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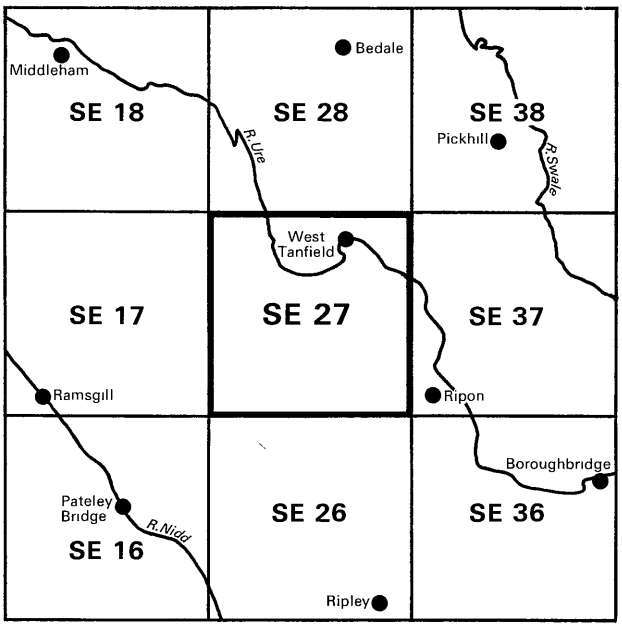

The sand and gravel resources of the country around West Tanfield, North Yorkshire

Description of 1:25 000 sheet SE 27

G. E. Strong and J. R. A. Giles

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

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

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PREFACE

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

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

This report describes the sand and gravel resources of 100 km^2 of country around West Tanfield, in North Yorkshire, shown on the accompanying 1:25 000 resource map. The survey was conducted by Mr J. R. A. Giles and Mr G. E. Strong. The work is based on the six-inch geological survey carried out in 1978-1980 by Dr A. H. Cooper, Mr J. G. O. Smart and Dr A. A. Wilson, each of whom have supplied information for the account of the geology of the district.

Mr G. I. Coleman (Land Agent) negotiated access to land for drilling. The ready co-operation of landowners and tenants in this work is gratefully acknowledged.

P. A. Sabine
Acting Director

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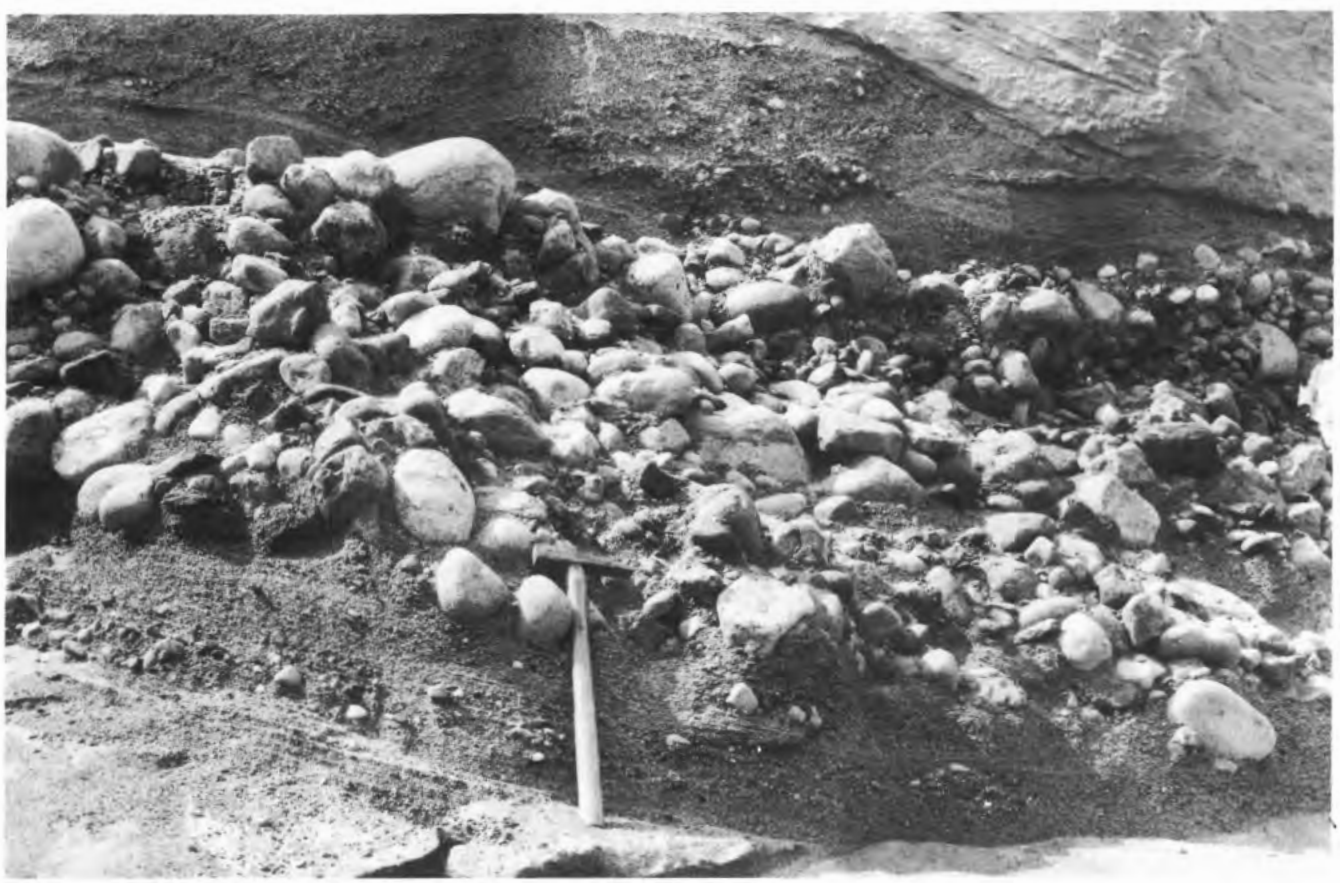

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SUMMARY

The geological maps of the Institute of Geological Sciences, pre-existing borehole information and boreholes drilled for the Industrial Minerals Assessment Unit form the basis of the assessment of the sand and gravel resources of the country around West Tanfield, North Yorkshire.

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

The assessed area is divided into three resource blocks, containing between 3.3 and 11.1 km^2 of sand and gravel. For each block the geology of the deposits is described, and the mineral-bearing area, the mean thickness of overburden and mineral and the mean gradings are stated. Detailed borehole data are also given. The geology, the position of the boreholes and the outlines of the resource blocks are shown on the accompanying map.

Notes

Each borehole registered with the Institute is identified by a four-element code (e.g. SE 27 NE 30). The first two elements define the 10-km square (of the National Grid) in which the borehole is situated; the third element defines a quadrant of that square, and the fourth is the accession number of the borehole. In the text of the report the borehole is normally referred to by the last two elements alone (e.g. NE 30).

All National Grid references in this publication lie within the 100-km square SE unless otherwise stated. Grid references may be given to eight figures, accurate to within 10 m, or to six figures for less precise locations.

Bibliographical reference

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INTRODUCTION

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

The survey provides information at the 'indicated' and 'inferred' levels. 'Indicated' assessments "are computed partly from specific measurements samples or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to permit the mineral bodies to be outlined completely or the grade established throughout". 'Inferred' assessments are those "based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements." (Bureau of Mines and Geological Survey, 1948, p 15).

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

a The deposit should average at least 1 m in thickness.
b The ratio of overburden to sand and gravel should be no more than 3:1.
c The proportion of fines (particles passing a 0.625 mm B.S. sieve) should not exceed 40 per cent.
d The deposit should lie within 25 m of the surface, this being taken as the likely maximum working depth under most circumstances. It follows from the second criterion that boreholes are drilled no deeper than 18 m if no sand and gravel has been proved.

A deposit of sand and gravel that broadly meets these criteria is regarded as 'potentially workable' and is described and assessed as 'mineral' in this report.

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

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

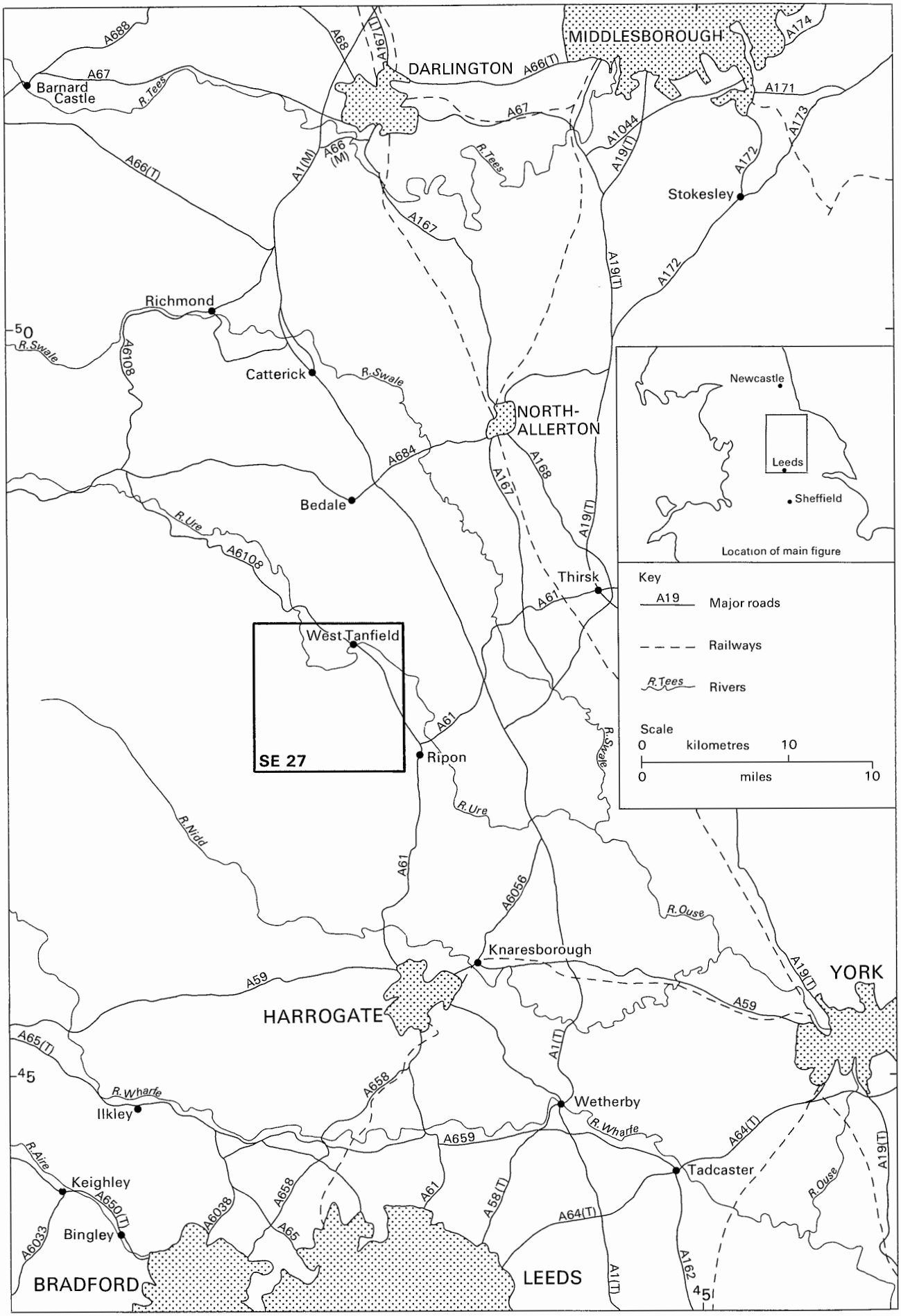

Figure 1 Map showing the location of sheet SE 27.

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 or land of high agricultural or landscape value, which might stand in the way of sand and gravel being exploited, although towns are excluded. The estimated total volume therefore bears no simple relationship to the amount that could be extracted in practice.

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

DESCRIPTION OF THE DISTRICT

The district comprises an area of 100 km^2 and lies to the west and north-west of Ripon, North Yorkshire (Figure 1). The Leeds - Harrogate - Thirsk road (A61) passes through Ripon and intersects the Great North Road (A1) 7 km to the north-east. The road from Ripon to Leyburn and Wensleydale (A6108) crosses the north-east corner of the district. The main East Coast railway passes about 12 km to the east.

The land is applied mainly to mixed agriculture, with some arboriculture in the central areas and sheep farming in the west. Sand and gravel are presently extracted from workings near West Tanfield and Magnesian Limestone is quarried near Sutton Grange [2852 7446] and North Stainley [280 758]. The main villages of the district are West Tanfield, Kirby Malzeard [235 744] and Grewelthorpe [230 762].

The district can be divided into three broad physiographic areas. In the west, moorland of the Pennine foothills forms high ground rising to 265 m near Grewelthorpe. A central area stretching from West Tanfield to Winksley [252 713] is dominated by the slightly lower but more irregular relief developed on glacial and fluvio-glacial deposits of clay, sand and gravel. The eastern part of the district is characterised by the gently undulating relief of the Magnesian Limestone dip-slope, which falls gently to the east beneath a generally thin drift cover.

Table 1 List of geological deposits.

DRIFT	
Quaternary	Peat
	Alluvium and Alluvial Fans
	River Terrace Deposits
	Head
	Fluvio-glacial Sand and Gravel
	Laminated Clay
	Glacial Sand and Gravel
	Till
	Morainic Drift
SOLID*	
Permian	Upper Magnesian Limestone
	Middle Marls
	Lower Magnesian Limestone
Carboniferous	
Westphalian	Shale with Nook House Sandstone
	Shale with Winksley Sandstone
Namurian	Shale with Laverton Sandstone
	Shale with Wandley Gill Sandstone
	Shale with Brimham Grits

* Shown undivided on the resource map

The drainage of the district is essentially west to east. It is dominated in the north by the River Ure flowing from Wensleydale. The River Laver and its tributary Kex Beck drains the central and southern parts of the district and subsequently joins the River Ure east of Ripon.

Geology

The Solid and Drift deposits found in the district are listed in Table 1. The distribution of the major Drift deposits is indicated in Figure 2.

SOLID

Carboniferous The Carboniferous rocks of the district are largely Namurian in age but there are outliers of Westphalian strata in the Winksley and Galphay [254 727] areas. They consist predominantly of mudstones, siltstones and sandstones but fireclays, ganisters and, less commonly, thin coals are also present. They have been described in detail by Wilson and Thompson (1965). River and stream sections provide the best exposures of the rocks, notably the section through the Brimham Grits at the Hack Fall gorge on the River Ure [235 775]. Sandstones have been worked in the past from numerous small quarries in the area, but there are no active workings. The Lower Brimham Grit was extensively quarried at Clints Hill [164 780], just to the west of the area, to provide stone for reservoir work.

Permian A sharp, uneven unconformity, gently sloping to the east, separates the Carboniferous rocks from those of the Permian (Smith, 1974), which lie mainly to the east of a line running roughly southward from West Tanfield.

The Lower Magnesian Limestone, a yellowish grey fine-grained dolomitic limestone, forms a broad tract of country between West Tanfield and Studley Roger [290 701]. The limestone is generally obscured by drift, but there are scattered exposures, notably along the bed of the River Ure and in working quarries at North Stainley and Sutton Grange.

The succeeding Middle Marls consist of reddish brown thinly bedded calcareous mudstone, commonly containing gypsum and anhydrite. The formation is variable in thickness (30 to 70 m) due to the removal of evaporites by groundwater, a process that has resulted in extensive foundering of the overlying beds. The Middle Marls are concealed by drift except for two small patches near Spigot Well Hill [297 740].

The Upper Magnesian Limestone, which underlies the north-east of the district, around East Tanfield, is, again, mainly hidden beneath drift but is exposed in a quarry at Chapel Hill [293 793]. It is composed largely of yellowish grey thinly bedded dolomitic limestone, with abundant vughs. As a result of dissolution of gypsum and anhydrite in the underlying Middle Marls, the Upper Magnesian Limestone is locally foundered and brecciated.

DRIFT

The north of England was glaciated on several occasions during the Pleistocene but all the glacial deposits of the West Tanfield district are thought to date from the late Devensian cold event, 26 000 to 10 000 years ago. North Yorkshire received ice from several directions simultaneously: Lake District ice crossed the Pennines via the Stainmore and Tyne gaps and was diverted southwards; Scottish ice, with Cheviot erratics, entered the Vale of York over the Tees lowland; and local ice occupied the major dales.

On the basis of erratic content, Raistrick (1926) traced the western limit of the Vale of York ice through West Tanfield, Mickley [258 770] and Kirby Malzeard. The area to the west of this line was affected only by local Dales ice.

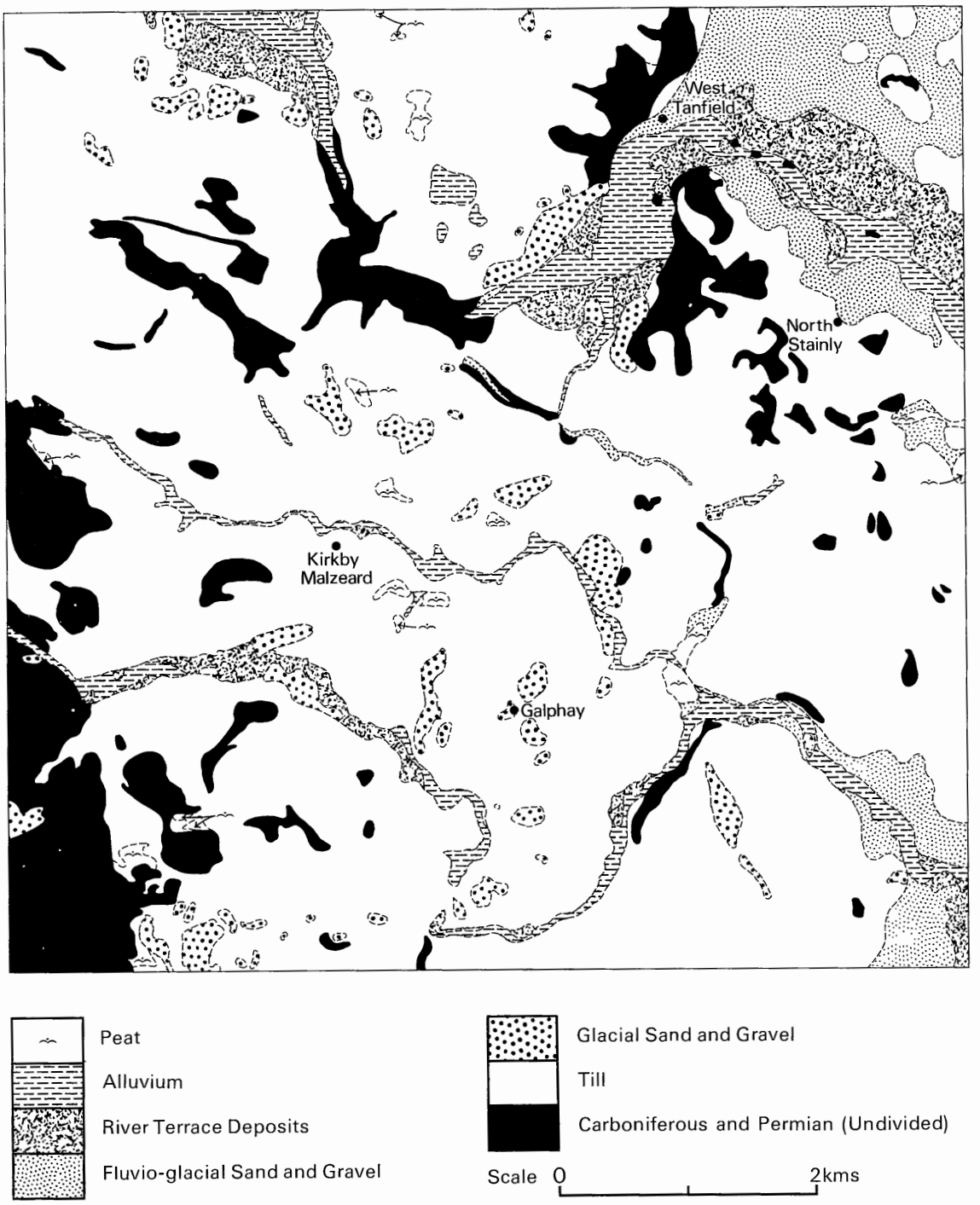

Figure 2 Drift geology (simplified to show only the main units).

Morainic Drift Two small areas of morainic drift have been mapped in the south-west of the district on Skelding Moor [209 709 and 208 703]. They form irregular mounds composed mainly of locally derived sandstone debris.

Till Much of the district is covered by till which in places is more than 18 metres thick (as proved by assessment boreholes). It generally consists of stony clay with a yellowish brown (10 YR 2/2 - 5/4) sandy clay matrix, but there are widespread variations in colour and sand content. The contained clasts consist mainly of pebbles, cobbles and boulders of Carboniferous limestone and sandstone, with high concentrations of dolomitic limestone near the Permian outcrop. However, more exotic erratics, such as Shap granite and Whin Sill, have been recorded in the east of the district.

Glacial Sand and Gravel Deposits included under this heading form sheets, discrete mounds and sporadic sinuous ridges over much of the district. They are very variable in composition and range from bouldery gravel at one extreme to silt at the other, the latter being notable in the Laverton-Azerley area.

The variability of the sand and gravel deposits is well displayed in Westwood Quarry [255 774] (Plate 1). Some of the gravel in this quarry is cemented by calcium carbonate, apparently as the result of evapotranspiration of descending lime-rich groundwater. The intergranular cement consists of a delicate honeycomb fabric of

Table 2 Composition of gravel (+4 -32 mm fraction) from the mineral-bearing drift deposits (percentages by weight). The table shows the mean for each deposit and the range of variation.

Deposit	Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone	Quartz	Ironstone	Coal
Fluvial Deposits								
Mean	54	32	trace	14	0	trace	trace	0
Maximum	61	49	5	20	0	trace	2	0
Minimum	35	19	0	0	0	0	0	0
Fluvio-glacial Sand and Gravel								
Mean	38	34	2	25	trace	trace	trace	0
Maximum	71	85	13	77	2	trace	4	0
Minimum	0	9	0	0	0	0	0	0
Glacial Sand and Gravel								
Mean	47	43	2	8	trace	trace	trace	trace
Maximum	71	53	7	26	1	1	2	trace
Minimum	37	24	0	0	0	0	0	0

whisker calcite which coalesces to form thin tufa coatings on grains and pebbles. The amount of pore filling decreases with depth and is negligible below 4.0 m (see Plate 1a).

The relationships between the 'Glacial Sand and Gravel' and till are complex. Most of the gravels, sands and silts were probably deposited on top of, adjacent to, within or beneath stagnating or retreating ice, and are now found overlying, within or beneath till.

Laminated Clay Laminated clays have not been mapped separately and, if they do occur at the surface, are included in the till outcrops. They have, however, been identified in numerous boreholes. They are particularly well developed at and to the east of Laverton and north of Galphay, where they have been proved to be up to 15.5 m in thickness without bottoming. They lie, for the most part, beneath till and glacial gravels, sands and silts, and are probably distal equivalents of the coarser melt-water deposits.

Fluvio-glacial Sand and Gravel To the east of West Tanfield there is an extensive, slightly undulating, gravel terrace. It has developed at the mouth of the Hack Fall gorge and extends northwards almost to Well [267 819] and eastwards to Wath [324 770], beyond the limits of the district. Gravel thicknesses in excess of 5 m have been observed in West Tanfield Quarry (NE E1) and Nosterfields Quarry (NE E2), and 7.4 m of gravel were recorded beneath overburden in borehole NE 24. The gravel consists mostly of pebble- and cobble-sized material, and is composed of variable amounts of Carboniferous limestone and sandstone and Permian dolomitic limestone (Table 2). The quarry sections show that the deposit is cross-bedded and that channel structures filled with stony clay are locally present. The thick overburden recorded in NE 24 may represent such a channel-fill.

Fluvio-glacial sand and gravel is also present on the floor and at the mouth of the glacial drainage system comprising the Carr House, Thieves Gill and Sleningford channels. These channels carried much of the water from the Ure in glacial or late glacial times prior to the cutting of the Hack Fall gorge. The deposits confined to the channels are relatively long and narrow and have proved thicknesses of up to 3.4 m (NE 40). At the mouths of the channels the fluvio-glacial sand and gravel are present over large areas and up to 6 m of gravel have been proved at Studley Roger (borehole SE 23).

Head Solifluxion deposits, consisting of silt with erratics and limestone fragments, fill the bottoms of dry valleys within the Lower Magnesian Limestone outcrop.

River Terrace Deposits River terraces along the valleys of the Ure and Laver form characteristic flat spreads with distinct back-features. Although a number of separate terrace levels have been identified, they are not distinguished on the map.

The best-developed terraces in the district are found along the River Ure downstream from Hack Fall gorge. Here the upper terraces, immediately below the level of the fluvio-glacial terrace described above, consist of gravel up to 8.0 m thick. The pebbles and cobbles are typically composed of Carboniferous limestone and sandstone from the Ure catchment, with lesser amounts of locally derived Permian dolomitic limestone. The lower terraces, nearer the level of the alluvium, are composed of stony clay (borehole NE 29).

The terraces of the Laver valley are of limited number and are each of small areal extent.

Alluvium and Alluvial Fan The alluvium of the River Ure appears to consist of gravel as well as silts and clays. A quarry sited on the floodplain at The Batts, east of North Stainley, shows 5 m of gravel beneath 0.5 m of soil but some or all of this deposit could be of fluvio-glacial origin. Upstream, a borehole (NE 33) north-east of Mickley proved 0.5 m of soil and stony clay resting on gravel, but the latter could correlate with the deposits of the river terrace.

Alluvial clay and silt, commonly associated with peat, floor numerous ill-drained hollows. Many of these hollows in the north-eastern part of the district are subsidence features resulting from the dissolution of Permian evaporites.

A number of alluvial fans have been identified in the Laver valley.

Peat This deposit, which is generally less than 2 m thick, occupies many areas of low-lying ill-drained land, and is commonly associated with alluvial silts and clays.

Composition of the Sand and Gravel Deposits

The unconsolidated aggregate resources of the district consist of glacial, fluvio-glacial and fluvial sand and gravel. Details of grading and composition of these deposits, as recorded in IMAU boreholes and collected sections, are given in Appendix E; they are summarised below and in Figures 4 and 5 and Table 2. The results of a number of physical and mechanical tests carried out according to BS 812 (British Standards Institution, 1975) on aggregates from selected boreholes are shown in Table 3.

Glacial Sand and Gravel Potentially workable glacial sand and gravel have an overall mean grading of 9 per

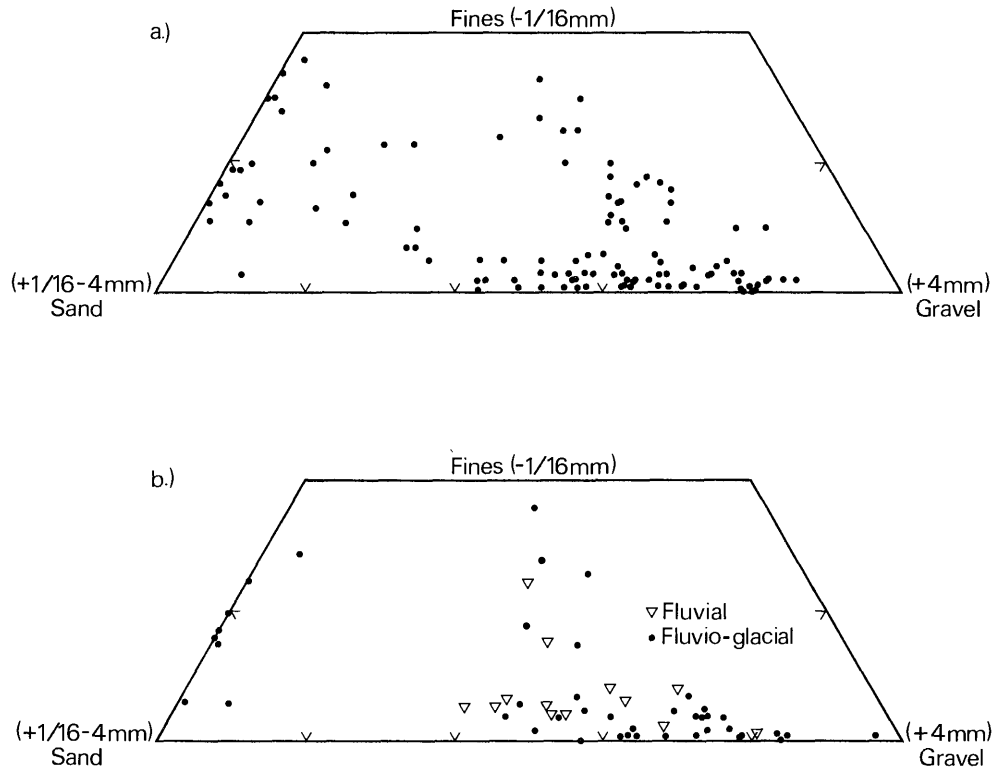

Figure 3 Triangular diagrams showing the distribution of individual sample gradings for a) glacial sand and gravel and b) fluvial and fluvio-glacial sand and gravel.

cent fines, 46 per cent sand and 45 per cent gravel. However, the deposits exhibit considerable variation: individual samples range from 'very clayey' sand through to gravel although clean to 'clayey' sandy gravel and gravel predominate (Figure 3a).

The gravel fractions are mainly coarse and the clasts predominantly subangular to rounded. Carboniferous limestone and sandstone, in roughly equal proportions, commonly account for some 90 per cent of the fraction, but Magnesian Limestone may be a major component (up to 26 per cent); subordinate constituents include ironstone, chert, mudstone, quartz and coal (Table 2). The sand fractions contain approximately equal proportions of the fine and medium grades with subordinate but notable amounts of the coarse grade. The sand generally comprises subangular to subrounded quartz and lithic grains, the latter dominating the coarse grade. Fines consist of moderate yellowish brown clay with some silt.

Fluvio-glacial Sand and Gravel Potentially workable sands and gravels classified thus are typically sands, 'clayey' sands, sandy gravels and gravels, and have a mean grading of 5 per cent fines, 34 per cent sand and 61 per cent gravel. Compared to the glacial mineral deposits there is a notable absence of pebbly sands and a scarcity of 'clayey' gravels.

In the gravel fractions, coarse grade material is more common than fine or cobbles. As in the glacial deposits, Carboniferous limestone and sandstone occur in roughly equal proportions but there is generally a higher Magnesian Limestone content resulting from the deposition of much of the fluvio-glacial sand and gravel on or near a Magnesian Limestone substrate. Up to 4 per cent of ironstone may be present in addition to usually small amounts of chert, mudstone and quartz (Table 2). The sand fractions are coarser than those of the glacial sand and gravel, and consist of roughly equal proportions of

Table 3 Physical and mechanical properties of the aggregate from selected boreholes.

Borehole	Aggregate impact value	Aggregate crushing value	Relative density		Water absorption as % dry weight
			oven-dried basis	saturated and surface-dried basis	
Fluvial Deposits					
NE 28	29	20.3	2.55	2.61	2.5
NE 30	27	19.4	2.55	2.60	2.4
NE 35	23	18.5	2.57	2.62	1.8
Fluvio-glacial Sand and Gravel					
NE 24	29	18.7	2.58	2.64	2.3
NE 26	27	18.8	2.51	2.56	2.0
SE 21	30	23.9	2.52	2.62	3.8
Glacial Sand and Gravel					
SW 22	26	-	2.54	2.59	1.9
SE 12	30	-	2.53	2.60	2.4
SE 13	26	19.8	2.57	2.61	1.7
SE 19	28	22.4	2.52	2.60	2.8

the medium and coarse grades and lesser amounts of the fine grade. Moderate brown clay and silt constitute the fines fraction.

River Terrace Deposits and Alluvium Under this heading are included deposits worked from a pit dug through alluvium east of North Stainley, deposits which may, however, consist at least in part of fluvio-glacial sand and gravel. These and other potentially workable fluvial deposits in the Ure valley below Mickley consist typically of gravels and sandy gravels. Their fines content is usually less than 15 per cent and their mean grading, based on only 13 samples, is 8 per cent fines, 41 per cent sand and 51 per cent gravel.

The gravel fractions are composed of subangular to rounded pebbles, cobbles and boulders, mostly of Carboniferous limestone and sandstone but with, at least at one locality, up to 20 per cent of Magnesian Limestone (Table 2). The sand fractions consist of fine to coarse, subangular to subrounded quartz and lithic grains. Fines generally comprise moderate yellowish brown clay with some silt.

Gravel proved in the Laver valley by borehole SE 24 is included with the fluvial deposits although it could be wholly or in part of fluvio-glacial origin.

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 geological data are shown in black and the mineral resource information in shades of red.

Geological data The geological boundary lines, symbols, etc., shown are taken from the geological map of this area, which was surveyed recently at the scale of 1:10 560. This information was obtained by detailed application of field mapping techniques by the Institute's field staff. The geological boundaries are the best interpretation of the information available at the time of survey. However, local irregularities and discrepancies may be revealed as new evidence from boreholes and excavations becomes available.

Borehole data, which include the stratigraphic relations, thicknesses and mean particle size distributions of the sand and gravel samples collected during the assessment survey, are also shown on the map.

Mineral resource information The mineral-bearing ground is divided into resource blocks (see Appendix A). Within a resource block the mineral is subdivided into areas where it is exposed, that is, where the overburden averages less than 1 m in thickness, and areas where it is present in continuous (or almost continuous) spreads beneath overburden.

Areas where bedrock crops out, where boreholes indicate absence of sand and gravel beneath cover and where sand and gravel beneath cover is interpreted to be not potentially workable are uncoloured on the map; where appropriate, the relevant criterion is noted. In such cases it has been assumed that mineral is absent except in infrequent and relatively minor patches that can neither be outlined nor assessed quantitatively in the context of this survey. Areas of unassessed sand and gravel, for example in built-up areas, are indicated by a red stipple.

The area of the mineral-bearing ground is measured, where possible, from the mapped geological boundary lines. The whole of this area is considered as mineral-bearing, even though it may include small areas where sand and gravel is not present or is not potentially workable. Inferred boundaries have been inserted to delimit areas where sand and gravel beneath cover is interpreted to be not potentially workable or absent. Such boundaries (for which a distinctive zigzag symbol is used) are drawn primarily for the purpose of volume estimation. The symbol is intended to indicate an approximate location within a likely zone of occurrence rather than to represent the breadth of the zone, its size being determined 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 4. Fuller grading particulars are shown in Figures 3 to 6 and Tables 5 to 7 inclusive.

Accuracy of results For resource blocks A and B, assessed at the indicated level, the accuracy of the results at the 95 per cent probability level (that is, on average nineteen out of every twenty sets of limits constructed in this way contain the true value for the volume of mineral) is 37 per cent and 45 per cent respectively. However, the true volumes are more likely to be nearer the figure estimated than either of the limits. Moreover, it is probable that roughly the same percentage limits would apply for the statistical estimate of mineral volume within a very much smaller parcel of ground (say 100 hectares) containing similar sand and gravel deposits, if the results from the same number of sample points (as provided by, say, ten boreholes) were used in the calculation. Thus, if closer limits are needed for a quotation of reserves, data from more sample points would be required, even if the area were quite small. This point can be illustrated by considering the whole of the potentially workable sand and gravel in blocks A, B and C. The total volume (162 million m^3) can be estimated to limits of $\pm$ 24 per cent at the 95 per cent probability level by a calculation based on the data from

Table 4 The sand and gravel resource of the district: statistical summary.

Block	Area		Mean thickness			Volume of sand and gravel			Mean grading percentage		
	Block	Mineral	Overburden	Mineral	Waste		Limits at the 95% probability level		Fines	Sand	Gravel
	km^2	km^2	m	m	m	$m^3 \times 10^6$	$\pm$ %	$\pm$ $m^3 \times 10^6$	$-\frac{1}{16}$ mm	$+\frac{1}{16}$–4 mm	+4 mm
A	11.1	11.1	4.4	7.3	1.7	81	37	30	8	42	50
B	10.8	8.4	1.3	7.9	1.1	66	45	30	8	45	47
C	29.5	3.3	2.4	3.5	3.3	15*	Speculative		8	29	63

* Inferred assessment of volume

Table 5 Bock A: data from IMAU boreholes and section.

Borehole or section	Recorded thickness			Mean grading percentage						
	Over-burden	Mineral	Waste part-ings	Fines	Sand			Gravel		
					Fine	Medium	Coarse	Fine	Coarse	Cobble
	m	m	m	$-\frac{1}{16}$ mm	$+\frac{1}{16}-\frac{1}{4}$ mm	$+\frac{1}{4}$-1 mm	+1-4 mm	+4-16 mm	+16-64 mm	+64 mm
NW 21*	1.8	11.7	-	3	4	13	12	22	38	8
NW 23	5.9	19.1	-	6	11	17	13	20	25	8
SW 18*	4.9	7.6	-	3	15	44	14	11	9	4
SW 22*	1.3	10.2	9.4	14	26	17	12	13	16	2
SW 23	3.7	4.9	-	12	23	9	9	14	23	10
SW 24	12.9	5.6	-	22	30	21	6	9	11	1
SW 26*	3.0	4.4	3.6	7	4	11	15	13	36	14
SE 12*	2.5	8.3	-	8	14	24	13	14	17	10
SE 13	1.1	12.7	-	3	5	12	15	18	30	17
SE 14	9.7	(0.8)	-	33	16	9	7	14	16	5
SE 17	3.8	6.8	-	19	29	9	6	13	20	4
SE 18*	7.0	3.4	-	13	8	11	14	26	22	6
SE 19*	2.2	7.2	-	3	4	7	14	28	36	8
SE E1	0.1	1.0	-	2	2	10	10	32	38	6

* Borehole abandoned before reaching prescribed depth

sample points spread across the three resource blocks. However, it must be emphasised that the quoted volume of mineral has no simple relationship with the amount that could be extracted in practice, as no allowance has been made in the calculations for any restraints (such as existing buildings and roads) on the use of the land for mineral working.

Notes on the Resource Blocks

The eastern part of the district is divided into three resource blocks. Block A encompasses glacial sand and gravel present, mainly beneath overburden, in the south and central parts of the district. Blocks B and C include glacial, fluvio-glacial and fluvial deposits.

The area to the west of West Tanfield, Kirkby Malzeard and Winksley consists of an undulating upland, which has been examined, but its resources not assessed. It is mainly covered with till through which numerous, generally minor, areas of bedrock protrude. Glacial sand and gravel is present at the surface in many, mainly small, isolated patches. Fluvial deposits, consisting mainly of silts and clays, are found in the valleys of the River Laver and its tributaries. Of the 13 IMAU boreholes and 11 commercial boreholes drilled in this area only two found potentially workable material. Borehole NW 14 proved 6.0 metres of gravel beneath 7.5 metres of overburden, and borehole NW 17, drilled into an isolated mound of glacial sand and gravel, proved 12.0 metres of 'clayey' pebbly sand and gravel beneath thin overburden. However, the lateral extent of the deposits is not known. Much more intensive investigation, which cannot be justified for an assessment at the 'indicated' level, would be needed to demonstrate the distribution of mineral with more certainty.

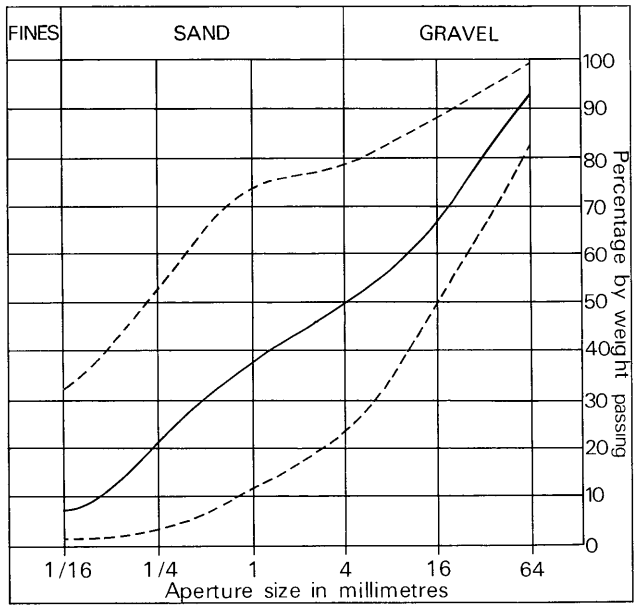

Figure 4 Grading characteristics of the mineral in block A. The continuous line is the cumulative frequency curve of the mean grading of the block as a whole; the broken lines denote the envelope within which the mean grading curves for individual boreholes fall.

Block A The undulating country around Galphay forms this block. Hereabouts, bedrock is masked by a thick sequence of sands, gravels, silts and clays, in places more than 49 m thick. Mineral within this sequence probably consists of a series of overlapping lenses of sand and gravel, mostly beneath overburden.

Sand and gravel found beneath overburden in boreholes SE 9 and 14 is not potentially workable. The area of barren ground around the sites cannot be outlined at the level of this survey but the findings are taken into account in assessing the resources. Elsewhere boreholes have proved up to 19.1 m of mineral. Its mean grading is 8 per cent fines, 42 per cent sand and 50 per cent gravel (including 8 per cent cobbles) but there is considerable variation (see Figure 4). Gravel normally predominates but sands and pebbly sands, which may be 'clayey' or 'very clayey', are also present and in boreholes SW 18 and 22 account for the greater part of the mineral. The mineral within the block has a mean proved thickness of 7.3 m and an estimated volume of 81 million $\pm$ 37 per cent.

Overburden, normally consisting of stony clay, may be up to 12.9 m thick but averages 4.4 m. Thick waste partings were recorded in boreholes SW 22 and 26 and non-IMAU borehole SW 2.

Table 6 Block B: data from IMAU boreholes and sections.

Borehole or section	Recorded thickness			Mean grading percentage						
	Over-burden	Mineral	Waste part-ings	Fines	Sand			Gravel		
	m	m	m	-$\frac{1}{16}$ mm	Fine +$\frac{1}{16}$-$\frac{1}{4}$ mm	Medium +$\frac{1}{4}$-1 mm	Coarse +1-4 mm	Fine +4-16 mm	Coarse +16-64 mm	Cobble +64 mm
NE 24	6.9	7.4	-	4	5	13	15	25	31	7
NE 26	0.9	6.0	2.7	1	5	22	9	20	32	11
NE 28*	1.1	8.0	5.3	7	9	15	20	21	19	9
NE 30	0.5	12.1	4.5	6	6	17	12	25	30	4
NE 32	0.9	21.8	-	12	36	22	8	6	9	7
NE 33*	0.5	1.8	-	4	7	12	24	23	25	5
NE 34	1.2	2.0	-	2	11	16	16	23	31	1
NE 35	3.0	10.2	-	4	7	21	15	21	25	7
NE 36	nil	9.7	0.5	25	20	11	7	11	17	9
NE E1	0.2	5.3	-	3	2	14	20	31	29	1
NE E2	0.2	5.3	-	6	6	21	14	21	27	5
NE E3	0.5	5.0	-	8	10	16	9	18	31	8

Boreholes NE 25, 29 and 31 did not prove mineral

*Borehole abandoned before reaching prescibed depth

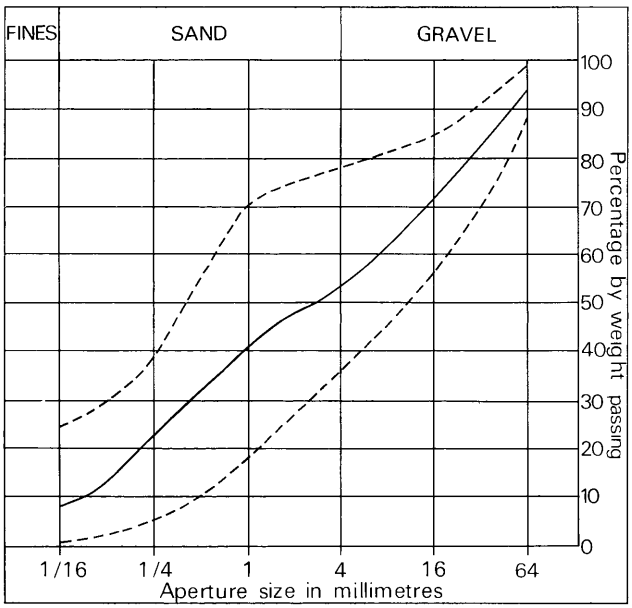

Figure 5 Grading characteristics of the mineral in block B (for explanation see figure 4).

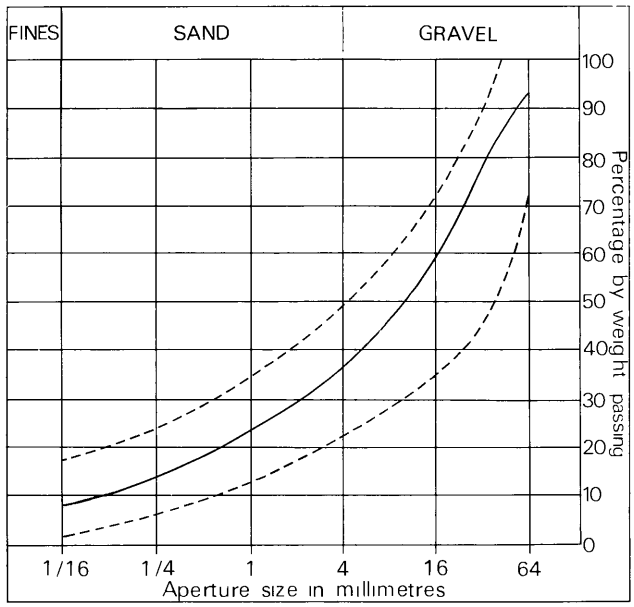

Figure 6 Grading characteristics of the mineral in block C (for explanation see Figure 4).

Block B Near West Tanfield a number of terraces have been built up in and adjacent to the Ure valley. The highest terrace, which is thought to be fluvio-glacial in origin, extends beyond the northern margin and, there, has been described by Giles (1982). Borehole NE 24, sited on the western part of the terrace, found 7.4 m of gravel beneath 6.9 m of stony clay, but the latter is thought to be localised channel-fill because a pit section just to the north reveals 5.3 m of gravel beneath thin soil. In the north-east corner of the district, borehole NE 26 proved two beds of gravel, 1.2 m and 4.8 m thick, separated by 2.7 m of stony clay, all overlain by 0.9 m of soil and stony clay.

Glacial sand and gravel was encountered beneath till and fluvial deposits in boreholes NE 30 and 35, and is present at the surface south and south-west of West Tanfield. It consists largely of gravels, which may be 'very clayey' but, near Mickley, boreholes NE 32 and NE 36 found the gravel to be underlain by 'clayey' to 'very clayey' sand.

The fluvial deposits associated with the River Ure consist of alluvium and a number of remnant terraces at various levels. Borehole NE 29 sited close to the river found only thin soil and 1.3 m of stony clay resting on dolomitic limestone, and the lower terraces are thought to be free of potentially workable sand and gravel. Other boreholes and a section [297 769] at The Batts proved partly 'clayey' gravels. The highly conjectural limit of the barren ground around borehole NE 29 is shown by a 'zig-zag' boundary.

Proved thicknesses of mineral in the block range up to 21.8 m but are generally less than 12 m. However, a number of boreholes were abandoned before reaching the prescribed depth, some of them whilst still within mineral. The mean proved thickness is 7.9 m. Sand and gravel has been extracted from an area of about

Table 7 Block C: data from IMAU boreholes.

Borehole	Recorded thickness			Mean grading percentage						
	Overburden	Mineral	Waste partings	Fines	Sand			Gravel		
	m	m	m	$-\frac{1}{16}$ mm	Fine $+\frac{1}{16}$-$\frac{1}{4}$ mm	Medium $+\frac{1}{4}$-1 mm	Coarse +1-4 mm	Fine +4-16 mm	Coarse +16-64 mm	Cobble +64 mm
NE 40	0.1	3.4	-	16	8	9	15	23	23	6
NE 41	0.5	2.0	-	9	9	12	12	29	29	0
SE 20	0.1	4.9	-	14	10	9	10	18	34	5
SE 21	9.0	5.9	2.6	2	4	14	15	28	31	6
SE 23	1.9	6.0	3.7	7	4	8	12	23	37	9
SE 24*	0.8	2.2	-	2	4	8	9	13	37	27

Boreholes NE 37, 38 and 39 and SE 15, 16 and 22 did not prove mineral

*Borehole abandoned in mineral

1.2 km^2. The volume of mineral remaining is estimated at 66 million m^3 $\pm$ 45 per cent and its mean grading as 8 per cent fines, 45 per cent sand and 47 per cent gravel. However, if the sands proved at depth in boreholes NE 32 and 36 are excluded from the assessment the mean proved thickness becomes 6.3 m, the estimated mineral volume 53 million m^3 $\pm$ 32 per cent and the mean grading 6 per cent fines, 36 per cent sand and 58 per cent gravel.

Proved thicknesses of overburden are generally low, and most of the mineral is shown on the resource map as 'exposed' - including that beneath the Ure floodplain. However, the alluvium has not been investigated fully and may in fact include areas where the overburden exceeds one metre in thickness. An area of glacial mineral beneath the supposedly barren lower river terraces is shown as 'mineral beneath overburden'. Waste partings were found in a number of boreholes (Table 6).

Block C The glacial drainage system comprising the Carr House, Thieves Gill and Sleningford channels includes several small isolated deposits of fluvio-glacial sand and gravel, two of which have been investigated by boreholes NE 40 and 41 and shown to consist largely of gravel. At Ellington the channel system joins the Laver valley and below this point a fluvio-glacial terrace is developed. Borehole SE 23 sited on this terrace found two beds of fluvio-glacial gravel separated by partly laminated clays. However, some distance to the north, borehole SE 21 found only 0.6 m of fluvio-glacial 'very clayey' gravel.

Glacial sand and gravel is found at the surface in a few places and was encountered beneath till in borehole SE 21. The distribution of this mineral deposit beneath overburden cannot be predicted with any confidence and its presence is indicated on the resource map only where it occurs at the surface. However, the presence of numerous small outcrops of bedrock and the failure of a number of boreholes to prove sand and gravel suggest the absence of mineral from much of the area.

A speculative estimate of the volume of mineral present in the block is 15 million m^3. Its mean grading, based on IMAU boreholes, is 8 per cent fines, 29 per cent sand and 63 per cent gravel.

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APPENDIX A

FIELD AND LABORATORY PROCEDURES

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

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

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

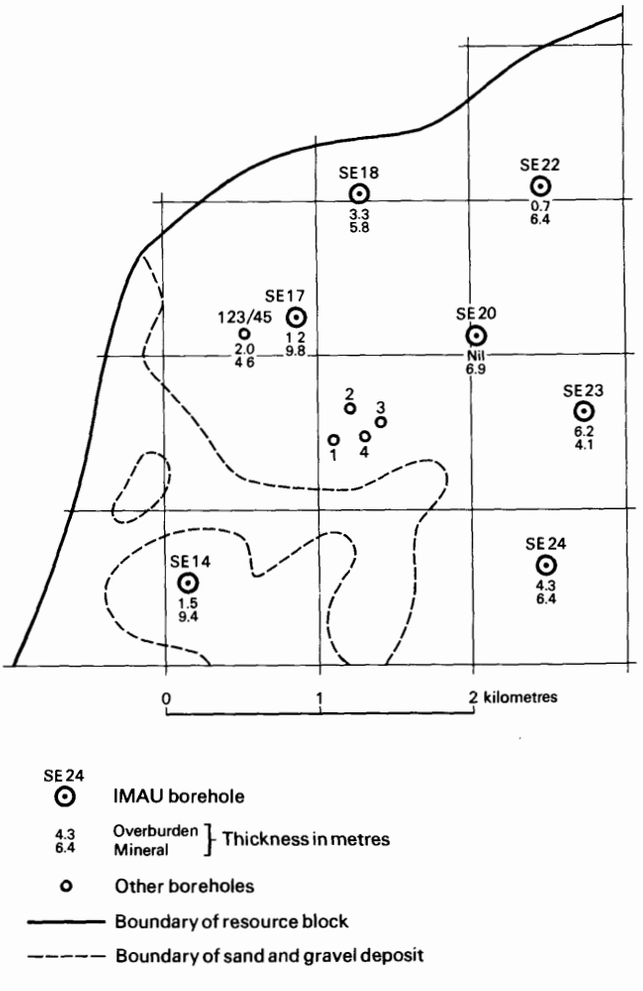
The drilling machine employed should be capable of providing a continuous sample representative of all unconsolidated deposits, so that the in-situ grading can be determined, if necessary, to a depth of 30 m (100 ft) at a diameter of about 200 mm (8 in), beneath different types of overburden. It should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

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

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

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

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



Example of resource block assessment: map of a fictitious block

APPENDIX B

STATISTICAL PROCEDURE

Statistical assessment

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

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

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

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

4 The above relationship may be transposed such that

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

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

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

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

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

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

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

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

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

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

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

$\pm (t/\sqrt{n}) \times S_{\bar{l}_m}$ or as a percentage

$\pm (t/\sqrt{n}) \times S_{\bar{l}_m} \times (100/\bar{l}_m)$ per cent, where t is Student's t at the 95 per cent probability level for $(n-1)$ degrees of freedom, evaluated by reference to statistical tables. (In applying Student's t it is assumed that the measurements are distributed normally).

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

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

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

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

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

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

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

per cent,

and when n is greater than 20, as

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

per cent.

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

Inferred assessment

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

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

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

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

Block calculation

Scale: 1:25 000
Block: Fictitious

Area
Block: 11.08 km²
Mineral: 8.32 km²

Mean thickness
Overburden: 2.5 m
Mineral: 6.5 m

Volume
Overburden: 21 million m³
Mineral: 54 million m³

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

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

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

Calculation of confidence limits

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

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

$n = 8$

$t = 2.365$

L_V is calculated as

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

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

$= 20.3$

$\simeq 20$ per cent.

APPENDIX C

CLASSIFICATION AND DESCRIPTION OF SAND AND GRAVEL

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

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

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

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

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

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

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

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

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

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

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

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

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

The terms used in the field to describe the degree of rounding of particles, which is concerned with the sharpness of the edges and corners of a clastic fragment and not the shape (after Pettijohn, 1975), 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.

Classification of gravel, sand and fines

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

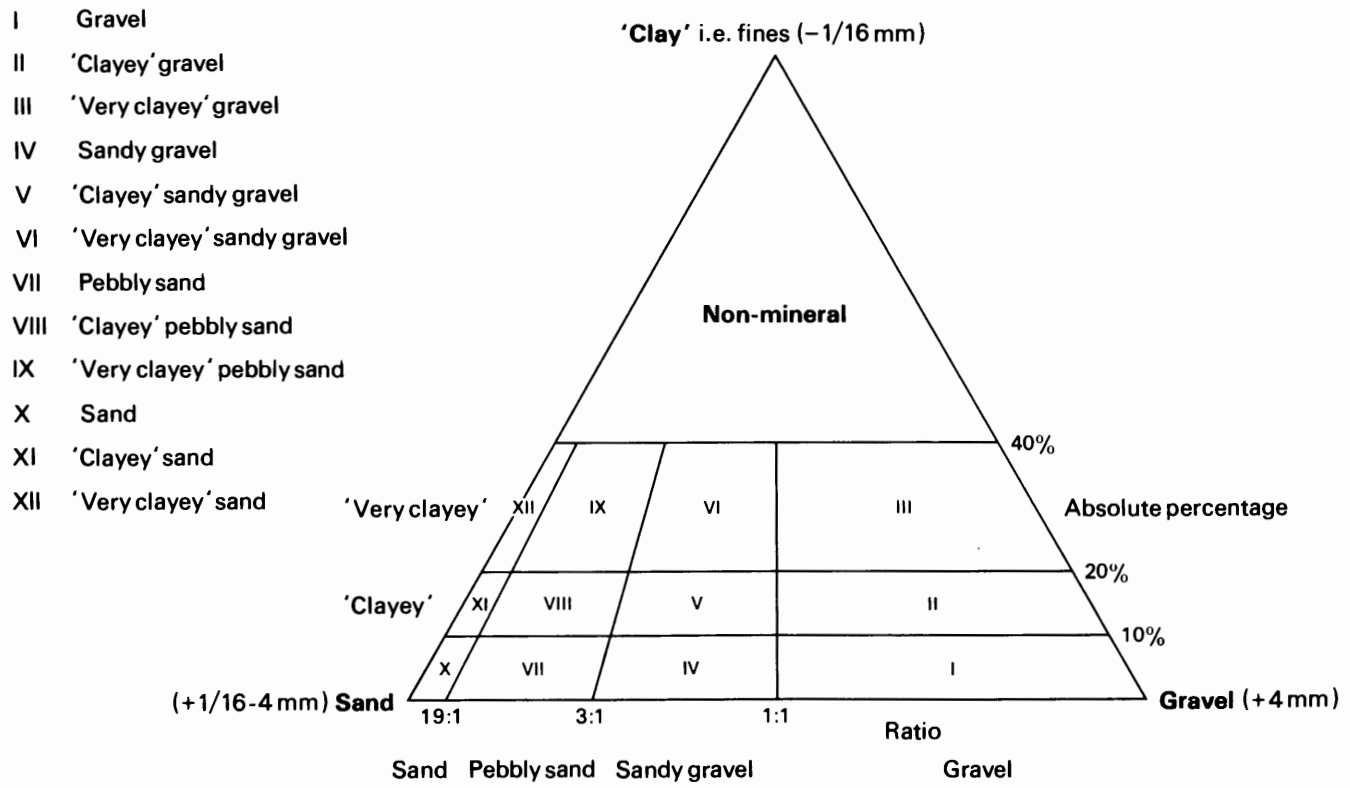


Diagram showing the descriptive categories used in the classification of sand and gravel

APPENDIX D

EXPLANATION OF THE BOREHOLE RECORDS

Annotated fictitious example

CK 66 NW 5[1] **6191 6962**[2] **Northfields**[3] **Block B**

Surface level c.+49.7 m[4]
Water struck at +45.9 m[5]
October 1972[6]

Overburden[7]	2.8 m
Mineral	5.4 m
Waste	1.1 m
Mineral	1.4 m
Bedrock	0.7 m+[8]

LOG

Geological classification	Lithology[9]	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Clay, silty, dark brown	2.6	2.8
River Terrace Deposits	**a** Gravel Gravel: fine to coarse, with cobbles towards base, angular to rounded flint and limestone with ironstone and some quartz and chalk Sand: medium with coarse and some fine, quartz and limestone	5.4	8.2
Boulder Clay	Clay, sandy and pebbly, red-brown	1.1	9.3
Glacial Sand and Gravel	**b** Sand, 'clayey' in part: fine, subangular to rounded, quartz with some coal	1.4	10.7
Lias	Mudstone, blue-grey, fossiliferous	0.7+	11.4

GRADING[10]

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	5	46	49	2.8-3.9	20	14	62	2	2	0	0
				3.8-4.8	2	2	12	18	42	24	0
				4.8-5.8	1	3	24	13	35	24	0
				5.8-6.8	0	4	21	20	26	29	0
				6.8-8.2*	4	3	23	10	23	30	7
				Mean	**5**	**5**	**28**	**13**	**25**	**22**	**2**
b	5	95	0	9.3-10.3	3	73	23	1	0	0	0
				10.3-10.7	9	85	5	1	0	0	0
				Mean	**5**	**77**	**17**	**1**	**0**	**0**	**0**
a+b	**5**	**56**	**39**	**Mean**	**5**	**20**	**26**	**10**	**20**	**17**	**2**

COMPOSITION[11]

	Depth below surface (m)	Percentages by weight in the +4-32 mm fraction				
		Flint	Quartz	Limestone	Chalk	Ironstone
	3.8-4.8	41	5	50	1	3
	4.8-5.8	39	3	45	5	8
	5.8-6.8	45	2	42	5	6
	6.8-8.2	19	6	61	3	11
	Mean	**35**	**4**	**51**	**3**	**7**

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

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

a The number of the 1:25 000 sheet on which the borehole lies, here CK 66.
b The quarter of the 1:25 000 sheet on which the borehole lies and the number of the borehole in a series for that quarter, here NW 5.

Thus the full Registration Number is CK 66 NW 5.

2 National Grid Reference
All National Grid References fall in the 100 km square identified by the first two letters of the Registration Number.

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 the borehole lies is stated.

4 Surface level
The surface level at the borehole site is given in metres above Ordnance Datum.

5 Groundwater conditions
If groundwater was present the level at which it was encountered is normally given (in metres relative to Ordnance Datum).

6 Type of drill and date of drilling
Unless otherwise stated, all boreholes were drilled by a shell and auger rig using 254 mm diameter casing. The month and year of completion of drilling 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 The plus sign (+) indicated that the base of the deposit was not reached during drilling.

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

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

For each bulk sample the percentages of fines (-$\frac{1}{16}$ mm), fine sand (+$\frac{1}{16}$-$\frac{1}{4}$ mm), medium sand (+$\frac{1}{4}$-1 mm), coarse sand (+1-4 mm), fine gravel (+4-16 mm), coarse and (+16-64 mm) and cobble gravel (+64 mm) are stated.

The mean gradings of groups of samples making up an identified bed of mineral are also given in detail and in summary. Where more than one bed is recognised the mean grading for the whole of the mineral in the borehole may be given. Where necessary, in calculating mean gradings, data for individual samples are weighted by the thickness represented. If, exceptionally, grading results are not available for a sample, the absence is noted in the log. In such cases the mean grading is calculated excluding the thickness represented by the missing data.

Fully representative sampling of sand and gravel is difficult to achieve, particularly where groundwater levels are high. Comparison between boreholes and adjacent exposures commonly suggests that in borehole samples the proportion of sand may be higher and the proportion of fines and coarse gravel may be lower. An asterisk indicates that a sample was obtained by chiselling; the grading stated may not represent that of the material *in situ*.

11 Composition
Details of the composition of selected samples or groups of samples may be given.

APPENDIX E

INDUSTRIAL MINERALS ASSESSMENT UNIT BOREHOLE RECORDS

SE 27 NW 13 **2175 7937** **Low Swinton** **Block A**

Surface level c +99.1 m
Water struck at c+82.8 m
September 1981

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, moderate yellowish brown, sandy, with pebbles, cobbles and boulders of Carboniferous sandstone, limestone and chert	4.1	4.3
	Clay, medium grey, silty, with laminae of fine-grained silty sand; sporadic pebbles	12.0	16.3
	Stony clay, dark yellowish brown, sandy, with pebbles of Carboniferous sandstone and limestone	1.7+	18.0

SE 27 NW 14 **2278 7938** **Badger Lane Farm** **Block A**

Surface level +77.7 m
Water level not recorded
September 1981

Overburden 7.5 m
Mineral 6.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
River Terrace Deposits	'Clayey' sand: fine, angular to rounded, equant, quartz with lithic grains	0.3	0.5
Till	Stony clay, olive grey, sandy, with pebbles of Carboniferous sandstone and limestone	7.0	7.5
Glacial Sand and Gravel	Gravel, sandy near top Gravel: coarse, subrounded to rounded, equant Carboniferous limestone and angular to rounded, equant sandstone	6.0+	13.5
	Borehole abandoned because of obstruction		

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
2	48	50	7.5-9.5*	2	12	27	17	20	19	3
			9.5-11.5*	1	6	23	16	21	31	2
			11.5-13.5	1	8	19	16	24	28	4
			Mean	**2**	**9**	**23**	**16**	**22**	**25**	**3**

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
9.5-11.5	71	27	0	0	1	1	0	0

SE 27 NW 15 2391 7962 Aldburgh Block A

Surface level c +99.0 m
Water not encountered
September 1981

Waste 7.3 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Stony clay, moderate yellowish brown becoming medium dark grey below 3.8m, sandy, with pebbles of Magnesian Limestone, Carboniferous limestone and sandstone	7.2	7.3
Upper Permian	Dolomitic limestone, pale yellowish orange	0.5+	7.8

SE 27 NW 16 2478 7909 High Haw Leas Block A

Surface level c +88.0 m
Water not encountered
August 1981

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, moderate yellowish brown with medium grey mottling	1.8	2.0
	Stony clay, dark yellowish brown, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone and Magnesian Limestone	12.8	14.8
	Clay, yellowish grey with light brown mottling, laminated in part	0.5	15.3
	Silty clay, medium grey with light brown mottling, laminated in part; sporadic pebbles	2.2	17.5
	Stony clay, light brown, sandy, with pebbles and cobbles of sandstone	0.5+	18.0

SE 27 NW 17 **2380 7869** **Aldburgh Hall** **Block A**

Surface level +99.8 m
Groundwater conditions not recorded
July 1981

Overburden 0.3 m
Mineral 12.0 m
Waste 9.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Sand and Gravel	**a** 'Clayey' pebbly sand Gravel: fine and coarse, angular to rounded, equant; Carboniferous limestone and sandstone with some quartz Sand: medium, angular to rounded, equant; quartz and lithic grains	10.7	11.0
	b Gravel Gravel: coarse, angular to rounded, equant; Carboniferous limestone and sandstone with some chert Sand: coarse, angular to rounded, equant; lithic grains and quartz	1.3	12.3
	Clay, medium grey, with laminae of silty sand	9.3	21.6
Till	Stony clay, moderate yellowish brown, sandy, with pebbles of Carboniferous limestone and sandstone	0.4+	22.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	16	73	11	0.3-3.3	28	38	26	5	2	1	0
				3.3-4.3	15	14	35	16	9	8	3
				4.3-5.0	7	7	40	15	13	18	0
				5.0-6.0	11	23	58	6	1	1	0
				6.0-7.0	14	43	41	2	0	0	0
				7.0-8.2	13	35	30	7	8	7	0
				8.2-11.0	11	30	35	4	11	9	0
				Mean	**16**	**30**	**37**	**6**	**6**	**5**	**trace**
b	4	22	74	11.0-12.3*	4	2	6	14	17	41	16
a+b	**15**	**67**	**18**	**0.3-12.3**	**15**	**27**	**33**	**7**	**7**	**9**	**2**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
b	11.0-12.3	59	38	2	0	trace	trace	1	trace

SE 27 NW 18 **2453 7831** **Stubbings** **Block A**

Surface level c +83.5 m
Water struck at c +76.0 m
July 1981

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Alluvium	Clay, moderate yellowish brown	0.3	0.4
Till	Clay, medium dark grey with dark yellowish brown mottling to 2.3 m, with laminae of silt and sand; thin bands of stony clay between 4.5 and 4.7 m and 6.4 and 6.6 m	7.1	7.5
	Stony clay, medium dark grey, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone and Magnesian Limestone	10.5+	18.0

SE 27 NW 19 **2432 7772** **Stubbings** **Block A**

Surface level c +78.0 m
Groundwater conditions not recorded
August 1981

Waste 17.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Stony clay, dark yellowish brown to 4.9 m then medium dark grey, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone and Magnesian limestone; sporadic thin bands of 'very clayey' gravel towards base	17.4+	17.5

SE 27 NW 20 **2478 7763** **Plump Hill** **Block A**

Surface level c +91.0 m
Groundwater conditions not recorded
August 1981

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Sandy clay, dark yellowish brown, with some pebbles	1.3	1.5
	Laminated clay, dark yellowish brown, with laminae of silt	1.1	2.6
	Stony clay, dark yellowish brown to 11.0 m then medium dark grey, with pebbles and cobbles of Carboniferous sandstone and limestone and Magnesian Limestone	15.4+	18.0

SE 27 NW 21 **2336 7516** **Mowbray View** **Block C**

Surface level +145.8 m
Water struck at +136.4 m
September 1981

Overburden 1.8 m
Mineral 11.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Stony clay, light brown, sandy, with pebbles and cobbles of Carboniferous sandstone and limestone	1.7	1.8
Glacial Sand and Gravel	Gravel Gravel: coarse, angular to rounded, equant; Carboniferous limestone and sandstone with some chert and ironstone Sand: medium and coarse, angular to rounded, equant; lithic grains and quartz	11.7+	13.5
	Borehole abandoned because of obstruction		

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
3	29	68	1.8-2.3	21	9	10	10	20	26	4
			2.3-3.3*	1	2	14	16	30	31	6
			3.3-4.3*	2	3	22	18	25	29	1
			4.3-5.3*	0	1	8	12	28	47	4
			5.3-6.3*	0	1	7	12	27	49	4
			6.3-7.3	3	5	14	13	31	32	2
			7.3-8.3*	3	11	16	9	17	39	5
			8.3-9.3*	2	6	26	15	15	36	0
			9.3-11.3*	4	3	13	10	15	45	10
			11.3-13.5*	0	1	7	11	19	37	25
			Mean	**3**	**4**	**13**	**12**	**22**	**38**	**8**

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
5.3-6.3	47	46	4	1	trace	0	2	0

SE 27 NW 22 **2343 7579** **High Farm** **Block A**

Surface level c +157.0 m
Water not encountered
July 1981

Waste 6.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Sand and Gravel	Sandy silt, moderate yellowish brown, with pebbles of Carboniferous limestone and sandstone	6.1+	6.4
	Borehole abandoned because of obstruction		

SE 27 NW 23 **2405 7543** **Grove Dale** **Block C**

Surface level +139.0 m
Groundwater conditions not recorded
September 1981

Overburden 5.9 m
Mineral 19.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Till	Clay, moderate yellowish brown, sandy, with pebbles, cobbles and boulders below 1.4 m	5.4	5.9
Glacial Sand and Gravel	**a** 'Very clayey' gravel Gravel: coarse, angular to well rounded, equant; Carboniferous sandstone and limestone with Magnesian Limestone Sand: fine, angular to subrounded, equant; quartz with lithic grains	2.0	7.9
	b Gravel Gravel: coarse, angular to rounded, equant; Carboniferous limestone and sandstone with some chert Sand: coarse, angular to rounded, equant; lithic grains and quartz	9.1	17.0
	c 'Clayey' pebbly sand Gravel: fine, angular to rounded, equant; Carboniferous limestone and sandstone with some ironstone Sand: medium, angular to subrounded, equant; lithic grains and quartz	2.0	19.0
	d Sandy gravel Gravel: coarse, angular to rounded, equant; Carboniferous limestone and sandstone Sand: medium, angular to rounded, equant; lithic grains and quartz	6.0+	25.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	20	35	45	5.9-7.9*	20	17	8	10	19	23	3
b	4	26	70	7.9-9.9*	6	6	10	14	26	28	10
				9.9-11.7*	6	10	13	16	27	19	9
				11.7-17.0*	2	4	7	10	27	38	12
				Mean	**4**	**5**	**9**	**12**	**27**	**32**	**11**
c	11	82	7	17.0-19.0	11	27	40	15	5	2	0
d	3	52	45	19.0-21.0*	6	13	21	17	16	22	5
				21.0-23.0*	2	15	29	11	8	20	15
				23.0-25.0*	2	8	23	20	19	25	3
				Mean	**3**	**12**	**24**	**16**	**14**	**23**	**8**
a-d	**6**	**41**	**53**	**5.9-25.0**	**6**	**11**	**17**	**13**	**20**	**25**	**8**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	5.9-7.9	39	42	1	17	0	0	1	0
b	7.9-9.9	51	44	4	1	0	0	0	0
c	21.0-23.0	47	47	1	1	1	1	2	0

SE 27 NE 24 **2746 7912** **West Tanfield** **Block B**

Surface level +45.4 m
Water struck at +38.4 m
July 1981

Overburden 6.9 m
Mineral 7.4 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Fluvio-glacial Sand and Gravel	Stony clay, moderate yellowish brown, sandy, with pebbles of Carboniferous limestone and sandstone	6.8	6.9
	Gravel Gravel: coarse, angular to rounded, equant and tabular; Carboniferous and Magnesian limestone with sandstone Sand: coarse, angular to rounded, equant; lithic grains and quartz	7.4	14.3
Upper Permian	Dolomitic limestone, greyish orange	0.2+	14.5

The stony clay between 0.1 and 6.9 m is thought to represent a channel fill deposit; adjacent exposures show only thin overburden

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16 -1/4	+1/4 -1	+1 -4	+4 -16	+16 -64	+64 mm
4	33	63	6.9-7.9	2	2	5	8	22	35	26
			7.9-8.9	1	3	15	13	22	38	8
			8.9-9.9	0	5	12	9	19	45	10
			9.9-10.9*	3	5	18	15	22	36	1
			10.9-11.9*	4	2	5	16	23	43	7
			11.9-14.3	7	9	18	21	31	14	0
			Mean	**4**	**5**	**13**	**15**	**25**	**31**	**7**

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
8.9-9.9	55	19	trace	25	trace	trace	1	0

SE 27 NE 25 **2890 7950** **Chapel Hill** **Block B**

Surface level c +44.0 m
Water not encountered
August 1981

Waste 3.8 m
Bedrock 0.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, dark yellowish brown, sandy and stony, becoming more so with depth; pebbles and cobbles of Carboniferous limestone and sandstone and Magnesian Limestone	3.6	3.8
Upper Permian	Dolomitic limestone, greyish orange, sandy	0.4+	4.2

SE 27 NE 26 **2967 7986** **Back Lane** **Block B**

Surface level +41.8 m
Water struck at +37.0 m
September 1981

Overburden 0.9 m
Mineral 1.2 m
Waste 2.7 m
Mineral 4.8 m
Waste 1.2 m
Bedrock 1.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvio-glacial Sand and Gravel	Stony clay, moderate yellowish brown, sandy, with pebbles of Carboniferous limestone and sandstone	0.7	0.9

	a Gravel Gravel: coarse, angular to subrounded, equant, prolate and tabular; Carboniferous limestone and sandstone with some Magnesian Limestone Sand: medium, angular to rounded, equant; lithic grains and quartz	1.2	2.1
	Clay, dark yellowish brown, sandy and pebbly	2.7	4.8
	b Gravel Gravel: coarse, well rounded to subangular, equant; Carboniferous sandstone and limestone with some chert and mudstone Sand: medium, well rounded to subangular, equant; lithic grains and quartz	4.8	9.6
Till	Clay, moderate brown, pebbly	1.2	10.8
Upper Permian	Mudstone, reddish brown	1.7+	12.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	1	36	63	0.9-2.1	1	3	19	14	25	37	1
b	1	36	63	4.8-5.8*	1	4	10	8	25	34	18
				5.8-6.8*	2	9	31	8	15	22	13
				6.8-7.8*	1	5	25	7	17	40	5
				7.8-9.6*	0	5	23	8	18	30	16
				Mean	**1**	**6**	**22**	**8**	**18**	**32**	**13**
a+b	**1**	**36**	**63**	**Mean**	**1**	**5**	**22**	**9**	**20**	**32**	**11**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	0.9-2.1	71	27	0	2	0	0	0	0
b	6.8-7.8	28	68	2	0	2	0	0	0

SE 27 NE 27 **2529 7821** **Westwood** **Block A**

Surface level c +86.0 m
Water not encountered
July 1981

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, dark yellowish brown with medium grey mottling to 3.0 m, then medium grey, with pebbles, cobbles and boulders of Carboniferous sandstone and limestone and Magnesian Limestone	17.8+	18.0

SE 27 NE 28 **2673 7835** **Quarry House** **Block B**

Surface level +48.1 m
Water struck at +44.9 m
August 1981

Overburden 1.1 m
Mineral 2.2 m
Waste 5.3 m
Mineral 5.8 m
Waste 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Made Ground	Rubble fill	0.3	0.3
River Terrace Deposits	Sandy clay, moderate yellowish brown, with sporadic pebbles	0.8	1.1
	a 'Clayey' sandy gravel Gravel: coarse, subangular to subrounded, equant Carboniferous limestone and angular to rounded, equant sandstone Sand: fine, medium and coarse, angular to rounded, equant; quartz and lithic grains	2.2	3.3
	Clay, medium grey, sandy, laminated in part	5.3	8.6
	b Gravel Gravel: fine, subrounded to rounded, equant Carboniferous limestone with angular to rounded, equant and tabular Magnesian Limestone and sandstone Sand: medium, subangular to rounded, equant; lithic grains and quartz	5.8	14.4
Till	Stony clay, moderate yellowish brown, sandy, with pebbles and cobbles of Carboniferous limestone, sandstone and Magnesian Limestone	1.1+	15.5
	Borehole abandoned because of obstruction		

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	14	45	41	1.1-2.1*	24	21	12	5	10	24	4
				2.1-3.3*	5	12	18	22	22	15	6
				Mean	**14**	**16**	**15**	**14**	**17**	**19**	**5**
b	4	43	53	8.6-9.6*	2	5	9	17	39	22	6
				9.6-10.6*	4	3	17	25	20	15	16
				10.6-11.6	5	8	20	17	16	21	13
				11.6-12.4*	5	5	15	36	24	13	2
				12.4-13.4*	6	3	11	20	22	32	6
				13.4-14.4*	6	10	21	19	11	11	22
				Mean	**4**	**6**	**15**	**22**	**23**	**19**	**11**
a+b	**7**	**44**	**49**	**Mean**	**7**	**9**	**15**	**20**	**21**	**19**	**9**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
b	10.6-11.6	61	19	trace	20	0	trace	trace	0

SE 27 NE 29 **2785 7860** **Mill Cottages** **Block B**

Surface level c +45.0 m
Water not encountered
August 1981

Waste 1.4 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
River Terrace Deposits	Stony clay, moderate yellowish brown, sandy, with pebbles and cobbles of Magnesian Limestone, Carboniferous limestone and sandstone	1.3	1.4
Upper Permian	Dolomitic limestone, yellowish orange	0.1+	1.5

SE 27 NE 30 **2893 7814** **East Tanfield** **Block B**

Surface level +40.0 m
Water struck at +32.0 m
August 1981

Overburden 0.5 m
Mineral 3.0 m
Waste 4.5 m
Mineral 9.1 m
Waste 3.2 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
River Terrace Deposits	Clay, pale yellowish brown, sandy, with pebbles and cobbles of Carboniferous limestone and sandstone	0.3	0.5
	a 'Clayey' gravel Gravel: fine, angular to rounded, equant Carboniferous limestone and subangular to rounded, equant and tabular sandstone with some Magnesian limestone Sand: fine and medium, angular to rounded, equant; lithic grains and quartz	3.0	3.5
Till	Stony clay, initially pale red but becoming pale yellowish brown by 4.0 m; pebbles of Magnesian Limestone, sandstone and Carboniferous limestone	4.5	8.0
Glacial Sand and Gravel	**b** Gravel Gravel: coarse, angular to rounded, equant, bladed and tabular; sandstone and Carboniferous limestone with some chert and Magnesian Limestone Sand: medium, angular to rounded, equant; lithic grains and quartz	9.1	17.1
	Clay, light bluish grey with pale red mottling, sandy, calcareous	3.2	20.3
Upper Permian	Dolomitic limestone, greyish orange	0.2+	20.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	15	40	45	0.5 - 3.5	15	15	15	10	25	20	0
b	3	34	63	8.0-9.0	2	1	8	8	27	48	6
				9.0-10.0	2	1	18	15	30	33	1
				10.0-11.0	10	2	11	4	19	40	14
				11.0-12.0*	1	2	18	17	21	39	2
				12.0-14.6	3	4	23	13	25	31	1
				14.6-16.0*	3	6	20	17	31	23	0
				16.0-17.1*	3	6	21	18	19	13	20
				Mean	**3**	**3**	**18**	**13**	**25**	**33**	**5**
a+b	**6**	**35**	**59**	**Mean**	**6**	**6**	**17**	**12**	**25**	**30**	**4**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	0.5-3.5	58	39	1	2	0	0	0	0
b	11.0-12.0	44	49	5	2	0	0	0	0

SE 27 NE 31 **2969 7825** **Rushwood** **Block B**

Surface level c +43.0 m
Water struck at c +38.7 m
August 1981

Waste 14.0 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, pale yellowish brown, becoming dark yellowish brown below 4.5 m, sandy, with pebbles and cobbles of Carboniferous sandstone and limestone	7.3	7.5
	Stony clay, moderate red, sandy, with pebbles of sandstone, siltstone and Magnesian Limestone; thin bands of 'very clayey' gravel below 9.5 m	6.1	13.6
	Silty clay, medium greyish blue, with tabular pebbles of Magnesian Limestone	0.4	14.0
Upper Permian	Dolomitic limestone, yellowish grey	0.2+	14.2

SE 27 NE 32 **2553 7743** **Westwood Quarry** **Block B**

Surface level +100.2 m
Water not encountered
July 1981

Overburden 0.9 m
Mineral 21.8 m
Waste 9.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Exposure		
	Soil	0.9	0.9
Glacial Sand and Gravel	**a** Gravel, upper 4.0 m partially cemented by calcium carbonate (see Plate 1) Gravel: coarse, subrounded to well rounded, equant and tabular; Carboniferous sandstone and limestone with some chert Sand: coarse, rounded, equant; lithic grains and quartz	5.1	6.0
	b Pebbly sand Gravel: fine, subrounded to well rounded, equant; Carboniferous limestone and sandstone Sand: medium, rounded, equant; quartz and lithic grains	3.9	9.9
	Borehole		
	c 'Clayey' sand: fine, subrounded to rounded, equant; quartz and lithic grains	12.8	22.7
Till	Silty clay, moderate yellowish brown to 23.9 m then medium grey, laminated; sporadic pebbles of Carboniferous limestone and sandstone, thin bands of gravel between 23.4 m and 23.9 m and thin bands of stony clay below 26.8 m	9.2+	31.9

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	2	14	84	0.9-4.0	3	2	7	13	24	28	23
				4.0-6.0	0	0	0	3	14	47	36
				Mean	**2**	**1**	**4**	**9**	**20**	**36**	**28**
b	6	86	8	6.0-9.0	6	22	44	20	6	2	0
				9.0-9.9	No grading data available						
				Mean	**6**	**22**	**44**	**20**	**6**	**2**	**0**
c	18	82	0	9.9-10.9	29	60	5	1	1	4	0
				10.9-12.1	20	60	20	0	0	0	0
				12.1-14.1	16	47	28	8	1	0	0
				14.1-16.1	6	17	62	14	1	0	0
				16.1-18.4	25	56	17	2	0	0	0
				18.4-20.4	17	78	5	0	0	0	0
				20.4-22.7	16	68	16	0	0	0	0
				Mean	**18**	**55**	**23**	**4**	**trace**	**trace**	**0**
a+b+c	**12**	**66**	**22**	**0.9-22.7**	**12**	**36**	**22**	**8**	**6**	**9**	**7**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	4.0-6.0	43	53	3	1	0	0	0	0

SE 27 NE 33 **2614 7756** **Low Side** **Block B**

Surface level +53.2 m
Groundwater conditions not recorded
August 1981

Overburden 0.5 m
Mineral 1.8 m
Waste 11.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Stony clay, dark yellowish brown, with pebbles of Carboniferous limestone and sandstone	0.3	0.5
?River Terrace Deposits	Gravel Gravel: coarse, angular to rounded, equant; Carboniferous limestone and sandstone with some ironstone Sand: coarse, angular to rounded, equant; quartz and lithic grains	1.8	2.3
Till	Stony clay, medium grey, sandy, with pebbles, cobbles and boulders of Carboniferous limestone, sandstone and Magnesian Limestone	11.7+	14.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
4	43	53	0.5-2.3*	4	7	12	24	23	25	5

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
	0.5-2.3	49	49	0	0	0	0	2	0

SE 27 NE 34 **2888 7709** **Manor Farm** **Block B**

Surface level +41.8 m
Water struck at +37.3 m
August 1981

Overburden 1.2 m
Mineral 2.0 m
Waste 10.3 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvio-glacial Sand and Gravel	Stony clay, dark yellowish orange, sandy, with pebbles	1.0	1.2
	Gravel Gravel: coarse, subangular to rounded, equant; Carboniferous sandstone and limestone with some Magnesian Limestone and chert Sand: medium and coarse, angular to rounded, equant; lithic grains and quartz	2.0	3.2
	Sandy silt, olive grey, with bands of 'very clayey' sand	2.7	5.9
Till	Stony clay, dark yellowish brown, sandy, with pebbles of Carboniferous limestone and sandstone	7.6	13.5
Upper Permian	Dolomitic limestone, pale yellowish orange	0.3+	13.8

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$ mm
2	43	55	1.2-2.2	0	2	17	17	28	36	0
			2.2-3.2*	4	21	15	15	19	23	3
			Mean	**2**	**11**	**16**	**16**	**23**	**31**	**1**

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
1.2-2.2	62	33	2	3	trace	trace	0	0

SE 27 NE 35 **2973 7789** **Rushwood Hall** **Block B**

Surface level +36.6 m
Water struck at +29.5 m
August 1981

Overburden 3.0 m
Mineral 10.2 m
Waste 4.1 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
River Terrace Deposits	'Clayey' pebbly sand Gravel: fine, angular to rounded, equant; sandstone with Carboniferous limestone Sand: fine, angular to rounded, equant; quartz and lithic grains	0.5	0.7
Till	Stony clay, dark yellowish brown, sandy, with pebbles and cobbles of Carboniferous limestone, sandstone and Magnesian Limestone	2.3	3.0
Glacial Sand and Gravel	**a** 'Clayey' gravel Gravel: coarse, angular to subrounded, equant; Carboniferous limestone and sandstone with some chert and Magnesian Limestone Sand: fine and medium, angular to rounded, equant; quartz and lithic grains	1.5	4.5
	b Gravel Gravel: coarse, angular to subrounded, equant; Carboniferous limestone and sandstone Sand: medium, angular to rounded, equant; quartz and lithic grains	8.7	13.2
	Clay, moderate red, calcareous; sporadic pebbles	4.1	17.3
Upper Permian	Marl, moderate red	0.2+	17.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	13	28	59	3.0-4.0*	14	12	11	8	18	29	8
				4.0-4.5	11	10	9	7	21	40	2
				Mean	**13**	**11**	**10**	**7**	**19**	**34**	**6**
b	2	46	52	4.5-5.5	1	12	19	11	19	29	9
				5.5-6.5*	0	3	29	25	22	18	3
				6.5-7.5*	1	2	14	13	23	35	12
				7.5-9.5*	1	5	30	16	19	27	2
				9.5-11.5*	2	5	19	19	25	20	10
				11.5-13.2*	5	10	21	15	19	21	9
				Mean	**2**	**6**	**23**	**17**	**21**	**24**	**7**
a+b	**4**	**43**	**53**	**3.0-13.2**	**4**	**7**	**21**	**15**	**21**	**25**	**7**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	4.0-4.5	56	37	4	2	0	0	1	0
b	6.5-7.5	60	38	1	1	0	trace	0	0

SE 27 NE 36 **2618 7679** **Old Sleningford Farm** **Block B**

Surface level +78.1 m
Groundwater conditions not recorded
July 1981

Mineral	7.5 m
Waste	0.5 m
Mineral	2.2 m
Waste	16.9 m
Bedrock	0.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Exposure		
Glacial Sand and Gravel	**a** 'Very clayey' gravel Gravel: coarse, subangular to rounded, equant and tabular; Carboniferous sandstone and limestone with some Magnesian Limestone and chert Sand: fine, medium and coarse, subangular to rounded, equant; quartz and lithic grains	7.5	7.5
	Borehole		
	Stony clay, pale yellowish brown, sandy, with pebbles	0.4	7.9
	Clay, moderate yellowish brown, laminated	0.1	8.0
	b 'Very clayey' pebbly sand Gravel: fine and coarse, subangular to rounded, equant; Carboniferous sandstone and limestone Sand: fine, rounded, equant; quartz with some lithic grains	2.2	10.2
	Silt, medium grey, laminated, sandy	8.4	18.6
Till	Stony clay, medium grey changing to pale red at 24.6m, sandy, with pebbles, cobbles and boulders of Carboniferous limestone, sandstone and Magnesian Limestone and sporadic pebbles of red marl	8.5	27.1
Carboniferous	Sandstone, medium light grey	0.4+	27.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	23	30	47	0.0-1.0	25	18	9	6	12	14	16
				1.0-2.0	17	5	7	11	16	36	8
				2.0-3.0	16	7	8	9	15	21	24
				3.0-4.0	18	9	8	9	18	28	10
				4.0-5.0	26	14	13	8	10	22	7
				5.0-6.0	25	16	17	9	12	21	0
				6.0-7.5	31	7	11	9	11	14	17
				Mean	**23**	**11**	**10**	**9**	**13**	**22**	**12**
b	31	65	4	8.0-9.0	33	46	10	3	4	4	0
				9.0-10.2	30	57	11	1	1	0	0
				Mean	**31**	**52**	**11**	**2**	**2**	**2**	**0**
a+b	**25**	**38**	**37**	**Mean**	**25**	**20**	**11**	**7**	**11**	**17**	**9**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	3.0-4.0	41	53	2	3	0	trace	1	0

SE 27 NE 37 **2630 7617** **Carr House** **Block B**

Surface level c +85.3 m
Water not encountered
September 1981

Waste 14.5 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, disturbed	0.8	0.8
Till	Stony clay, moderate yellowish brown, sandy, with pebbles and cobbles of Carboniferous limestone, sandstone and Magnesian Limestone	13.7	14.5
Carboniferous	Shale, black, weathered	0.1+	14.6

SE 27 NE 38 **2966 7641** **Blue Cap Wood** **Block B**

Surface level c +40.4 m
Water not encountered
July 1981

Waste 14.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, initially moderate yellowish brown, changing to dusky yellowish brown at 2.0 m and to medium grey at 8.0 m; sandy, with pebbles and cobbles of Carboniferous limestone, sandstone and Magnesian Limestone; thin bands of 'clayey' gravel below 6.0 m	13.8+	14.0
	Borehole abandoned because of slow progress		

SE 27 NE 39 **2553 7523** **Westfield** **Block B**

Surface level c +114.0 m
Water not encountered
August 1981

Waste 1.1 m
Bedrock 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, light brown, sandy	0.9	1.1
Carboniferous	Sandstone, dark yellowish orange	1.5+	2.6

SE 27 NE 40 **2614 7556** **Frizer Hall** **Block B**

Surface level +89.0 m
Water not encountered
August 1981

Overburden 0.1 m
Mineral 3.4 m
Waste 3.2 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Fluvio-glacial Sand and Gravel	**a** 'Very clayey' gravel Gravel: coarse, subrounded to rounded, equant and tabular; Carboniferous sandstone with chert and some ironstone Sand: fine, rounded, equant; quartz with some lithic grains	1.0	1.1
	b Gravel Gravel: coarse and fine, angular to subrounded, equant and bladed; Carboniferous limestone with sandstone and Magnesian Limestone and some ironstone and chert Sand: coarse, angular to rounded, equant; lithic grains and quartz	2.4	3.5

Till	Stony clay, medium dark grey, sandy, with pebbles, cobbles and boulders of Magnesian Limestone and Carboniferous limestone and sandstone	3.2	6.7
Carboniferous	Sandstone, pale yellowish brown	0.2+	6.9

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	37	31	32	0.1-1.1	37	16	11	4	10	13	9
b	7	32	61	1.1-2.1*	8	4	8	28	28	23	1
				2.1-3.5*	7	5	7	13	28	34	6
				Mean	**7**	**5**	**8**	**19**	**28**	**29**	**4**
a+b	**16**	**32**	**52**	**0.1-3.5**	**16**	**8**	**9**	**15**	**23**	**23**	**6**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	0.1-1.1	0	85	13	0	0	trace	2	0
b	2.1-3.5	60	23	2	11	trace	trace	4	0

SE 27 NE 41 **2968 7561** **North Park Farm** **Block B**

Surface level +45.1 m
Water not encountered
September 1981

Overburden 0.5 m
Mineral 2.0 m
Waste 2.8 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvio-glacial Sand and Gravel	Clay, dusky yellow, silty, pebbly	0.3	0.5
	Gravel Gravel: fine and coarse, angular to rounded, equant; Magnesian Limestone with Carboniferous limestone and sandstone Sand: medium and coarse, angular to rounded, equant; lithic grains and quartz	2.0	2.5
Till	Stony clay, pale yellowish brown, with pebbles and cobbles, mainly of Magnesian Limestone	2.8	5.3
Upper Permian	Dolomitic limestone, yellowish orange	1.0+	6.3

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
9	33	58	0.5-1.5	16	13	15	11	20	25	0
			1.5-2.5	2	5	8	13	39	33	0
			Mean	**9**	**9**	**12**	**12**	**29**	**29**	**0**

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
1.5-2.5	22	19	0	59	0	0	0	0

SE 27 NE E1 **2798 7928** **West Tanfield Quarry** **Block B**

Surface level c +46.0 m
July 1981

Overburden 0.2 m
Mineral 5.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvio-glacial Sand and Gravel	Gravel Gravel: coarse, subangular to rounded, equant and tabular; Carboniferous limestone and sandstone with Magnesian Limestone Sand: coarse, angular to rounded, equant; lithic grains and quartz An adjacent sump in the quarry floor shows till at base	5.3+	5.5

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
3	36	61	0.2-5.5	3	2	14	20	31	29	1

SE 27 NE E2 **2782 7958** **Nosterfield Quarry** **Block B**

Surface level c +47.0 m
September 1981

Overburden 0.2 m
Mineral 5.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvio-glacial Sand and Gravel	Gravel Gravel: coarse, angular to rounded, equant; Carboniferous limestone and sandstone with some Magnesian Limestone Sand: medium, angular to rounded, equant; lithic grains and quartz	5.3+	5.5

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$ mm
6	41	53	0.2-5.5	6	6	21	14	21	27	5

SE 27 NE E3 **2972 7688** **The Batts** **Block B**

Surface level c +42.6 m
September 1981

Overburden 0.5 m
Mineral 5.0 m
Waste 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
?Alluvium	Gravel Gravel: coarse, subangular to subrounded, equant; Carboniferous sandstone and limestone Sand: medium, subrounded to rounded, equant; lithic grains and quartz	5.0	5.5
Till	Stony clay, medium grey, sandy, with pebbles and cobbles	1.0+	6.5

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$ mm
8	35	57	0.5 - 5.5	8	10	16	9	18	31	8

SE 27 SW 18 **2423 7487** **North Close Farm** **Block C**

Surface level +118.8 m
Water struck at +106.8 m (artesian head)
September 1981

Overburden 4.9 m
Mineral 7.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, disturbed	0.7	0.7
Peat	Peat, dusky yellowish brown, sandy	0.8	1.5
Till	Stony clay, yellowish brown, sandy, with pebbles and cobbles of Carboniferous limestone and sandstone: band of gravel between 1.5 m and 2.1 m	3.4	4.9
Glacial Sand and Gravel	**a** Gravel Gravel: coarse, angular to rounded, equant and bladed; Carboniferous sandstone and limestone with chert Sand: medium, angular to rounded, equant; lithic grains and quartz	1.4	6.3
	b Pebbly sand with sporadic thin bands of silt and clay Gravel: fine, angular to rounded, equant; Carboniferous limestone and sandstone Sand: medium, angular to rounded, equant; quartz and lithic grains	5.7	12.0
	c Gravel Gravel: fine, angular, equant; Carboniferous limestone and sandstone Sand: coarse, angular to rounded, equant; lithic grains and quartz	0.5+	12.5
	Borehole abandoned because of artesian discharge		

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	2	30	68	4.9-6.3*	2	5	18	7	16	31	21
b	3	87	10	6.3-12.0	3	18	53	16	8	2	0
c	3	30	67	12.0-12.5	3	4	12	14	32	28	7
a+b+c	**3**	**73**	**24**	**4.9-12.5**	**3**	**15**	**44**	**14**	**11**	**9**	**4**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	4.9-6.3	45	48	7	0	trace	trace	0	0
b	12.0-12.5	54	40	1	4	trace	trace	1	0

SE 27 SW 19 **2454 7450** **Lawnwith Farm** **Block A**

Surface level c +114.0 m
Water not encountered
July 1981

Waste 15.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, moderate yellowish brown, sandy	2.0	2.2
	Stony clay, medium dark grey, sandy, with pebbles and cobbles of Carboniferous limestone and sandstone	12.8+	15.0

SE 27 SW 20 **2258 7334** **Laverton** **Block A**

Surface level c +132.0 m
Water struck at c +131.0 m
September 1981

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
River Terrace Deposits	Sandy silt, pale yellowish orange with medium grey mottling	0.8	1.0
	Clay, medium grey, with bands of fine-grained silty sand	2.0	3.0
Laminated Clay	Clay, moderate yellowish brown, laminated, with bands of fine-grained silty sand	15.0+	18.0

SE 27 SW 21 **2357 7343** **Willow House** **Block A**

Surface level c +157.0 m
Water not encountered
July 1981

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, medium grey, with some pebbles and cobbles	2.4	2.6
Laminated Clay	Silt, olive grey, with laminae of fine-grained silty sand	6.2	8.8
	Clay, olive grey	3.1	11.9
	Sandy silt, medium grey, laminated, with some bands of clay	6.1+	18.0

SE 27 SW 22 **2426 7339** **West Lees** **Block C**

Surface level +149.4 m
Water not encountered
July 1981

Overburden	1.3 m
Mineral	6.0 m
Waste	9.4 m
Mineral	4.2 m
Waste	1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, moderate yellowish brown, sandy, with pebbles and cobbles of sandstone, Carboniferous limestone and Magnesian Limestone	1.1	1.3
Glacial Sand and Gravel	**a** 'Very clayey' pebbly sand Gravel: fine, subangular to rounded, equant; sandstone with Carboniferous limestone and Magnesian Limestone Sand: fine, angular to rounded, equant; quartz and lithic grains	6.0	7.3
	Sandy silt, moderate yellowish brown, with bands of clay and sporadic pebbles	3.0	10.3
	Clay, moderate yellowish brown becoming medium grey below 10.5m, with laminae of fine-grained silty sand	1.8	12.1
	Sandy silt, as above	4.6	16.7
	b Gravel Gravel: coarse, subangular to rounded, equant; sandstone and Carboniferous limestone with Magnesian Limestone Sand: medium and coarse, angular to rounded, equant; lithic grains and quartz	4.2	20.9
Laminated Clay	Clay, laminated, moderate yellowish brown, with thin bands of fine-grained silty sand	1.1+	22.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	22	72	6	1.3-2.3	23	28	19	11	9	10	0
				2.3-3.3	16	58	19	5	2	0	0
				3.3-4.3	21	44	23	9	3	0	0
				4.3-5.3	18	48	23	10	1	0	0
				5.3-6.3	20	33	20	16	10	1	0
				6.3-7.3	36	48	9	5	2	0	0
				Mean	**22**	**44**	**19**	**9**	**4**	**2**	**0**
b	2	34	64	16.7-17.7*	2	1	5	12	24	52	4
				17.7-18.7*	1	2	6	11	31	37	12
				18.7-20.9*	3	5	25	18	23	26	0
				Mean	**2**	**3**	**16**	**15**	**25**	**35**	**4**
a+b	**14**	**55**	**31**	**Mean**	**14**	**26**	**17**	**12**	**13**	**16**	**2**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
b	17.7 - 18.7	40	44	1	15	0	0	0	0

SE 27 SW 23 **2449 7308** **Braithwaite Hall** **Block C**

Surface level +153.4 m
Water struck at +136.4 m
August 1981

Overburden 3.7 m
Mineral 4.9 m
Waste 12.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, moderate brown, sandy, with pebbles, cobbles and boulders	3.5	3.7
Glacial Sand and Gravel	**a** 'Clayey' gravel Gravel: coarse, angular to rounded, equant and bladed; Carboniferous limestone and Magnesian Limestone with sandstone Sand: coarse, fine and medium, angular to rounded, equant; lithic grains and quartz	2.4	6.1
	b 'Clayey' sandy gravel Gravel: fine, angular to subangular, equant; Carboniferous limestone, Magnesian Limestone and sandstone Sand: fine, angular to rounded, equant; quartz and lithic grains	1.5	7.6
	c 'Clayey' sand: fine, angular to rounded, equant; quartz and lithic grains	1.0	8.6
	Silt, moderate yellowish brown, sandy	7.0	15.6
Till	Clay, medium grey	5.4+	21.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	10	13	77	3.7-4.5*	10	4	3	6	16	42	19
				4.5-6.1	No grading data available						
b	10	60	30	6.1-7.1	10	25	15	20	20	10	0
				7.1-7.6	No grading data available						
c	19	79	2	7.6-8.6	19	65	11	3	2	0	0
a+b+c	**12**	**41**	**47**	**3.7-8.6**	**12**	**23**	**9**	**9**	**14**	**23**	**10**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	3.7-4.5	49	24	trace	26	0	0	1	0

SE 27 SW 24 **2496 7326** **Braithwaite Hall** **Block C**

Surface level +142.2 m
Water struck at +127.2 m
August 1981

Overburden 12.9 m
Mineral 5.6 m
Waste 5.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, dark yellowish brown, sandy, with pebbles and cobbles of Carboniferous limestone and sandstone and Magnesian Limestone	12.7	12.9
Glacial Sand and Gravel	**a** Gravel Gravel: coarse, angular to rounded, tabular, bladed and equant; sandstone and Carboniferous limestone with Magnesian Limestone Sand: medium and coarse, angular to rounded, equant; lithic grains and quartz	2.1	15.0
	b 'Very clayey' sand Sand: fine, angular to rounded, equant; quartz and lithic grains	3.5	18.5
	Silt, yellowish brown, sandy	5.0+	23.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	5	39	56	12.9-13.9	7	16	29	18	14	16	0
				13.9-14.9*	2	1	2	12	32	44	7
				14.9-15.0	No grading data available						
				Mean	**5**	**8**	**16**	**15**	**23**	**30**	**3**
b	32	68	0	15.0-15.5	30	42	27	1	0	0	0
				15.5-17.5	No grading data available						
				17.5-18.5	34	43	22	1	0	0	0
				Mean	**32**	**44**	**23**	**1**	**0**	**0**	**0**
a+b	**22**	**57**	**21**	**12.9-18.5**	**22**	**30**	**21**	**6**	**9**	**11**	**1**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	13.9-14.9	37	39	0	24	trace	0	0	0

SE 27 SW 25 **2323 7299** **Missies Farm** **Block A**

Surface level c +133.0 m
Water not encountered
September 1981

Waste 20.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Clay, medium grey becoming greyish red towards base, silty in part	19.9+	20.0

SE 27 SW 26 **2477 7269** **Plover Hill House** **Block C**

Surface level +145.6 m
Water struck at +138.6 m
August 1981

Overburden 3.0 m
Mineral 0.9 m
Waste 3.6 m
Mineral 3.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, moderate yellowish brown, sandy	2.8	3.0
Glacial Sand and Gravel	**a** 'Clayey' gravel Gravel: coarse, angular to well rounded, equant; Carboniferous limestone and sandstone with Magnesian Limestone Sand: coarse, rounded, equant; lithic grains and quartz	0.9	3.9
Till	Stony clay, medium dark brown, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone	3.6	7.5
Glacial Sand and Gravel	**b** Gravel Gravel: coarse, angular to rounded, equant; Carboniferous limestone and sandstone with Magnesian Limestone and chert Sand: coarse, angular to rounded, equant; lithic grains and quartz	3.5+	11.0
	Borehole abandoned because of slow progress		

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	11	31	58	3.0-3.9*	11	6	10	15	15	30	13
b	6	30	64	7.5-9.5	6	4	11	15	13	37	14
				9.5-11.0*	No grading data available						
				Mean	**6**	**4**	**11**	**15**	**13**	**37**	**14**
a+b	**7**	**30**	**63**	**Mean**	**7**	**4**	**11**	**15**	**13**	**36**	**14**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	3.0-3.9	44	33	0	23	0	0	0	0
b	7.5-9.5	46	33	8	13	0	0	0	0

SE 27 SE 12 **2562 7448** **Azerley Park** **Block C**

Surface level +97.4 m
Water struck at 91.7 m
July 1981

Overburden 2.5 m
Mineral 8.3 m
Waste 9.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Stony clay, yellowish brown, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone	2.4	2.5
Glacial Sand and Gravel	**a** 'Clayey' gravel Gravel: coarse, angular to rounded, equant and bladed; sandstone and Carboniferous limestone with Magnesian Limestone and some chert Sand: fine, angular to rounded, equant; quartz and lithic grains	1.0	3.5
	b 'Clayey' sand: medium, angular to rounded, equant; quartz and lithic grains	2.0	5.5
	c Gravel Gravel: coarse, angular to subrounded, equant and bladed; sandstone and Carboniferous limestone with Magnesian Limestone and some chert and ironstone Sand: medium, angular to rounded, equant; lithic grains and quartz	5.3	10.8
	Silt, greyish orange, sandy	9.2+	20.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	14	31	55	2.5-3.5	14	12	10	9	12	21	22
b	16	81	3	3.5-4.5	17	48	34	1	0	0	0
				4.5-5.5	14	25	51	4	2	4	0
				Mean	**16**	**36**	**42**	**3**	**1**	**2**	**0**
c	4	44	52	5.5-6.5*	3	4	19	15	16	26	17
				6.5-7.5*	5	6	19	15	23	22	10
				7.5-8.5*	4	5	28	29	17	15	2
				8.5-9.5*	3	5	19	17	17	15	24
				9.5-10.5	4	8	16	13	25	28	6
				10.5-10.8	No grading data available						
				Mean	**4**	**6**	**20**	**18**	**19**	**21**	**12**
a+b+c	**8**	**51**	**41**	**2.5-10.8**	**8**	**14**	**24**	**13**	**14**	**17**	**10**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	2.5-3.5	38	52	4	6	0	0	trace	0
b	6.5-7.5	42	46	3	7	0	0	2	0

SE 27 SE 13 **2610 7446** **Azerley Grange** **Block C**

Surface level +98.0 m
Water struck at +88.8 m
July 1981

Overburden 1.1 m
Mineral 12.7 m
Waste 8.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial Sand and Gravel	Stony clay, light brown, sandy, with pebbles and cobbles of Carboniferous limestone and sandstone	1.0	1.1
	a 'Clayey' gravel Gravel: fine and coarse, rounded to well rounded, equant and bladed; Carboniferous limestone and sandstone with some Magnesian Limestone Sand: coarse, angular to rounded, equant; lithic grains and quartz	1.0	2.1
	b Gravel Gravel: coarse, angular to rounded, equant to bladed; sandstone and Carboniferous limestone with some chert and Magnesian Limestone Sand: coarse, angular to subangular, equant; lithic grains and quartz	10.0	12.1
	c Sandy gravel Gravel: coarse, angular to rounded, equant; sandstone and Carboniferous limestone with some chert and Magnesian Limestone Sand: coarse, angular to rounded, equant; lithic grains and quartz	1.7	13.8
	Silt, moderate yellowish brown, sandy	2.2	16.0
Till	Stony clay, moderate yellowish brown, sandy with pebbles, cobbles and boulders of Carboniferous limestone and sandstone	6.2+	22.2

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	12	33	55	1.1-2.1	12	9	10	14	27	27	1
b	2	29	69	2.1-3.1*	1	2	6	12	19	41	19
				3.1-4.1*	2	6	17	12	13	36	14
				4.1-5.1*	3	7	16	10	11	27	26
				5.1-6.1*	2	4	9	15	24	28	18
				6.1-7.1*	1	2	6	11	17	32	31
				7.1-8.1*	1	5	15	17	14	18	30
				8.1-9.1*	1	2	10	16	17	26	28
				9.1-10.1*	2	5	14	13	16	27	23
				10.1-11.1	3	5	14	17	22	34	5
				11.1-12.1*	5	1	5	14	23	38	14
				Mean	**2**	**4**	**11**	**14**	**18**	**30**	**21**
c	5	54	41	12.1-13.1	5	11	20	23	18	23	0
				13.1-13.8	No grading data available						
a+b+c	**3**	**32**	**65**	**1.1-13.8**	**3**	**5**	**12**	**15**	**18**	**30**	**17**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	1.1-2.1	60	35	1	4	trace	trace	trace	0
b	6.1-7.1	43	48	6	3	0	0	0	0
c	12.1-13.1	40	50	5	5	0	0	0	0

SE 27 SE 14 **2579 7333** **Holster Hill Farm** **Block C**

Surface level +115.1 m
Water struck at +104.6 m
July 1981

Overburden 9.7 m
Mineral 0.8 m
Waste 7.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, light brown, sandy, with pebbles and cobbles	9.5	9.7
Glacial Sand and Gravel	'Very clayey' gravel Gravel: coarse, angular to subrounded, equant; Carboniferous limestone and sandstone with Magnesian Limestone Sand: fine, angular to rounded, equant; quartz and lithic grains	0.8	10.5
Laminated Clay	Clay, dark grey, laminated	7.5+	18.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
33	32	35	9.7-10.5	33	16	9	7	14	16	5

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
9.7-10.5	51	35	1	13	trace	trace	trace	0

SE 27 SE 15 **2660 7343** **Back Wood** **Block B**

Surface level c +83.0 m
Water struck at c +71.8 m
July 1981

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Clay, moderate yellowish brown, sandy, with sporadic pebbles	2.8	2.9
	Stony clay, medium grey, sandy, with pebbles, cobbles and boulders	8.3	11.2
Laminated Clay	Silty clay, medium grey, laminated	6.8+	18.0

SE 27 SE 16 **2980 7324** **Dancing Lane** **Block B**

Surface level c +66.0 m
Groundwater conditions not recorded
August 1981

Waste 10.5 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Stony clay, moderate brown, sandy, with pebbles, cobbles and boulders of Carboniferous limestone, sandstone and Magnesian Limestone	10.4	10.5
Upper Permian	Dolomitic limestone, greyish orange	0.5+	11.0

SE 27 SE 17 **2564 7291** **Galphay** **Block C**

Surface level +127.2 m
Water struck at +118.2 m
July 1981

Overburden 3.8 m
Mineral 6.8 m
Waste 11.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, light brown, silty, with pebbles and cobbles	3.6	3.8
Glacial Sand and Gravel	'Clayey' sandy gravel Gravel: coarse, angular to subrounded, equant; sandstone and Carboniferous limestone with Magnesian Limestone Sand: fine, angular to rounded, equant; quartz and lithic grains	6.8	10.6
	Silt, moderate reddish brown, sandy	0.2	10.8
Laminated Clay	Clay, medium grey, with laminae of fine-grained silty sand	11.2+	22.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
19	44	37	3.8-4.8	24	13	10	9	15	22	7
			4.8-5.6	No grading data available						
			5.6-6.6	23	33	13	7	7	12	5
			6.6-7.6*	14	13	11	8	21	31	2
			7.6-8.6	11	27	5	3	17	31	6
			8.6-9.6	No grading data available						
			9.6-10.6	22	59	5	2	5	5	2
			Mean	**19**	**29**	**9**	**6**	**13**	**20**	**4**

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
6.6-7.6	43	49	1	7	0	0	0	0

SE 27 SE 18 **2688 7277** **Cow Meyers** **Block C**

Surface level +72.5 m
Water struck at +65.4 m
July 1981

Overburden 7.0 m
Mineral 3.4 m
Waste 1.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, dark yellowish brown, sandy, with pebbles and cobbles of sandstone and Carboniferous limestone	6.8	7.0

Glacial Sand and Gravel	'Clayey' gravel Gravel: fine, angular to subrounded, equant; sandstone, Carboniferous limestone and Magnesian Limestone Sand: coarse, angular to rounded, equant; lithic grains and quartz	3.4	10.4
Till	Stony clay, yellowish brown, sandy, with pebbles and cobbles	1.9+	12.3
	Borehole abandoned because of obstruction		

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
13	33	54	7.0-8.1	18	11	13	17	23	13	5
			8.1-9.1*	4	5	8	9	23	37	14
			9.1-10.1	15	9	14	14	33	15	0
			10.1-10.4	No grading data available						
			Mean	**13**	**8**	**11**	**14**	**26**	**22**	**6**

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
8.1-9.1	36	38	0	26	0	0	0	0

SE 27 SE 19 **2551 7155** **Laver Banks Farm** **Block C**

Surface level +143.2 m
Water struck at +139.7 m
June 1981

Overburden 2.2 m
Mineral 7.2 m
Waste 7.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, moderate yellowish brown, sandy, with pebbles, cobbles and boulders of Carboniferous limestone, sandstone and Magnesian Limestone	2.0	2.2
Glacial Sand and Gravel	Gravel Gravel: coarse, angular to rounded, equant and bladed; sandstone and Carboniferous limestone with Magnesian Limestone Sand: coarse, angular to subrounded, equant; lithic grains and quartz	7.2	9.4
Laminated Clay	Clay, moderate yellowish brown changing to medium grey at 15.5 m, with laminae of fine-grained sand	7.6+	17.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
3	25	72	2.2-3.2	3	3	4	13	28	41	8
			3.2-4.2	2	2	3	8	23	40	22
			4.2-5.2	3	4	6	11	28	38	10
			5.2-6.1	5	7	13	17	23	30	5
			6.1-7.1	3	4	7	12	30	39	5
			7.1-8.1*	2	5	9	21	35	26	2
			8.1-9.4*	3	4	7	14	27	41	4
			Mean	**3**	**4**	**7**	**14**	**28**	**36**	**8**

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
4.2-5.2	38	47	0	15	0	trace	0	0

SE 27 SE 20 **2736 7183** **Studley Moor** **Block B**

Surface level +104.3 m
Water not encountered
June 1981

Overburden 0.1 m
Mineral 4.9 m
Waste 7.0 m
Bedrock 0.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Made Ground	Brick rubble	0.1	0.1
Glacial Sand and Gravel	'Clayey' gravel Gravel: coarse, angular to rounded, equant; sandstone and Carboniferous limestone with Magnesian Limestone Sand: fine, coarse and medium, angular to subrounded, equant; lithic grains and quartz	4.9	5.0
Till	Stony clay, initially pale yellowish brown, becoming medium grey at 5.5 m and then changing to dark yellowish brown at 7.8 m sandy, with pebbles, initially of Carboniferous limestone and sandstone but from 7.8 m increasing amounts of Magnesian Limestone are found until at the base this is the only pebble type	7.0	12.0
Upper Permian	Dolomitic limestone, pale orange	0.6+	12.6

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
14	29	57	0.1-1.1	17	10	8	8	18	36	3
			1.1-2.1	14	9	7	7	15	35	13
			2.1-3.1	18	10	9	11	21	31	0
			3.1-5.0*	10	11	10	11	18	35	5
			Mean	**14**	**10**	**9**	**10**	**18**	**34**	**5**

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
1.1-2.1	37	53	trace	10	0	0	0	0

SE 27 SE 21 **2900 7139** **Sunley Raynes** **Block B**

Surface level +47.0 m
Water struck at +38.0 m
September 1981

Overburden 9.0 m
Mineral 3.0 m
Waste 2.6 m
Mineral 2.9 m

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvio-glacial Sand and Gravel	Stony clay, moderate brown, sandy, with pebbles and cobbles	0.7	1.0
	'Very clayey' gravel Gravel: coarse; Carboniferous limestone and sandstone Sand: coarse; lithic grains and quartz	0.6	1.6
Till	Stony clay, light brown, silty, with pebbles, cobbles and boulders	7.4	9.0
Glacial Sand and Gravel	**a** Gravel Gravel: coarse, subrounded to rounded, equant, bladed and tabular; Carboniferous limestone and sandstone with Magnesian Limestone and some chert Sand: medium, angular to rounded, equant; lithic grains and quartz	3.0	12.0
Till	Stony clay, moderate brown, sandy, with pebbles and cobbles	2.6	14.6
Glacial Sand and Gravel	**b** Gravel Gravel: coarse, angular to rounded, equant and tabular; Magnesian Limestone with Carboniferous limestone and sandstone Sand: coarse and medium, angular to rounded, equant; lithic grains and quartz	2.9	17.5
Upper Permian	Dolomitic limestone, pale orange	0.2+	17.7

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
a	2	33	65	9.0-10.0	1	2	8	6	21	43	19
				10.0-11.0	0	5	26	13	19	29	8
				11.0-12.0	4	6	21	13	26	29	1
				Mean	**2**	**4**	**18**	**11**	**22**	**34**	**9**
b	3	31	66	14.6-15.6	4	6	16	22	28	24	0
				15.6-16.6	2	2	7	17	35	37	0
				16.6-17.5	3	3	8	16	39	24	7
				Mean	**3**	**3**	**10**	**18**	**36**	**28**	**2**
a+b	**2**	**33**	**65**	**Mean**	**2**	**4**	**14**	**15**	**28**	**31**	**6**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	10.0-11.0	46	44	2	8	0	0	0	0
b	15.6-16.6	14	9	0	77	0	0	0	0

SE 27 SE 22 **2783 7038** **Low Lindrick** **Block B**

Surface level c +88.3 m
Water not encountered
June 1981

Waste 1.9 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Stony clay, moderate yellowish brown, silty, with pebbles of sandstone and Magnesian Limestone	1.8	1.9
Upper Permian	Dolomitic limestone, greyish orange	0.3+	2.2

SE 27 SE 23 **2954 7026** **Studley Rodger** **Block B**

Surface level +44.3 m
Groundwater conditions not recorded
September 1981

Overburden 1.9 m
Mineral 2.5 m
Waste 3.7 m
Mineral 3.5 m
Bedrock 0.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Stony clay, moderate yellowish brown, sandy, with pebbles and cobbles of Carboniferous limestone, sandstone and Magnesian Limestone	1.6	1.9
Fluvio-glacial Sand and Gravel	a 'Very clayey' gravel Gravel: coarse and fine, angular to well rounded, equant; Magnesian Limestone and sandstone with Carboniferous limestone Sand: medium and fine, angular to rounded, equant; lithic grains and quartz	1.0	2.9
	b Gravel Gravel: coarse, angular to rounded, equant; Magnesian Limestone, sandstone and Carboniferous limestone Sand: coarse, angular to rounded, equant; lithic grains and quartz	1.5	4.4
	Clay, moderate brown, laminated in part	3.7	8.1

	c Gravel Gravel: coarse, angular to rounded, equant; Carboniferous limestone with Magnesian Limestone and sandstone Sand: coarse, angular to rounded, equant; lithic grains and quartz	3.5	11.6
Upper Permian	Dolomitic limestone, pale orange	0.4+	12.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	29	34	37	1.9-2.9	29	12	13	9	18	19	0
b	5	26	69	2.9-3.9	5	4	9	15	28	39	0
				3.9-4.4	5	5	9	10	30	37	4
				Mean	**5**	**4**	**9**	**13**	**29**	**39**	**1**
c	**2**	**20**	**78**	8.1-9.2*	2	2	7	7	20	44	18
				9.2-10.2*	1	1	7	13	20	47	11
				10.2-11.2*	4	2	7	16	26	32	13
				11.2-11.6*	No grading data available						
				Mean	**2**	**1**	**7**	**12**	**22**	**42**	**14**
a+b+c	7	24	69	**Mean**	**7**	**4**	**8**	**12**	**23**	**37**	**9**

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	1.9-2.9	19	26	0	55	0	trace	0	0
b	3.9-4.4	30	34	1	35	0	0	0	0
c	9.2-10.2	50	24	0	26	0	0	0	0

SE 27 SE 24 **2854 7210** **Clotherholme Farm** **Block B**

Surface level +50.6 m
Water not encountered
September 1981

Overburden 0.8 m
Mineral 2.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.8	0.8
Alluvium	Gravel Gravel: coarse, angular to rounded, equant and bladed; sandstone and Carboniferous limestone with Magnesian Limestone Sand: medium and coarse, angular to rounded, equant; lithic grains and quartz	2.2+	3.0
	Borehole abandoned because of obstruction		

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
2	21	77	0.8 - 1.3*	8	9	11	6	7	18	41
			1.3 - 3.0*	1	2	7	10	15	43	22
			Mean	**2**	**4**	**8**	**9**	**13**	**37**	**27**

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 -32 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
0.8 - 1.3	35	45	0	20	0	0	0	0

SE 27 SE E1 **2618 7400** **Home Farm** **Block C**

Surface level c +92.0 m
July 1981

Overburden 0.1 m
Mineral 1.0 m
Waste 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial Sand and Gravel	Gravel Gravel: coarse, subangular to rounded, equant and tabular; sandstone and Carboniferous limestone with some Magnesian Limestone Sand: medium and coarse, subangular to rounded, equant; lithic grains and quartz	1.0	1.1
	Sandy silt, moderate yellowish brown	0.9+	2.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
2	22	76	0.1-1.1	2	2	10	10	32	38	6

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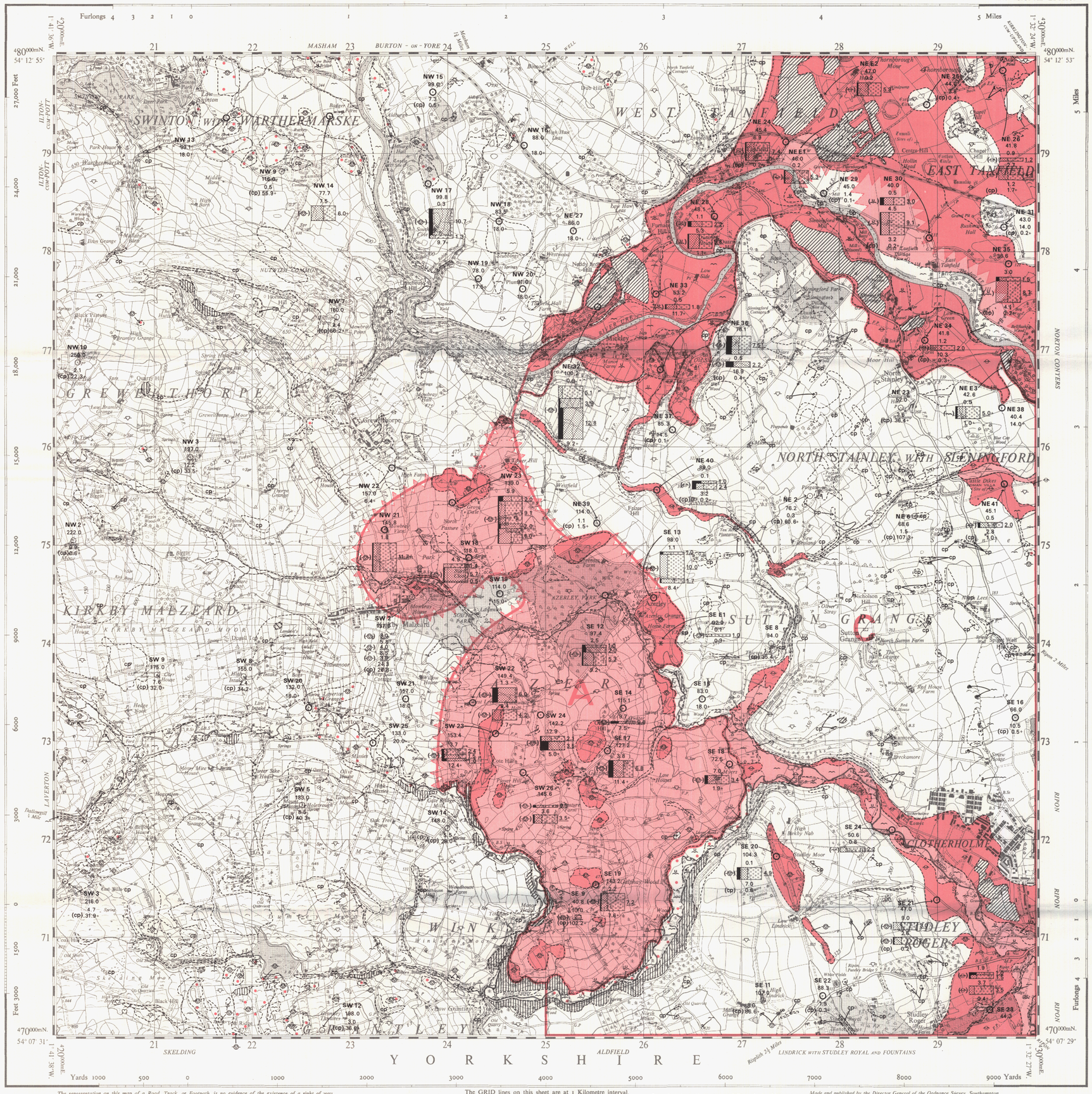
INSTITUTE OF GEOLOGICAL SCIENCES

INDUSTRIAL MINERALS ASSESSMENT UNIT

THE SAND & GRAVEL RESOURCES OF SHEET SE 27 (WEST TANFIELD, NORTH YORKSHIRE)

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

ORDNANCE SURVEY
SHEET SE27
PROVISIONAL EDITION



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

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

Compiled from 6" sheets last fully revised 1907–28. Other partial systematic revision 1938–51 has been incorporated.

Made and published by the Director General of the Ordnance Survey, Southampton. Reprinted with minor corrections 1958.

Geological survey on the six-inch scale by A.H. Cooper J.G.O. Smart and A.A. Wilson in 1978-80. J.G.O. Smart and E.G. Smith, District Geologists.

Sand and Gravel survey by J.R.A. Giles and G.E. Strong in 1981. R.G. Thurrell, Head, Industrial Minerals Assessment Unit.

1:25,000 Sand and Gravel Resource Sheet published 1983
G.M. Brown, D.Sc., F.R.S., Director, Institute of Geological Sciences.

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.

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SE 18 51	SE 28	SE 38 52
SE 17	SE 27	SE 37
SE 16 61	SE 26	SE 36 62

Diagram showing relation of the National Grid 1 : 25,000 sheets with the One-Inch Geological Sheets

THE SAND & GRAVEL RESOURCES OF SHEET SE 27 (WEST TANFIELD, NORTH YORKSHIRE)

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

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EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Landslip L-1

DRIFT

- **Peat** P-1
- **Alluvium** - clays, silts and gravels A-78
- **Alluvial Fan** AF-4
- **River Terrace Deposits (undifferentiated)** - mainly gravels and sandy gravels, partly 'clayey' RT-34
- **Head** H-12
- **Fluvio-glacial Sand and Gravel** - gravels, sandy gravels, sands and 'clayey' sands FL-30
- **Glacial Sand and Gravel** - gravels, sandy gravels, pebbly sands and sands, commonly 'clayey' to 'very clayey' GS-87
- **Till** - stony clay TL-9
- **Morainic Drift** - heterogeneous deposits with generally high sandstone content MD-4

SOLID

- cp **Carboniferous and Permian (undivided)** - mainly mudstone, siltstone, sandstone, dolomitic limestone and dolomite

Made Ground MG-2

Areas worked for sand and gravel

BOUNDARY LINES

- Geological boundary, Drift
- Inferred boundary between recognised categories of deposits
- Resource Block boundary

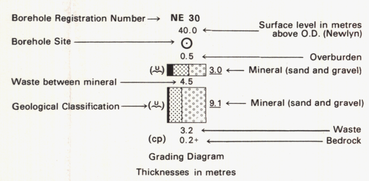
Broken lines denote uncertainty.

BOREHOLE DATA

SITE LOCATIONS

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

I.M.A.U. BOREHOLES



Grading Diagram

Thicknesses in metres

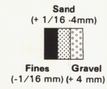
Note:
(i) Figures underlined denote thicknesses used in the assessment of resources.
(ii) The + sign indicates that the base of the deposit was not reached.
(iii) The Geological Classification is given only for mineral and bedrock.

Borehole Registration Number

Each I.M.A.U. borehole is identified by a Registration Number, e.g. NE 30. The letters refer to the quarter sheet and the figures to the I.G.S. serial numbers for that quarter. The unique designation for borehole NE 30 is SE 27 NE 30.

Grading Diagrams

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



The height of the diagram is proportional to the mineral thickness

The widths of the divisions show the proportions of **Fines, Sand** and **Gravel**, but small amounts of gravel may be omitted or exaggerated.

OTHER BOREHOLES

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

EXPOSURE RECORDS

Information from the inspection of exposures is shown in the same way as for boreholes but they are located by an asterisk thus *.

CATEGORIES OF DEPOSITS

- **Exposed mineral, assessed.** CAT-E2
- **Continuous or almost continuous spreads of mineral beneath overburden** CAT-C1
- **Sand and gravel either not potentially workable (see Report) or absent** CAT-A2
- **Sand and gravel not assessed** CAT-N1

RESOURCE BLOCKS

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

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

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