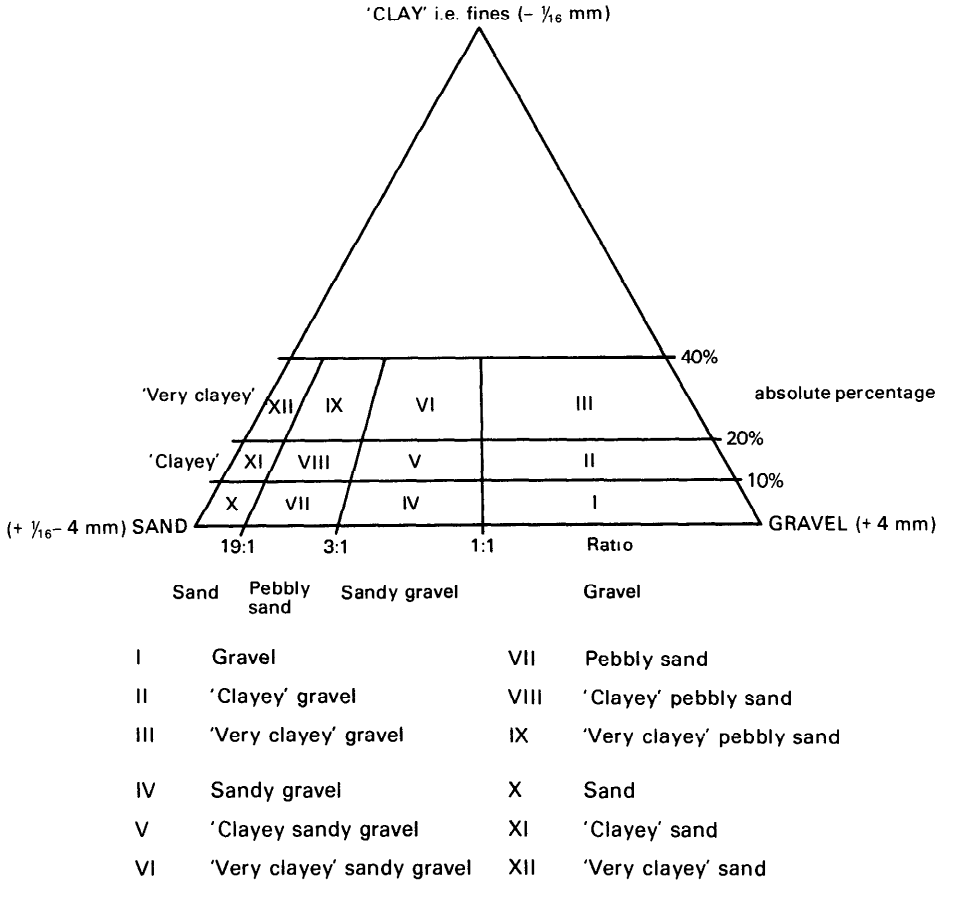


Fig. 6. Example of resource block assessment: map of a ficticious block



I	Gravel	VII	Pebbly sand
II	'Clayey' gravel	VIII	'Clayey' pebbly sand
III	'Very clayey' gravel	IX	'Very clayey' pebbly sand
IV	Sandy gravel	X	Sand
V	'Clayey sandy gravel	XI	'Clayey' sand
VI	'Very clayey' sandy gravel	XII	'Very clayey' sand

Fig. 7. Diagram showing the descriptive categories used in the classification of sand and gravel

Appendix D: Explanation of the Borehole Records

ANNOTATED EXAMPLE

SK 88 SW 13[1] 8125 8241[2] Sturton le Steeple[3] Block A

Surface level (+4.6 m) +15 ft[4]
Water level +2.2 m (+7 ft)[5]
November 1971[6]

[7]Overburden 0.8 m (2.5 ft)[8]
Mineral 8.3 m (27.0 ft)
Bedrock 1.4 m+[9] (4.5 ft+)

		Thickness m	(ft)	Depth m	(ft)
	Topsoil and clay	0.8	(2.5)	0.8	(2.5)
First Terrace[10]	A. Pebbly sand[11] Sand: medium, subrounded quartz with coal specks Gravel: fine, subrounded to well rounded quartz, quartzite flint and sandstone	3.0	(10.0)	3.8	(12.5)
	B. Sandy gravel Sand: medium, subrounded quartz Gravel: fine, subrounded to well rounded quartz, quartzite and flint	5.3	(17.5)	9.1	(30.0)
Keuper Marl	Mudstone, red	1.4+	(4.5+)	10.5	(34.5)

		%	mm	%
A.	Gravel	5	+16	1
			-16+4	4
	Sand	84	-4+1	2
			-1+$\frac{1}{4}$	53
			-$\frac{1}{4}$+1/16	29
	Fines	11	-1/16	11
B.	Gravel	29	+16	5
			-16+4	24
	Sand	69	-4+1	9
			-1+$\frac{1}{4}$	50
			-$\frac{1}{4}$+1/16	10
	Fines	2	-1/16	2

Depth below surface (m)[12]	Percentage[13] Fines	Sand	Gravel
0.8 - 1.8	[25	73	2][14]
1.8 - 2.8	6	83	11
2.8 - 3.8	4	95	1
3.8 - 4.8	trace	37	63
4.8 - 5.8	3	77	20
5.8 - 6.8	3	65	32
6.8 - 7.8	4	77	19
7.8 - 9.1	1	85	14

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

1. Borehole Registration Number.
Each Mineral Assessment Unit (MAU) borehole is identified by a Registration Number. This consists of two statements.

1) The number of the 1:25 000 sheet on which the borehole lies, for example, SK 88
2) The quarter of the 1:25 000 sheet on which the borehole lies and its number in a series for that quarter, for example, SW 13

Thus the full Registration Number is SK 88 SW 13. Note that some boreholes lie on sheet SK 78.

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

3. 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 it lies is stated.

4. 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.

5. Groundwater Conditions
Three kinds of entry are made: the record indicates the level at which groundwater stood on completion of drilling (in m and ft above or below OD); or that water was not struck; or that no record of groundwater conditions was made.

6. Type of Drill and Date of Drilling
Unless otherwise stated a conventional Pilcon shell and auger rig was used in the survey generally in conjunction with 8-inch diameter casing; occasionally 6-inch casing was used in difficult ground. The month and year of completion of the borehole are stated.

7. Overburden, Mineral, Waste and Bedrock
Mineral is sand and gravel which, as part of a deposit, falls within the arbitrary definition of potentially workable material (see p. 1). Bedrock is the 'formation', 'country rock' or 'rock head' below which potentially workable sand and gravel will not be found. Waste is any material other than bedrock or mineral. Where waste occurs between the surface and mineral it is classified as overburden.

8. Thickness and Depth
Measurements were made in metres. Conversions from metres to feet (shown in brackets) have been rounded to the nearest 0.5 ft. Where figures have been rounded in this way there may be a discrepancy between the sum of the thicknesses and the recorded depths.

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

10. Geological Classification
The geological classification (p. 3) is given whenever possible.

11. 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. The description of other rocks is based on visual examination, in the field.

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

13. Grading Results
The limits are as follows: gravel, +4 mm; sand, -4+1/16 mm; fines, -1/16 mm.

14. If, exceptionally, grading results are not available, an attempt is made to give grading information by comparing the grading and field descriptions of adjacent samples with the samples in question. Such estimates are shown in square brackets.

15. Mean Grading
The grading of the full thickness of the mineral horizon identified in the log is the mean of the individual sample gradings weighted by the thicknesses represented, if these vary. The classification used is shown in Table 3.

Fully representative sampling of sand and gravel is difficult to achieve particularly where groundwater levels are high. Comparison between boreholes and adjacent exposures suggests that in borehole samples the proportion of sand may be higher and the proportions of fines and coarse gravel (+16 mm) may be lower.

Appendix E: List of Boreholes Used in the Assessment of Resources

MINERAL ASSESSMENT UNIT BOREHOLES

Borehole No.	Grid reference (all fall in 100 km square SK)	Borehole No.	Grid reference (all fall in 100 km square SK)
SK 78 NE (p. 21)		SK 88 SW (pp. 31-43)	
25	7932 8953	3	8200 8431
26	7962 8861	4	8249 8338
		5	8187 8218
SK 78 SE		6	8307 8237
(p. 21)		7	8275 8145
		8	8242 8073
26	7993 8373	9	8146 8475
27	7978 8265	10	8028 8430
		11	8150 8374
SK 88 NW		12	8086 8308
(pp. 22-31)		13	8125 8241
		14	8034 8186
46	8108 8947	15	8164 8135
47	8056 8867	16	8063 8080
48	8162 8830	17	8169 8028
49	8061 8760	18	8329 8440
50	8041 8709	19	8404 8433
51	8160 8700	20	8339 8267
52	8111 8620	21	8376 8187
53	8050 8522	22	8393 8047
54	8240 8615		
55	8160 8543		
56	8290 8777	SK 88 SE	
57	8371 8736	(p. 43)	
58	8220 8742		
59	8442 8637	6	8915 8177
60	8320 8631		
61	8272 8558		
62	8360 8542		
77	8023 8565		
SK 88 NE (p. 31)			
6	8719 8608		

OTHER BOREHOLES

SK 88 NW 33, 34, 35, 36, 39, 41, 43, 44, and two confidential records.

SK 78 NE 25 7932 8953 Marsh Farm, Beckingham

Surface level (+4.6 m) +15 ft
Water not struck
December 1971

Waste 0.7 m (2.5 ft)
Bedrock 1.0 m + (3.5 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.3	(1.0)	0.3	(1.0)
Alluvium	Clay, sandy, reddish brown	0.4	(1.5)	0.7	(2.5)
Keuper Marl	Mudstone, red and green	1.0+	(3.5+)	1.7	(5.5)

SK 78 NE 26 7962 8861 Saundby

Surface level (+7.0 m) +23 ft
Waste level not recorded
December 1971

Waste 1.0 m (3.5 ft)
Bedrock 1.0 m+ (3.5 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.3	(1.0)	0.3	(1.0)
Alluvium	Sandy clay, reddish brown and grey with sand pockets	0.7	(2.5)	1.0	(3.5)
Keuper Marl	Mudstone, red and green	1.0+	(3.5+)	2.0	(6.5)

SK 78 SE 26 7993 8373 Littleborough Road, Sturton le Steeple

Surface level (+4.9 m) +16 ft
Water level not recorded
December 1971

Waste 3.4 m (11.0 ft)
Bedrock 1.6 m+ (5.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
First Terrace	Clay, pale brown	1.5	(5.0)	1.5	(5.0)
	Sandy silt, mottled brown and black	0.3	(1.0)	1.8	(6.0)
	Clay, pale brown	1.6	(5.0)	3.4	(11.0)
Keuper Marl	Mudstone, red	1.6+	(5.0+)	5.0	(16.5)

SK 78 SE 27 7978 8265 Catchwater Drain, Fenton

Surface level (+4.6 m) +15 ft
Water level not recorded
December 1971

Waste 1.4 m (4.5 ft)
Bedrock 1.6 m+ (5.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.3	(1.0)	0.3	(1.0)
First Terrace	Sandy clay, reddish brown	1.1	(3.5)	1.4	(5.0)

SK 78 SE 27 cont

Keuper Marl	Mudstone, red		1.6+	(5.0+)	3.0	(10.0)

SK 88 NW 46 8108 8947 Gainsborough Block B

Surface level (+2.4 m) +8 ft
Water level not recorded
December 1971

Waste 10.0 m (33.0 ft)
Bedrock 0.8 m+ (2.5 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
Alluvium	Topsoil	0.3	(1.0)	0.3	(1.0)
Alluvium	Silt and clay, grey, brown and black, laminated, micaceous, peaty to 7.3 m pebbly at base	9.7	(32.0)	10.0	(33.0)
Keuper Marl	Mudstone, weathered, green, gypsiferous	0.8+	(2.5+)	10.8	(35.5)

SK 88 NW 47 8056 8867 Gainsborough Block B

Surface level (+1.8 m) +6 ft
Water level not recorded
December 1971

Overburden 5.0 m (16.5 ft)
Mineral 4.5 m (15.0 ft)
Bedrock 1.0 m+ (3.5 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.4	(1.5)	0.4	(1.5)
Alluvium	Silt and silty clay, yellow, brown and grey; ochreous at top, becoming micaceous and laminated with sand pockets in lower part	4.6	(15.0)	5.0	(16.5)
First Terrace	Pebbly sand and sandy gravel Gravel: fine, well rounded vein quartz, sandstone and quartzite, with sub-rounded flint, chert and mudstone and some igneous pebbles. Increasing proportion of subangular green siltstone downwards Sand: medium, subrounded to well rounded quartz and rock fragments	4.5	(15.0)	9.5	(31.0)
Keuper Marl	Mudstone, red and green, hard	1.0+	(3.5+)	10.5	(34.5)

	%	mm	%
Gravel	26	+ 16	6
		- 16 + 4	20
Sand	73	- 4 + 1	7
		- 1 + $\frac{1}{4}$	58
		- $\frac{1}{4}$ + 1/16	8
Fines	1	- 1/16	1

Depth below surface (m)	Percentage Fines	Sand	Gravel
5.0 - 6.0	3	93	4
6.0 - 7.0	trace	80	20
7.0 - 8.0	trace	65	35
8.0 - 9.5	trace	57	43

SK 88 NW 48 8162 8830 Humble Carr Dyke, Gainsborough Block B

Surface Level (+3.0 m) +10 ft
Water level not recorded
November 1971

Overburden 4.0 m (13.0 ft)
Mineral 3.8 m (12.5 ft)
Bedrock 1.2 m+ (40 ft +)

		Thickness		Depth	
		m	(ft)	m	(ft)
Alluvium	Clay, buff	1.1	(3.5)	1.1	(3.5)
	Peat, dark brown	2.9	(9.5)	4.0	(13.0)
First Terrace	Pebbly sand Gravel: mainly fine, subrounded quartz, quartzite, sandstone, flint and chert Sand: medium, subangular to subrounded quartz	3.8	(12.5)	7.8	(25.5)
Keuper Marl	Mudstone, red and grey mottled	1.2+	(4.0+)	9.0	(29.5)

	%	mm	%
Gravel	17	+ 16	4
		- 16 + 4	13
Sand	81	- 4 + 1	10
		- 1 + ¼	64
		- ¼ + 1/16	7
Fines	2	- 1/16	2

Depth below surface (m)	Percentage Fines	Sand	Gravel
4.0 - 5.0	5	70	25
5.0 - 6.0	trace	80	20
6.0 - 7.0	trace	92	8
7.0 - 7.8	2	81	17

SK 88 NW 49 8061 8760 Bole Ings, Bole Block B

Surface level (+4.0 m) +13 ft
Water level not recorded
December 1971

Overburden 1.5 m (5.0 ft)
Mineral 9.5 m+ (31.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	1.0	(3.5)	1.0	(3.5)
Alluvium	Sandy silty clay, brown, ochreous; some sand pockets	0.5	(1.5)	1.5	(5.0)
First Terrace	'Clayey' pebbly sand Gravel: fine, subangular flint and sandstone, well rounded quartz and quartzite. Some angular green siltstone Sand: fine and medium, well rounded quartz and subrounded rock fragments Fines: brown silt	9.5+	(31.0+)	11.0	(36.0)
	Borehole abandoned because of 'rising sand'				

	%	mm	%
Gravel	17	+ 16	10
		- 16 + 4	7
Sand	71	- 4 + 1	3
		- 1 + ¼	43
		- ¼ + 1/16	25
Fines	12	- 1/16	12

Depth below surface (m)	Percentage Fines	Sand	Gravel
1.5 - 2.5	30	70	trace
2.5 - 3.5	13	85	2
3.5 - 4.5	10	89	1
4.5 - 5.5	22	73	5
5.5 - 6.5	trace	13	87
6.5 - 7.5	7	93	trace
7.5 - 8.5	7	93	trace
8.5 -10.0	17	80	3
10.0 -11.0	4	36	60

SK 88 NW 50 8041 8709 Bole Ings, Bole Block B

Surface level (+4.3 m) +14 ft
Water level not recorded
December 1971

Overburden 1.5 m (5.0 ft)
Mineral 3.2 m (10.5 ft)
Bedrock 1.3 m+ (4.5 ft+)

		Thickness m	Thickness (ft)	Depth m	Depth (ft)
	Topsoil	0.2	(0.5)	0.2	(0.5)
Alluvium	Silty clay, brown, soft; some sand pockets	1.3	(4.5)	1.5	(5.0)
First Terrace	Sand, medium, well rounded quartz with subrounded rock fragments. Some brown silt	3.2	(10.5)	4.7	(15.5)
Keuper Marl	Mudstone, red and green, hard	1.3+	(4.5+)	6.0	(19.5)

	%	mm	%
Gravel	trace	+ 16	0
		- 16 + 4	trace
Sand	96	- 4 + 1	2
		- 1 + $\frac{1}{4}$	63
		- $\frac{1}{4}$ + 1/16	31
Fines	4	- 1/16	4

Depth below surface (m)	Fines	Percentage Sand	Gravel
1.5 - 2.5	1	99	trace
2.5 - 3.5	[4	96	trace]
3.5 - 4.7	6	94	trace

SK 88 NW 51 8160 8700 Lea Marsh Block B

Surface level (+3.4 m) +11 ft
Water level not recorded
November 1971

Overburden 4.5 m (15.0 ft)
Mineral 2.7 m (9.0 ft)
Bedrock 1.3 m+ (4.5 ft)

		Thickness m	Thickness (ft)	Depth m	Depth (ft)
	Topsoil	0.3	(1.0)	0.3	(1.0)
Alluvium	Silt, clay and peat, grey and brown; some sand pockets	4.2	(14.0)	4.5	(15.0)
First Terrace	Sandy gravel Gravel: fine well rounded to subrounded quartz, quartzite and flint, with some angular green sandstone Sand: medium, well rounded quartz with subrounded rock fragments	2.7	(9.0)	7.2	(23.5)
Keuper Marl	Mudstone, soft, red and green	1.3+	(4.5+)	8.5	(28.0)

	%	mm	%
Gravel	37	+ 16	12
		- 16 + 4	25
Sand	63	- 4 + 1	14
		- 1 + $\frac{1}{4}$	44
		- $\frac{1}{4}$ + 1/16	5
Fines	trace	- 1/16	trace

Depth below surface (m)	Fines	Percentage Sand	Gravel
4.5 - 5.5	trace	47	53
5.5 - 6.5	1	72	27
6.5 - 7.2	trace	72	28

SK 88 NW 52 8111 8620 Lea Marsh Block B

Surface level (+3.7 m) +12 ft
Water level not recorded
November 1971

Overburden 5.5 m (18.0 ft)
Mineral 5.7 m (18.5 ft)
Bedrock 1.8 m (6.0 ft)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.2	(0.5)	0.2	(0.5)
Alluvium	Silt, clay and peat, grey and brown, ochreous	5.3	(17.5)	5.5	(18.0)
First Terrace	Sandy gravel Gravel: fine, well rounded to subrounded sandstone, quartz, flint, chert and igneous rock Sand: medium, well rounded to subrounded quartz and rock fragments	5.7	(18.5)	11.2	(36.5)
Keuper Marl	Mudstone, and clay, red and green	1.8+	(6.0+)	13.0	(42.5)

	%	mm	%
Gravel	41	+ 16	9
		- 16 + 4	32
		- 4 + 1	16
Sand	59	- 1 + ¼	39
		- ¼ + 1/16	4
Fines	trace	- 1/16	trace

Depth below surface (m)	Fines	Percentage Sand	Gravel
5.5 - 6.5	1	41	58
6.5 - 7.5	trace	59	41
7.5 - 8.5	trace	68	32
8.5 - 9.5	trace	62	38
9.5 - 10.5	trace	60	40
10.5 - 11.2	1	65	34

SK 88 NW 53 8050 8522 The Ferries, West Burton Block C

Surface level (+4.0 m) +13 ft
Water level not recorded
December 1971

Overburden 4.8 m (15.5 ft)
Mineral 3.9 m (13.0 ft)
Bedrock 1.3 m+ (4.5 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
Alluvium	Clay, pale brown	1.9	(6.0)	1.9	(6.0)
	Silt, pale brown, mottled brown and black	2.9	(9.5)	4.8	(15.5)
First Terrace	Sand, pebbly near base Gravel: fine, well rounded to subrounded quartz and quartzite Sand: medium, well rounded to subangular quartz with a little coal	3.9	(13.0)	8.7	(28.5)
Keuper Marl	Mudstone, red	1.3+	(4.5+)	10.0	(33.0)

	%	mm	%
Gravel	4	+ 16	0
		- 16 + 4	4
		- 4 + 1	4
Sand	93	- 1 + ¼	58
		- ¼ + 1/16	31
Fines	3	- 1/16	3

Depth below surface (m)	Fines	Percentage Sand	Gravel
4.8 - 5.8	3	97	trace
5.8 - 6.8	3	96	1
6.8 - 7.8	3	96	1
7.8 - 8.7	2	83	15

SK 88 NW 54 8240 8615 Lea Block B

Surface level (+3.4 m) +11 ft
Water level not recorded
November 1971

Waste 2.0 m (6.5 ft)
Bedrock 3.0 m+ (10 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.3	(1.0)	0.3	(1.0)
Alluvium	Silty clay, grey and brown, sandy and peaty in parts	1.0	(3.5)	1.3	(4.5)
First Terrace	'Clayey' pebbly sand Gravel: coarse, well rounded quartz and sandstone Sand: medium, well rounded quartz and rock fragments	0.7	(2.5)	2.0	(6.5)
Keuper Marl	Mudstone and clay; red and green	3.0+	(10.0+)	5.0	(16.5)

	%	mm	%
Gravel	14	+ 16	12
		- 16 + 4	2
Sand	73	- 4 + 1	1
		- 1 + $\frac{1}{4}$	57
		- $\frac{1}{4}$ + 1/16	15
Fines	13	- 1/16	13

Depth below surface (m)	Percentage Fines	Sand	Gravel
1.3 - 2.0	13	73	14

SK 88 NW 55 8160 8543 Knaith Reaches Block C

Surface level (+3.4 m) +11 ft
Water level +0.3 m (+1 ft)
December 1971

Overburden 9.0 m (29.5 ft)
Mineral 3.3 m (11.0 ft)
Bedrock 1.7 m+ (5.5 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
Alluvium	Clay, pale brown to 4.0 m, dark and peaty below; some sand pockets	9.0	(29.5)	9.0	(29.5)
First Terrace	Gravel, 'clayey' and sandy at top Gravel: coarse with fine, subrounded to well rounded quartz, quartzite and chert Sand: medium, subrounded to subangular, quartz with rock fragments and coal specks	3.3	(11.0)	12.3	(40.5)
Keuper Marl	Mudstone, red, finely laminated	1.7+	(5.5+)	14.0	(46.0)

	%	mm	%
Gravel	52	+ 16	34
		- 16 + 4	18
Sand	41	- 4 + 1	7
		- 1 + $\frac{1}{4}$	29
		- $\frac{1}{4}$ + 1/16	5
Fines	7	- 1/16	7

Depth below surface (m)	Fines	Percentage Sand	Gravel
9.0 - 10.0	19	76	5
10.0 - 11.0	2	40	58
11.0 - 12.3	1	15	84

SK 88 NW 56 8290 8777 Lea Wood Farm, Lea Block D

Surface level (+30.5 m) +100 ft
Water not struck
November 1971

Waste 7.2 m (23.5 ft)
Bedrock 0.8 m+ (2.5 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.3	(1.0)	0.3	(1.0)
?Boulder Clay	Clay, reddish brown, hard and blocky; some sand pockets and rounded limestone, quartz and flint gravel. Grey staining along fissures	6.9	(22.5)	7.2	(23.5)
Keuper Marl	Mudstone: hard, red and green	0.8+	(2.5+)	8.0	(26.0)

SK 88 NW 57 8371 8736 Priory Farm, Lea Block D

Surface level (+23.8 m) +78 ft
Water not struck
November 1971

Waste 2.0 m (6.5 ft)
Bedrock 1.0 m+ (3.5 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.4	(1.5)	0.4	(1.5)
Glacial Sand and Gravel	'Clayey' sand: medium and fine, well rounded quartz and rock fragments. Much brown silt and a little fine, well rounded quartz gravel	0.4	(1.5)	0.8	(2.5)
?Boulder clay	Clay: reddish brown, hard, occasional sand pockets, some rounded quartz and flint gravel. Greyer towards base	1.2	(4.0)	2.0	(6.5)
Rhaetic	Mudstone and clay: dark grey	1.0+	(3.5+)	3.0	(10.0)

	%	mm	%
Gravel	4	+ 16	2
		- 16 + 4	2
Sand	83	- 4 + 1	2
		- 1 + $\frac{1}{4}$	60
		- $\frac{1}{4}$ + 1/16	21
Fines	13	- 1/16	13

Depth below surface (m)	Fines	Percentage Sand	Gravel
0.4 - 0.8	13	83	4

SK 88 NW 58 8220 8742 Lea Block D

Surface level (+6.4 m) +21 ft
Water level not recorded
November 1971

Overburden 1.0 m (3.5 ft)
Mineral 1.7 m (5.5 ft)
Bedrock 1.3 m+ (4.5 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil and made ground	1.0	(3.5)	1.0	(3.5)
Glacial Sand and Gravel	Sand: medium, well rounded quartz and sub-rounded rock fragments	1.7	(5.5)	2.7	(9.0)
Keuper Marl	Mudstone and clay, red and green	1.3+	(4.5+)	4.0	(13.0)

	%	mm	%
Sand	99	- 4 + 1	2
		- 1 + $\frac{1}{4}$	77
		- $\frac{1}{4}$ + 1/16	20
Fines	1	- 1/16	1

Depth below surface (m)	Fines	Percentage Sand	Gravel
1.0 - 2.0	1	99	0
2.0 - 2.7	1	99	0

SK 88 NW 59 8442 8637 Lea Grange, Lea Block D

Surface level (+17.4 m) +57 ft
Water level not recorded
November 1971

Overburden 0.8 m (2.5 ft)
Mineral 2.0 m (6.5 ft)
Bedrock 2.2 m+ (7.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.8	(2.5)	0.8	(2.5)
Glacial Sand and Gravel	Sand, medium, subangular to rounded quartz and rock fragments; some brown silt	2.0	(6.5)	2.8	(9.0)
Rhaetic	Mudstone, dark grey	2.2+	(7.0+)	5.0	(16.5)

	%	mm	%
Sand	96	- 4 + 1	1
		- 1 + $\frac{1}{4}$	81
		- $\frac{1}{4}$ + 1/16	14
Fines	4	- 1/16	4

Depth below surface (m)	Fines	Percentage Sand	Gravel
0.8 - 1.8	2	98	0
1.8 - 2.8	6	94	0

SK 88 NW 60 8320 8631 Lea Hall, Lea Block D

Surface level (+14.3 m) +47 ft
Water level not recorded
November 1971

Overburden 0.2 m (0.5 ft)
Mineral 2.5 m (8.0 ft)
Bedrock 1.3 m+ (4.5 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.2	(0.5)	0.2	(0.5)
Glacial Sand and Gravel	Sand, medium, well rounded quartz and rock fragments; some brown silt and a trace of fine quartz and flint gravel	2.5	(8.0)	2.7	(9.0)
Keuper Marl	Mudstone, red and greenish grey, weathered at top	1.3+	(4.5+)	4.0	(13.0)

	%	mm	%
Gravel	trace	+ 16	0
		- 16 + 4	trace
Sand	98	- 4 + 1	2
		- 1 + $\frac{1}{4}$	76
		- $\frac{1}{4}$ + 1/16	20
Fines	2	- 1/16	2

Depth below surface (m)	Fines	Percentage Sand	Gravel
0.2 - 1.2	2	98	trace
1.2 - 2.2	1	99	trace
2.2 - 2.7	5	95	trace

SK 88 NW 61 8272 8558 Lea Block D

Surface level (+9.8 m) +32 ft
Water level not recorded
November 1971

Overburden 0.3 m (1.0 ft)
Mineral 3.7 m (12.0 ft)
Bedrock 1.5 m+ (5.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.3	(1.0)	0.3	(1.0)
Glacial Sand and Gravel	Sand: medium, well rounded quartz with rock fragments; trace of fine, well rounded quartz gravel; some clayey patches towards base	3.7	(12.0)	4.0	(13.0)
Keuper Marl	Mudstone and clay, red and green	1.5+	(5.0+)	5.5	(18.0)

	%	mm	%
Gravel	trace	+ 16	0
		- 16 + 4	trace
Sand	99	- 4 + 1	2
		- 1 + $\frac{1}{4}$	79
		- $\frac{1}{4}$ + 1/16	18
Fines	1	- 1/16	1

Depth below surface (m)	Fines	Percentage Sand	Gravel
0.3 - 1.3	2	98	trace
1.3 - 2.3	1	99	trace
2.3 - 3.3	1	99	trace
3.3 - 4.0	1	99	0

SK 88 NW 62 8360 8542 Knaith Park Block D

Surface level (+23.5 m) +77 ft
Water level +22.5 m (+74 ft)
November 1971

Overburden 0.4 m (1.5 ft)
Mineral 1.6 m (5.0 ft)
Waste 1.0 m (3.5 ft)
Bedrock 1.5 m+ (5.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.4	(1.5)	0.4	(1.5)
Glacial Sand and Gravel	'Clayey' sand, leached Sand: medium subangular to well rounded quartz and rock fragments. Some fine, well rounded quartz pebbles	1.6	(5.0)	2.0	(6.5)
?Boulder clay	Clay, weathered grey and brown: some sandy pockets	1.0	(3.5)	3.0	(10.0)
Rhaetic	Mudstone, dark grey	1.5+	(5.0+)	4.5	(15.0)

	%	mm	%
Gravel	trace	+ 16	0
		- 16 + 4	trace
Sand	86	- 4 + 1	trace
		- 1 + $\frac{1}{4}$	67
		- $\frac{1}{4}$ + 1/16	19
Fines	14	- 1/16	14

Depth below surface (m)	Fines	Percentage Sand	Gravel
0.4 - 1.4	13	87	trace
1.4 - 2.0	15	85	0

SK 88 NW 77 8023 8565 West Burton

Surface level (+4.3 m) +14 ft
Water level +2.8 m (+9 ft)
December 1971

Waste 5.5 m (18.0 ft)
Bedrock 1.5 m+ (5.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.3	(1.0)	0.3	(1.0)
Alluvium	Silt, grey and brown, micaceous some sandy patches; becomes dark, peaty and laminated below 1.5 m (5 ft)	5.2	(17.0)	5.5	(18.0)
Keuper Marl	Mudstone and clay, red and green	1.5+	(5.0+)	7.0	(23.0)

SK 88 NE 6 8719 8608 Kexby Block E

Surface level about +70 ft (+21.4 m)
Water level about +64 ft (+19.5 m)
Hand auger
June 1973

Overburden 0.9 m (3.0 ft)
Mineral 3.4 m (11.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil, sandy, pebbly	0.9	(3.0)	0.9	(3.0)
Glacial Sand and Gravel	'Clayey' sand: medium, subrounded to well rounded quartz grains. Some reddish clay bands	3.4+	(11.0+)	4.3	(14.0)

	%	mm	%
		- 4 + 1	14
Sand	84	- 1 + $\frac{1}{4}$	57
		- $\frac{1}{4}$ + 1/16	13
Fines	16	- 1/16	16

Depth below surface (m)	Percentage Fines	Sand	Gravel
0.9 - 4.5 m	16	84	0

SK 88 SW 3 8200 8431 Mother Drain, Sturton le Steeple Block C

Surface level (+3.4 m) +11 ft
Water level +3.4 m (+11 ft)
November 1971

Overburden 3.0 m (10.0 ft)
Mineral 7.0 m (23.0 ft)
Bedrock 1.5 m+ (5.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
Alluvium	Clay, light grey, peaty below 2.0 m	3.0	(10.0)	3.0	(10.0)
First Terrace	Sandy gravel, more sandy in upper part Gravel: fine, subrounded to well rounded, quartzite, quartz and chert Sand: medium, subangular to subrounded quartz	7.0	(23.0)	10.0	(33.0)

SK 88 SW 3 cont

Keuper Marl		Mudstone, red	
	%	mm	%
		+16	4
Gravel	25	-16 + 4	21
		- 4 + 1	13
Sand	74	- 1 + $\frac{1}{4}$	54
		- $\frac{1}{4}$ + 1/16	7
Fines	1	- 1/16	1

1.5+	(5.0+)		11.5 (37.5)

Depth below surface (m)	Percentage Fines	Sand	Gravel
3.0 - 4.0	5	87	8
4.0 - 5.0	1	81	18
5.0 - 6.0	trace	53	47
6.0 - 7.0	trace	78	22
7.0 - 8.0	trace	70	30
8.0 - 9.0	trace	80	20
9.0 -10.0	trace	69	31

SK 88 SW 4 8249 8338 Littleborough Block C

Surface level (+2.7 m) +9 ft
Water level not recorded
November 1971

Overburden 7.0 m (23.0 ft)
Mineral 3.0 m (10.0 ft)
Bedrock 1.5 m+ (5.0 ft+)

		Thickness m	(ft)	Depth m	(ft)
Alluvium	Clay, light brown to 3.0 m, dark and peaty below	7.0	(23.0)	7.0	(23.0)
First Terrace	Sandy gravel, part 'clayey' Gravel: fine, subrounded to well rounded quartz, quartzite and sandstone Sand: medium, well rounded to sub-angular quartz Fines: brown silt	3.0	(10.0)	10.0	(33.0)
Keuper Marl	Mudstone, red	1.5+	(5.0+)	11.5	(37.5)

	%	mm	%
		+ 16	6
Gravel	23	- 16 + 4	17
		- 4 + 1	8
Sand	68	- 1 + $\frac{1}{4}$	55
		- $\frac{1}{4}$ + 1/16	5
Fines	9	- 1/16	9

Depth below surface (m)	Percentage Fines	Sand	Gravel
7.0 - 8.0	14	67	19
8.0 - 9.0	7	66	27
9.0 -10.0	6	70	24

SK 88 SW 5 8187 8218 Littleborough Block C

Surface level (+4.3 m) +14 ft
Water level +2.8 m (+9.2 ft)
November 1971

Overburden 4.2 m (14.0 ft)
Mineral 4.3 m (14.0 ft)
Bedrock 1.5 m+ (5.0 ft+)

			Thickness m	Thickness (ft)	Depth m	Depth (ft)
Alluvium		Topsoil and pale brown sandy clay	4.2	(14.0)	4.2	(14.0)
First Terrace	(a)	Sand, medium, rounded quartz grains, some brown silt	2.0	(6.5)	6.2	(20.5)
	(b)	Gravel Sand: medium, well rounded quartz and quartzite Gravel: fine, well rounded quartz quartzite and sandstone with some subangular flint	2.3	(7.5)	8.5	(28.0)
Keuper Marl		Mudstone, red and green	1.5+	(5.0+)	10.0	(33.0)

	%	mm	%
(a) Gravel	trace	+ 16	0
		- 16 + 4	trace
		- 4 + 1	5
Sand	94	- 1 + $\frac{1}{4}$	69
		- $\frac{1}{4}$ + 1/16	20
Fines	6	- 1/16	6
(b) Gravel	54	+ 16	16
		- 16 + 4	38
Sand	46	- 4 + 1	7
		- 1 + $\frac{1}{4}$	31
		- $\frac{1}{4}$ + 1/16	8
Fines	trace	- 1/16	trace

Depth below surface (m)	Fines	Percentage Sand	Gravel
4.2 - 5.2	10	89	1
5.2 - 6.2	2	98	trace
6.2 - 7.2	trace	46	54
7.2 - 8.5	trace	46	54

SK 88 SW 6 8307 8237 Marton Block C

Surface level (+3.7 m) +12 ft
Water level not recorded
November 1971

Overburden 1.4 m (4.5 ft)
Mineral 5.1 m (16.5 ft)
Bedrock 1.5 m+ (5.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.4	(1.5)	0.4	(1.5)
Alluvium	Silty clay, laminated, grey and brown, with roots	1.0	(3.5)	1.4	(4.5)
First Terrace	Sand, 'clayey' near top, pebbly towards base Gravel: fine, well rounded quartz flint and sandstone Sand: medium, subangular to rounded, quartz and rock fragments, including some coal	5.1	(16.5)	6.5	(21.5)
Keuper Marl	Mudstone, red and green	1.5+	(5.0+)	8.0	(26.0)

	%	mm	%
		+ 16	1
Gravel	3	- 16 + 4	2
		- 4 + 1	4
Sand	92	- 1 + $\frac{1}{4}$	81
		- $\frac{1}{4}$ + 1/16	7
Fines	5	- 1/16	5

Depth below surface (m)	Fines	Percentage Sand	Gravel
1.4 - 2.4	9	90	1
2.4 - 3.4	13	87	0
3.4 - 4.4	1	99	0
4.4 - 5.4	1	87	12
5.4 - 6.5	trace	96	4

SK 88 SW 7 8275 8145 Cottam Block C

Surface level (+3.4 m) +11 ft
Water level not recorded
November 1971

Overburden 8.3 m (27.0 ft)
Mineral 4.7 m (15.5 ft)
Bedrock 1.5 m+ (5.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.3	(1.0)	0.3	(1.0)
Alluvium	Clay, pale brown, peaty in lower part	8.0	(26.0)	8.3	(27.0)
First Terrace	Sandy gravel Gravel: fine, well rounded to sub-angular quartz, quartzite, chert and mudstone Sand: medium, subrounded to well rounded quartz	4.7	(15.5)	13.0	(42.5)
Keuper Marl	Mudstone, red	1.5+	(5.0+)	14.0	(46.0)

	%	mm	%
		+ 16	14
Gravel	38	- 16 + 4	24
		- 4 + 1	18
Sand	59	- 1 + $\frac{1}{4}$	39
		- $\frac{1}{4}$ + 1/16	12
Fines	3	-1/16	3

Depth below surface (m)	Fines	Percentage Sand	Gravel
8.3 - 9.3	trace	54	46
9.3 - 10.3	6	94	trace
10.3 - 11.3	5	38	57
11.3 - 12.3	1	69	30
12.3 - 13.0	1	41	58

SK 88 SW 7 cont

Fines	3	- 1/16	3

SK 88 SW 8 8242 8073 Carr Drain, Cottam Block C

Surface level (+1.8 m) +6 ft
Water level not recorded
November 1971

Overburden 2.3 m (7.5 ft)
Mineral 9.3 m (30.5 ft)
Bedrock 1.4 m+ (4.5 ft+)

		Thickness m	Thickness (ft)	Depth m	Depth (ft)
	Topsoil	0.2	(0.5)	0.2	(0.5)
Alluvium	Clay, pale brown, sandy patches	2.1	(7.0)	2.3	(7.5)
First Terrace	Sandy gravel and gravel Gravel: fine and coarse, subrounded to well rounded quartz, quartzite, sandstone and chert Sand: medium, subangular to subrounded quartz and quartzite	9.3	(30.5)	11.6	(38.0)
Keuper Marl	Mudstone, red	1.4+	(4.5+)	13.0	(42.5)

	%	mm	%
Gravel	47	+ 16	20
		- 16 + 4	27
Sand	52	- 4 + 1	8
		- 1 + $\frac{1}{4}$	38
		- $\frac{1}{4}$ + 1/16	6
Fines	1	- 1/16	1

Depth below surface (m)	Fines	Percentage Sand	Gravel
2.3 - 3.3	6	75	19
3.3 - 4.3	trace	44	56
4.3 - 5.3	trace	54	46
5.3 - 6.3	trace	61	39
6.3 - 7.3	trace	60	40
7.3 - 8.3	trace	22	78
8.3 - 9.3	trace	18	82
9.3 - 10.3	trace	38	62
10.3 - 11.6	1	86	13

SK 88 SW 9 8146 8475 Mother Drain, Sturton le Steeple Block C

Surface level (+3.7 m) +12 ft
Water level not recorded
December 1971

Overburden 5.9 m (19.5 ft)
Mineral 8.4 m (27.5 ft)
Bedrock 1.7 m+ (5.5 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.3	(1.0)	0.3	(1.0)
Alluvium	Clay and peat	5.6	(18.5)	5.9	(19.5)
First Terrace	Sandy gravel, gravel below 9.9 m Gravel: fine and coarse, subrounded to well rounded quartz, quartzite and sandstone Sand: medium, subangular to subrounded quartz, quartzite and rock fragments	8.4	(27.5)	14.3	(47.0)
Keuper Marl	Mudstone, red	1.7+	(5.5+)	16.0	(52.5)

	%	mm	%
Gravel	43	+ 16	19
		- 16 + 4	24
		- 4 + 1	9
Sand	54	- 1 + $\frac{1}{4}$	39
		- $\frac{1}{4}$ + 1/16	6
Fines	3	- 1/16	3

Depth below surface (m)	Fines	Percentage Sand	Gravel
5.9 - 6.9	1	91	8
6.9 - 7.9	trace	86	14
7.9 - 8.9	trace	72	28
8.9 - 9.9	23	63	14
9.9 - 10.9	trace	54	46
10.9 - 11.9	trace	30	70
11.9 - 12.9	trace	18	82
12.9 - 14.3	trace	30	70

SK 88 SW 10 8028 8430 Upper Ings, Sturton le Steeple Block A

Surface level (+4.3 m) +14 ft
Water level not recorded
December 1971

Overburden 0.3 m (1.0 ft)
Mineral 6.5 m (21.5 ft)
Bedrock 1.2 m+ (4.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.3	(1.0)	0.3	(1.0)
First Terrace	Sand, part pebbly Gravel: fine, subangular to subrounded quartz Sand: medium, well rounded quartz and subangular to well rounded rock fragments	6.5	(21.5)	6.8	(22.5)
Keuper Marl	Mudstone, red	1.2+	(4.0+)	8.0	(26.0)

	%	mm	%
		+ 16	3
Gravel	7	- 16 + 4	4
		- 4 + 1	4
Sand	91	- 1 + $\frac{1}{4}$	64
		- $\frac{1}{4}$ + 1/16	23
Fines	2	- 1/16	2

Depth below surface (m)	Fines	Percentage Sand	Gravel
0.3 - 1.3	5	92	3
1.3 - 2.3	5	93	2
2.3 - 3.3	trace	99	1
3.3 - 4.3	1	92	7
4.3 - 5.3	trace	73	27
5.3 - 6.3	1	95	4
6.3 - 6.8	2	98	trace

SK 88 SW 11 | 8150 8374 | Upper Ings, Sturton le Steeple | Block A

Surface level (+4.6 m) +15 ft
Water level not recorded
December 1971

Overburden 0.7 m (2.5 ft)
Mineral 6.2 m (20.5 ft)
Bedrock 1.6 m+ (5.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.7	(2.5)	0.7	(2.5)
First Terrace	Sand, very 'clayey' at top, pebbly at base Gravel: fine, well rounded quartz and quartzite Sand: medium, subrounded to well rounded quartz and rock fragments	6.2	(20.5)	6.9	(22.5)
Keuper Marl	Mudstone, red	1.6+	(5.0+)	8.5	(28.0)

	%	mm	%
		+ 16	1
Gravel	4	- 16 + 4	3
		- 4 + 1	2
Sand	88	- 1 + $\frac{1}{4}$	66
		- $\frac{1}{4}$ + 1/16	20
Fines	8	- 1/16	8

Depth below surface (m)	Fines	Percentage Sand	Gravel
0.7 - 1.7	28	72	trace
1.7 - 2.7	12	88	trace
2.7 - 3.7	4	95	1
3.7 - 4.7	1	99	0
4.7 - 5.7	4	96	0
5.7 - 6.9	1	80	19

SK 88 SW 12 | 8086 8308 | Fenton Gorse | Block A

Surface level (+4.3 m) +14 ft
Water level +3.1 m (+10 ft)
December 1971

Overburden 1.0 m (3.5 ft)
Mineral 3.5 m (11.5 ft)
Bedrock 1.5 m+ (5.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
Alluvium	Clay, light brown, sandy	1.0	(3.5)	1.0	(3.5)
First Terrace	Sand, with a little gravel Gravel: fine, well rounded quartz and sandstone Sand: medium subangular to subrounded quartz	3.5	(11.5)	4.5	(15.0)
Keuper Marl	Mudstone, red	1.5+	(5.0+)	6.0	(19.5)

	%	mm	%
		+ 16	1
Gravel	2	- 16 + 4	1
		- 4 + 1	2
Sand	97	- 1 + $\frac{1}{4}$	79
		- $\frac{1}{4}$ + 1/16	17
Fines	1	- 1/16	1

Depth below surface (m)	Fines	Percentage Sand	Gravel
1.0 - 2.8	trace	98	2
2.8 - 3.8	1	99	trace
3.8 - 4.5	trace	96	4

SK 88 SW 13 8125 8241 Sturton le Steeple Block A

Surface level (+4.6 m) +15 ft
Water level +2.2 m (+7 ft)
November 1971

Overburden 0.8 m (2.5 ft)
Mineral 8.3 m (27.0 ft)
Bedrock 1.4 m+ (4.5 ft+)

			Thickness m	Thickness (ft)	Depth m	Depth (ft)
		Topsoil	0.8	(2.5)	0.8	(2.5)
First Terrace	(a)	'Clayey' pebbly sand Gravel: fine, subrounded to well rounded quartz, quartzite, flint and sandstone Sand: medium, subrounded quartz with coal specks	3.0	(10.0)	3.8	(12.5)
	(b)	Sandy gravel Gravel: fine, subrounded to well rounded quartz, quartzite and flint Sand: medium, subrounded quartz	5.3	(17.5)	9.1	(30.0)
Keuper Marl		Mudstone, red	1.4+	(4.5+)	10.5	(34.5)

	%	mm	%
(a) Gravel	5	+ 16	1
		- 16 + 4	4
Sand	84	- 4 + 1	2
		- 1 + ¼	53
		- ¼ + 1/16	29
Fines	11	- 1/16	11
(b) Gravel	29	+ 16	5
		- 16 + 4	24
Sand	69	- 4 + 1	9
		- 1 + ¼	50
		- ¼ + 1/16	10
Fines	2	- 1/16	2

Depth below surface (m)	Percentage Fines	Sand	Gravel
0.8 - 1.8	25	73	2
1.8 - 2.8	6	83	11
2.8 - 3.8	4	95	1
3.8 - 4.8	trace	37	63
4.8 - 5.8	3	77	20
5.8 - 6.8	3	65	32
6.8 - 7.8	4	77	19
7.8 - 9.1	1	85	14

SK 88 SW 14 8034 8186 Habblesthorpe Block A

Surface level (+5.2 m) +17 ft
Water level not recorded
November 1971

Overburden 1.0 m (3.5 ft)
Mineral 4.8 m (15.5 ft)
Bedrock 1.2 m+ (4.0 ft+)

		Thickness m	Thickness (ft)	Depth m	Depth (ft)
	Topsoil	0.4	(1.5)	0.4	(1.5)
First Terrace	Clay, light brown	0.6	(2.0)	1.0	(3.5)
	Sand, pebbly below 5.0 m (16.5 ft) Gravel: fine, subrounded to well rounded quartz and quartzite Sand: medium, subrounded to subangular quartz and rock fragments; some coal specks	4.8	(15.5)	5.8	(19.0)
Keuper Marl	Mudstone, red	1.2+	(4.0+)	7.0	(23.0)

	%	mm	%
Gravel	2	+ 16	0
		- 16 + 4	2
		- 4 + 1	2
Sand	97	- 1 + $\frac{1}{4}$	92
		- $\frac{1}{4}$ + 1/16	3
Fines	1	- 1/16	1

Depth below surface (m)	Fines	Percentage Sand	Gravel
1.0 - 2.0	trace	100	trace
2.0 - 3.0	1	99	trace
3.0 - 4.0	1	97	2
4.0 - 5.0	1	97	2
5.0 - 5.8	1	93	6

SK 88 SW 15 8164 8135 Coates Farm, Cottam Block A

Surface level (+3.7 m) +12 ft
Water level not recorded
November 1971

Overburden 0.4 m (1.5 ft)
Mineral 8.2 m (27.0 ft)
Bedrock 1.4 m+ (4.5 ft+)

		Thickness m	Thickness (ft)	Depth m	Depth (ft)
	Topsoil	0.4	(1.5)	0.4	(1.5)
First Terrace	Sand, pebbly in parts Gravel: fine, subrounded to well rounded quartz and quartzite Sand: medium, subangular to subrounded quartz; some carbonaceous material	8.2	(27.0)	8.6	(28.0)
Keuper Marl	Mudstone, red	1.4+	(4.5+)	10.0	(33.0)

	%	mm	%
Gravel	5	+ 16	1
		- 16 + 4	4
		- 4 + 1	4
Sand	94	- 1 + $\frac{1}{4}$	71
		- $\frac{1}{4}$ + 1/16	19
Fines	1	- 1/16	1

Depth below surface (m)	Fines	Percentage Sand	Gravel
0.4 - 1.4	1	99	trace
1.4 - 2.4	1	97	2
2.4 - 3.4	4	88	8
3.4 - 4.4	1	98	1
4.4 - 5.4	trace	99	trace
5.4 - 6.4	1	94	5
6.4 - 7.4	1	92	7
7.4 - 8.6	1	86	13

SK 88 SW 16 8063 8080 Cottam Block A

Surface level (+4.3 m) +14 ft
Water level +2.0 m (+6.5 ft)
November 1971

Overburden 0.6 m (2.0 ft)
Mineral 4.4 m (14.5 ft)
Waste 1.2 m (4.0 ft)
Bedrock 1.3 m+ (4.5 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.3	(1.0)	0.3	(1.0)
First Terrace	Clay, slightly sandy, light brown	0.3	(1.0)	0.6	(2.0)
	Sand: medium, subangular to subrounded quartz and rock fragments; a little fine well rounded quartz and quartzite gravel	4.4	(14.5)	5.0	(16.5)
	Clay, pale brown	1.2	(4.0)	6.2	(20.5)
Keuper Marl	Mudstone, greyish green	1.3+	(4.5+)	7.5	(24.5)

	%	mm	%
Gravel	1	+ 16	trace
		- 16 + 4	1
Sand	98	- 4 + 1	2
		- 1 + ¼	71
		- ¼ + 1/16	25
Fines	1	- 1/16	1

Depth below surface (m)	Fines	Percentage Sand	Gravel
0.6 - 1.6	1	99	trace
1.6 - 2.6	trace	99	1
2.6 - 3.6	1	99	trace
3.6 - 4.6	1	96	3
4.6 - 5.0	1	97	2

SK 88 SW 17 8169 8028 Cottam Block A

Surface level (+4.9 m) +16 ft
Water level +2.6 m (+8.5 ft)
November 1971

Overburden 0.3 m (1.0 ft)
Mineral 6.7 m (22.0 ft)
Bedrock 1.0 m+ (3.5 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.3	(1.0)	0.3	(1.0)
First Terrace	Sand, pebbly towards base	6.7	(22.0)	7.0	(23.0)
	Gravel: fine, subrounded to well rounded quartz, quartzite and chert				
	Sand: mainly medium, subrounded to well rounded quartz				
Keuper Marl	Mudstone, red	1.0+	(3.5+)	8.0	(26.0)

	%	mm	%
Gravel	3	+ 16	trace
		- 16 + 4	3
Sand	94	- 4 + 1	2
		- 1 + ¼	63
		- ¼ + 1/16	29
Fines	3	- 1/16	3

Depth below surface (m)	Fines	Percentage Sand	Gravel
0.3 - 1.3	14	85	1
1.3 - 2.3	1	98	1
2.3 - 3.3	2	98	trace
3.3 - 4.3	1	97	2
4.3 - 5.3	1	98	1
5.3 - 6.3	2	91	7
6.3 - 7.0	1	90	9

SK 88 SW 18 8329 8440 Central Park Farm, Knaith Block D

Surface level (+27.7 m) +91 ft
Water not struck
November 1971

Waste 4.0 m (13.0 ft)
Bedrock 0.2 m+ (0.5 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.4	(1.5)	0.4	(1.5)
Glacial Sand and Gravel	'Clayey' pebbly sand Gravel: fine, well rounded quartz Sand: medium, well rounded quartz	0.8	(2.5)	1.2	(4.0)
?Boulder clay	Clay, pale brown and grey; ochreous sandy pockets and a few pebbles of flint and sandstone	1.3	(4.5)	2.5	(8.0)
	Clay, grey with greenish and brown areas, appears reworked; some pebbles of black shale and limestone	1.5	(5.0)	4.0	(13.0)
Rhaetic	Shale, black with pyrite cubes and bivalves	0.2+	(0.5+)	4.2	(14.0)

	%	mm	%
Gravel	5	+ 16	2
		- 16 + 4	3
Sand	79	- 4 + 1	2
		- 1 + ¼	65
		- ¼ + 1/16	12
Fines	16	- 1/16	16

Depth below surface (m)	Percentage Fines	Sand	Gravel
0.4 - 1.2	16	79	5

SK 88 SW 19 8404 8433 Broom Hills, Knaith Block E

Surface level (+28.7 m) +94 ft
Water not struck
November 1971

Waste 3.0 m (10.0 ft)
Bedrock 3.0 m+ (10.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.4	(1.5)	0.4	(1.5)
?Boulder clay	Clay: reddish-brown and grey; some sandy pockets and pebbles of limestone, sandstone, flint and quartz with mudstone towards base	2.6	(8.5)	3.0	(10.0)
Lower Lias	Clay and limestone, dark grey, fossiliferous	3.0+	(10.0+)	6.0	(19.5)

SK 88 SW 20 8339 8267 Gate Burton Block D

Surface level (+13.7 m) +45 ft
Water level not recorded
November 1971

Overburden 0.4 m (1.5 ft)
Mineral 3.0 m (10.0 ft)
Bedrock 1.6 m+ (5.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.4	(1.5)	0.4	(1.5)
Glacial Sand and Gravel	Sand, mainly 'clayey', pebbly at base Gravel: fine, well rounded quartz, flint and sandstone Sand: medium, subangular to well rounded quartz and rock fragments	3.0	(10.0)	3.4	(11.0)
Keuper Marl	Mudstone, red and green, with thin green sandstone bands	1.6+	(5.0+)	5.0	(16.5)

	%	mm	%
Gravel	2	+ 16	2
		- 16 + 4	trace
Sand	89	- 4 + 1	1
		- 1 + ¼	72
		- ¼ + 1/16	16
Fines	9	- 1/16	9

Depth below surface (m)	Fines	Percentage Sand	Gravel
0.4 - 1.4	12	88	trace
1.4 - 2.4	2	98	0
2.4 - 3.4	13	80	7

SK 88 SW 21 8376 8187 Marton Block D

Surface level (+7.9 m) +26 ft
Water level not recorded
November 1971

Overburden 0.4 m (1.5 ft)
Mineral 1.7 m (5.5 ft)
Waste 0.3 m (1.0 ft)
Bedrock 1.6 m+ (5.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.4	(1.5)	0.5	(1.5)
Glacial Sand and Gravel	'Clayey' sand Sand: medium, subangular to well rounded quartz with coal specks Fines: brown silt	1.7	(5.5)	2.1	(7.0)
?Boulder clay	Clay, reddish brown and grey; with iron staining and a little fine grained quartz and flint gravel	0.3	(1.0)	2.4	(8.0)
Keuper Marl	Mudstone, greenish grey, hard, with thin bands of green sandstone	1.6+	(5.0+)	4.0	(13.0)

	%	mm	%
Gravel	1	+ 16	1
		- 16 + 4	trace
Sand	86	- 4 + 1	1
		- 1 + ¼	64
		- ¼ + 1/16	21
Fines	13	- 1/16	13

Depth below surface (m)	Fines	Percentage Sand	Gravel
0.4 - 1.4	13	86	1
1.4 - 2.1	14	86	trace

SK 88 SW 22 8393 8047 Brampton Block D

Surface level (+5.2 m) +17 ft
Water level not recorded
November 1971

Waste 1.0 m (3.5 ft)
Bedrock 1.5 m+ (5.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.4	(1.5)	0.4	(1.5)
Glacial Sand and Gravel	'Very clayey' pebbly sand Gravel: fine, subangular pale green sandstone Sand: medium, subrounded quartz and rock fragments Fines: brown silt	0.6	(2.0)	1.0	(3.5)
Keuper Marl	Mudstone, red and green, hard	1.5+	(5.0+)	2.5	(8.0)

	%	mm	%
Gravel	9	+ 16	3
		- 16 + 4	6
Sand	69	- 4 + 1	3
		- 1 + ¼	35
		- ¼ + 1/16	31
Fines	22	- 1/16	22

Depth below surface (m)	Percentage Fines	Sand	Gravel
0.4 - 1.0	22	69	9

SK 88 SE 6 8915 8177 Stow Block E

Surface level (+14.3 m) +47 ft
Water not struck
November 1971

Waste 2.5 m (8.0 ft)
Bedrock 0.9 m+ (3.0 ft+)

		Thickness		Depth	
		m	(ft)	m	(ft)
	Topsoil	0.3	(1.0)	0.3	(1.0)
Glacial Sand and Gravel	Clay, reddish brown and grey, some ochreous areas and sand pockets; a little fine, well rounded flint and sandstone gravel	2.2	(7.0)	2.5	(8.0)
Lower Lias	Limestone and clay, dark grey, fossiliferous	0.9+	(3.0+)	3.4	(11.0)

Appendix G: Conversion Table, Metres to Feet (to nearest 0.5 ft)

m	ft	m	ft	m	ft	m	ft	m	ft
0.1	0.5	6.1	20	12.1	39.5	18.1	59.5	24.1	79
0.2	0.5	6.2	20.5	12.2	40	18.2	59.5	24.2	79.5
0.3	1	6.3	20.5	12.3	40.5	18.3	60	24.3	79.5
0.4	1.5	6.4	21	12.4	40.5	18.4	60.5	24.4	80
0.5	1.5	6.5	21.5	12.5	41	18.5	60.5	24.5	80.5
0.6	2	6.6	21.5	12.6	41.5	18.6	61	24.6	80.5
0.7	2.5	6.7	22	12.7	41.5	18.7	61.5	24.7	81
0.8	2.5	6.8	22.5	12.8	42	18.8	61.5	24.8	81.5
0.9	3	6.9	22.5	12.9	42.5	18.9	62	24.9	81.5
1.0	3.5	7.0	23	13.0	42.5	19.0	62.5	25.0	82
1.1	3.5	7.1	23.5	13.1	43	19.1	62.5	25.1	82.5
1.2	4	7.2	23.5	13.2	43.5	19.2	63	25.2	82.5
1.3	4.5	7.3	24	13.3	43.5	19.3	63.5	25.3	83
1.4	4.5	7.4	24.5	13.4	44	19.4	63.5	25.4	83.5
1.5	5	7.5	24.5	13.5	44.5	19.5	64	25.5	83.5
1.6	5	7.6	25	13.6	44.5	19.6	64.5	25.6	84
1.7	5.5	7.7	25.5	13.7	45	19.7	64.5	25.7	84.5
1.8	6	7.8	25.5	13.8	45.5	19.8	65	25.8	84.5
1.9	6	7.9	26	13.9	45.5	19.9	65.5	25.9	85
2.0	6.5	8.0	26	14.0	46	20.0	65.5	26.0	85.5
2.1	7	8.1	26.5	14.1	46.5	20.1	66	26.1	85.5
2.2	7	8.2	27	14.2	46.5	20.2	66.5	26.2	86
2.3	7.5	8.3	27	14.3	47	20.3	66.5	26.3	86.5
2.4	8	8.4	27.5	14.4	47	20.4	67	26.4	86.5
2.5	8	8.5	28	14.5	47.5	20.5	67.5	26.5	87
2.6	8.5	8.6	28	14.6	48	20.6	67.5	26.6	87.5
2.7	9	8.7	28.5	14.7	48	20.7	68	26.7	87.5
2.8	9	8.8	29	14.8	48.5	20.8	68	26.8	88
2.9	9.5	8.9	29	14.9	49	20.9	68.5	26.9	88.5
3.0	10	9.0	29.5	15.0	49	21.0	69	27.0	88.5
3.1	10	9.1	30	15.1	49.5	21.1	69	27.1	89
3.2	10.5	9.2	30	15.2	50	21.2	69.5	27.2	89
3.3	11	9.3	30.5	15.3	50	21.3	70	27.3	89.5
3.4	11	9.4	31	15.4	50.5	21.4	70	27.4	90
3.5	11.5	9.5	31	15.5	51	21.5	70.5	27.5	90
3.6	12	9.6	31.5	15.6	51	21.6	71	27.6	90.5
3.7	12	9.7	32	15.7	51.5	21.7	71	27.7	91
3.8	12.5	9.8	32	15.8	52	21.8	71.5	27.8	91
3.9	13	9.9	32.5	15.9	52	21.9	72	27.9	91.5
4.0	13	10.0	33	16.0	52.5	22.0	72	28.0	92
4.1	13.5	10.1	33	16.1	53	22.1	72.5	28.1	92
4.2	14	10.2	33.5	16.2	53	22.2	73	28.2	92.5
4.3	14	10.3	34	16.3	53.5	22.3	73	28.3	93
4.4	14.5	10.4	34	16.4	54	22.4	73.5	28.4	93
4.5	15	10.5	34.5	16.5	54	22.5	74	28.5	93.5
4.6	15	10.6	35	16.6	54.5	22.6	74	28.6	94
4.7	15.5	10.7	35	16.7	55	22.7	74.5	28.7	94
4.8	15.5	10.8	35.5	16.8	55	22.8	75	28.8	94.5
4.9	16	10.9	36	16.9	55.5	22.9	75	28.9	95
5.0	16.5	11.0	36	17.0	56	23.0	75.5	29.0	95
5.1	17	11.1	36.5	17.1	56	23.1	76	29.1	95.5
5.2	17	11.2	36.5	17.2	56.5	23.2	76	29.2	96
5.3	17.5	11.3	37	17.3	57	23.3	76.5	29.3	96
5.4	17.5	11.4	37.5	17.4	57	23.4	77	29.4	96.5
5.5	18	11.5	37.5	17.5	57.5	23.5	77	29.5	97
5.6	18.5	11.6	38	17.6	57.5	23.6	77.5	29.6	97
5.7	18.5	11.7	38.5	17.7	58	23.7	78	29.7	97.5
5.8	19	11.8	38.5	17.8	58.5	23.8	78	29.8	98
5.9	19.5	11.9	39	17.9	58.5	23.9	78.5	29.9	98
6.0	19.5	12.0	39.5	18.0	59	24.0	78.5	30.0	98.5

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REPORTS OF THE INSTITUTE OF GEOLOGICAL SCIENCES

Assessment of British Sand and Gravel Resources

No. 1 The sand and gravel resources of the country south-east of Norwich, Norfolk: Description of 1 : 25 000 resource sheet TG 20. By E. F. P. Nickless. Price £1.15. Report No. 71/20

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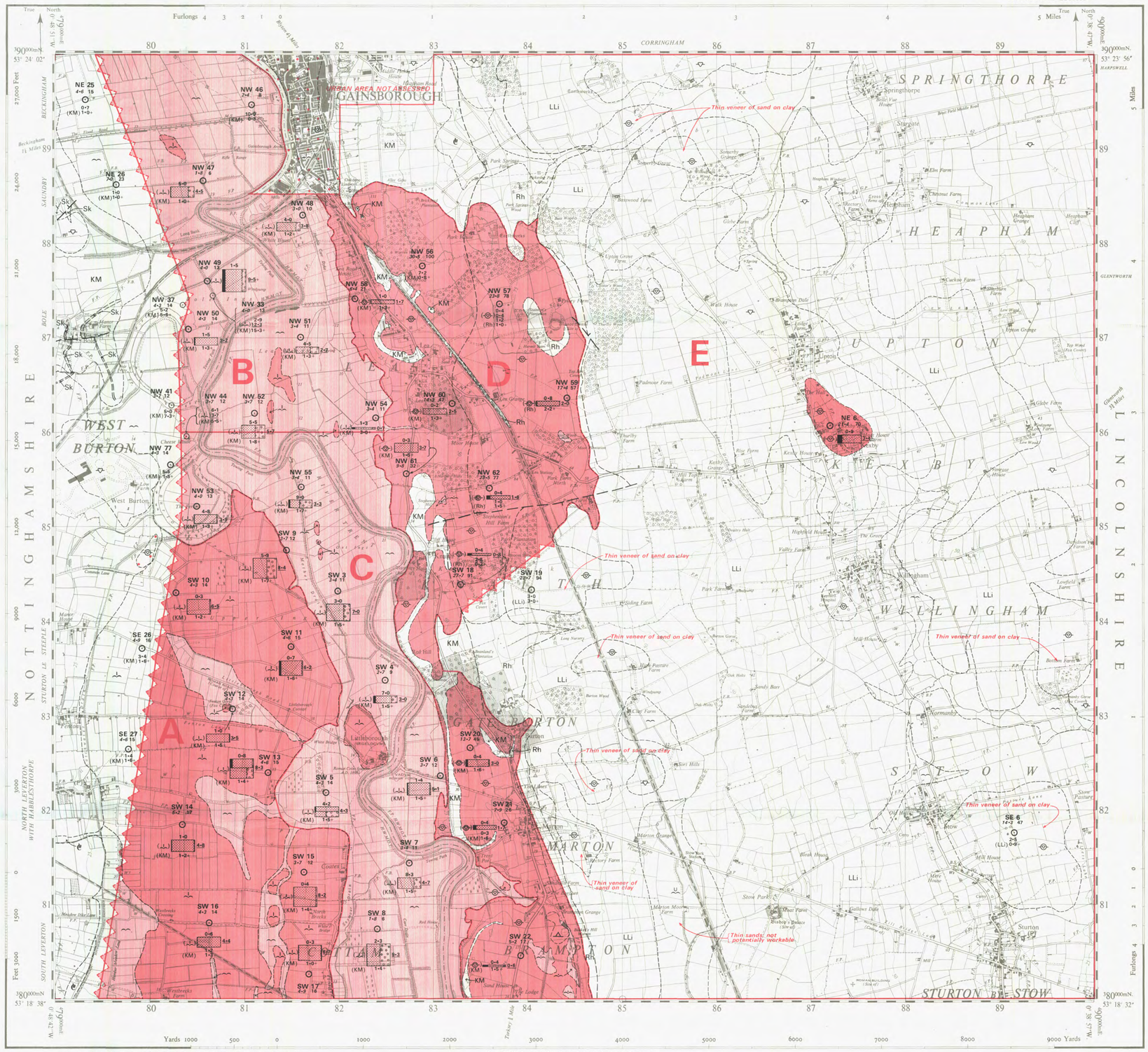
INSTITUTE OF GEOLOGICAL SCIENCES

MINERAL ASSESSMENT UNIT

THE SAND AND GRAVEL RESOURCES OF SHEET SK 88 & PART OF SK 78 (GAINSBOROUGH, LINCS)

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

ORDNANCE SURVEY
SHEET SK88 & Pt SK78
PROVISIONAL EDITION



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

19

EXPLANATION OF SYMBOLS AND ABBREVIATIONS

DRIFT

RECENT AND PLEISTOCENE

- **Blown Sand** - well-rounded sands. BS-3
- **Peat** P-1
- **Alluvium** - clay, sandy clay and silt, with beds of sand and peat A-9
- **1st Terrace of the River Trent** - sand and gravel in varying proportions. 1T-2
- **Head** - soliflucted deposits of variable composition. H-1
- **Older River Deposits** - clay with sand and gravel. OR-1
- **Glacial Sand and Gravel** - sand with sporadic pebbles. GS-7
- **Boulder Clay** - hard, stony clay. BC-2

SOLID

JURASSIC AND PERMO-TRIASSIC

- LLi **Lower Lias** - dark, impure limestones and mudstones.
- Rh **Rhaetic** - dark, pyritic shales and mudstones.
- KM **Keuper Marl** - red and green laminated mudstone with gypsum bands.
- Sk **Skerry Bands in Keuper Marl** - hard green sandstones.

BOUNDARY LINES

- Geological boundary, Drift.
- Geological boundary, Solid. Broken line denotes uncertainty.
- Fault, crossmark indicates downthrow side.
- Resource Block boundary.
- Inferred boundary between recognised categories of deposits.

BOREHOLE DATA

SITE LOCATIONS

- Mineral Assessment Unit (M.A.U.) Boreholes.
- Other Boreholes.

M.A.U. BOREHOLES

Borehole Registration Number → SW 11
4-6 15 ← Surface level in metres and feet above O.D. (Newlyn)
Borehole Site →
Geological Classification Grading Diagram → 0-7 / (-.-) 6-2 / (KM) 1-6+
0-7 ← Overburden thickness in metres
6-2 ← Mineral (Sand and Gravel) thickness in metres
1-6+ ← Bedrock

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 conversions to metres of measurements recorded in feet.
(iv) The Geological Classification is given only for mineral and bedrock.

Borehole Registration Number

Each M.A.U. borehole is identified by a Registration Number eg. SW 11. The letters refer to the quarter sheet and the figures to the I.G.S. Serial Number for that quarter. The unique designation for borehole SW 11 is SK 88 SW 11.

Note:
The western margin of this map is on sheet SK 78.

Grading Diagrams

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

Sand (+1/16–4mm) / Fines (-1/16 mm) / Gravel (+4mm)

The height of the diagram is proportional to the mineral thickness.

The widths of the divisions show the proportions of **Fines**, **Sand** and **Gravel**.

OTHER BOREHOLES

The layout of information is the same as for M.A.U. boreholes, though 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-C2
- **Sand and gravel either not potentially workable (see Report) or absent.** CAT-A1
- **Sand and gravel not assessed.** CAT-N1

Where appropriate on other sheets a fifth category 'Discontinuous spreads of sand and gravel beneath overburden is recognised.

RESOURCE BLOCKS

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

Detailed records may be consulted at the appropriate office of the Institute of Geological Sciences on application to Head, Mineral Assessment Unit

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 feet above Mean Sea Level at Newlyn.

Contour values are in feet

1 square inch on this map represents 99·638 acres on the ground.

Compiled from 6" sheets last fully revised 1904-18. Other partial systematic revision 1938-51 has been incorporated.

(a) Geological survey on the Six-Inch scale by G.H.Rhys and E.G.Smith in 1947-61, V.A.Eyles, A.W.Woodland and D.R.A.Ponsford, District Geologists.

(b) Original geological survey on the One-Inch scale published in 1886, partially revised on the Six-Inch scale by D.Thomas in 1971.

Sand and Gravel Survey by J.H.Lovell and J.R.Gozzard in 1971, under the supervision of D.Price, R.G.Thurrell, Head, Mineral Assessment Unit.

1:25,000 Sand and Gravel Resource Sheet published 1975.
Sir Kingsley Dunham, D.Sc., F.R.S., *Director, Institute of Geological Sciences.*

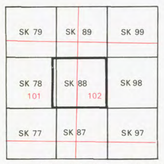


Diagram showing the relation of the National Grid 1:25 000 sheets with the One-Inch New Series Geological Sheets, 101 and 102

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.

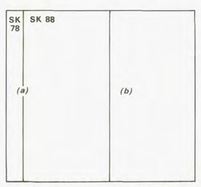


Diagram to show derivation of geological lines

Compiled and drawn in the Leeds Office of the Institute of Geological Sciences.

Printed and published by the Director General *of the* Ordnance Survey, Southampton, 1975, *for the* Institute of Geological Sciences.
1/50/75