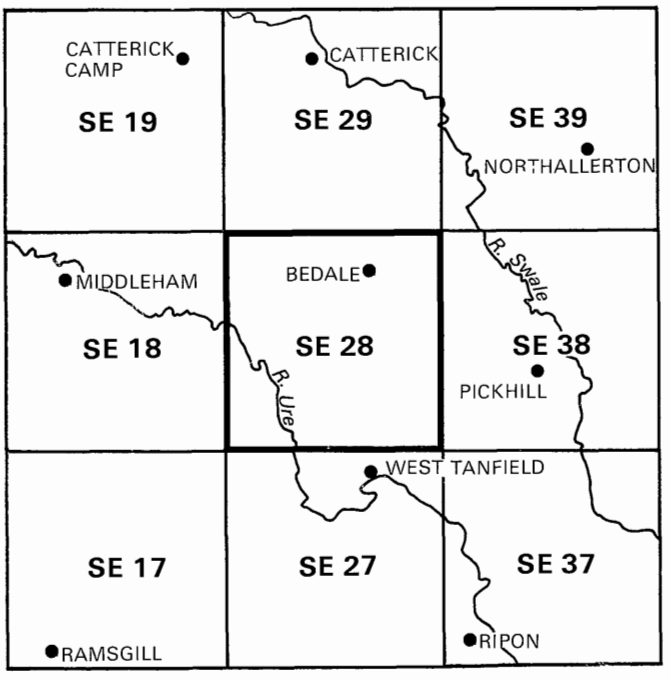
INSTITUTE OF GEOLOGICAL SCIENCES

Natural Environment Research Council

Mineral Assessment Report 119



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

Description of 1:25 000 sheet SE 28

J. R. A. Giles

Contributors
A. H. Cooper, J. G. O. Smart and A. A. Wilson

ISBN 0 11 884319 2*

London Her Majesty's Stationery Office 1982

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

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

Any enquiries concerning this report may be addressed to
Head, Industrial Minerals Assessment Unit,
Institute of Geological Sciences,
Keyworth, Nottingham NG12 5GG.

PREFACE

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

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

This report describes the sand and gravel resources of 100 km^2 of country around Bedale, North Yorkshire, shown on the accompanying 1:25 000 resource map. The survey was conducted by Mr J. R. A. Giles, assisted in the drilling and sampling programme by Messrs C. Corser, J. H. Lovell, R. Stanczyszyn and J. B. L. Wild. 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 contributed to the geological account of the district.

Mr J. D. Burnell (Land Agent) negotiated access to land for drilling. The ready cooperation of landowners and tenants in this work is gratefully acknowledged.

G. M. Brown
Director

Institute of Geological Sciences
Exhibition Road
London SW7 2DE

12 May 1982.

CONTENTS

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

Description of 1:25 000 sheet SE 28

J. R. A. Giles

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 Bedale, 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. Where feasible the reliability of the volume estimates is given at the symmetrical 95 per cent probability level.

The assessed area is divided into four resource blocks, containing between 2.0 and 10.6 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 grading of the mineral 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 28 NE 31). 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 31).

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, for less precise locations such as farms, to six figures, accurate to within 100 m.

Bibliographical reference

GILES, J. R. A. 1982. The sand and gravel resources of the country around Bedale, North Yorkshire: description of 1:25 000 resource sheet SE 28. **Miner. Assess. Rep. Inst. Geol. Sci.**, No 119.

Author

J. R. A. Giles, BSc
Institue of Geological Sciences, Nicker Hill
Keyworth, Nottingham NG12 5GG.

Contributors

A. H. Cooper PhD
J. G. O. Smart BSc
A. A. Wilson PhD
Institute of Geological Sciences, Ring Road Halton,
Leeds LS15 8TQ.

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. As the assessment is at the indicated level, parts of such a deposit may not satisfy all the criteria.

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

For the particular needs of assessing sand and gravel resources, a grain-size classification based on the geometric scale $\frac{1}{16}$ 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).

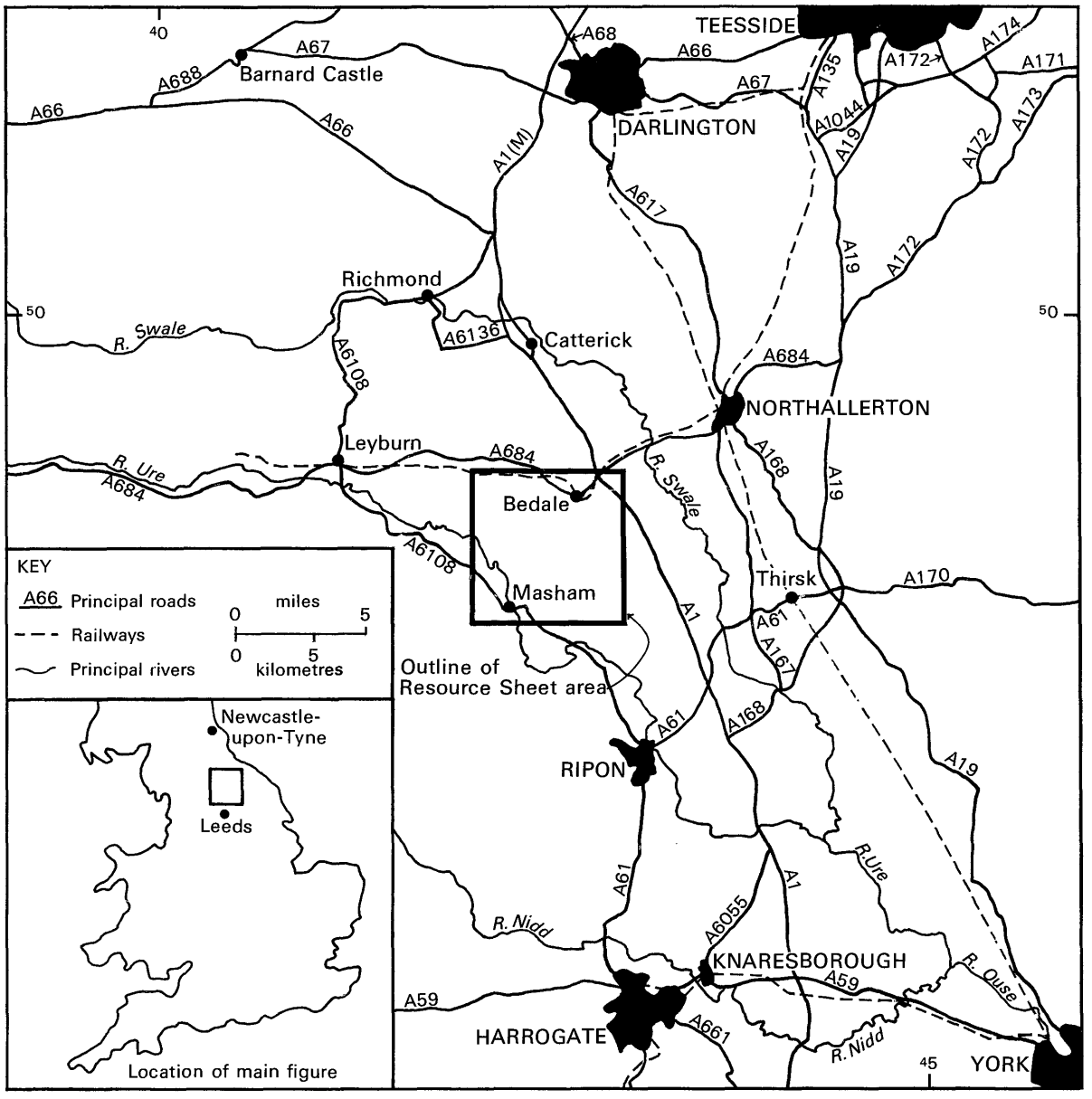


Figure 1 Map showing location of the district.

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

General

The market town of Bedale, the principal settlement of the district, lies 40 km south-west of Teesside and 55 km north of Leeds (Figure 1). It is served by the A684 which affords easy access to the A1. The Northallerton to Settle railway line, which formerly served Bedale, is now used as a mineral railway carrying limestone. Masham, a market town in the south-west of the district is the only other sizeable settlement; it lies on the A6108 Wensleydale to Ripon road. There is an RAF base at Leeming and sand and gravel and Magnesian Limestone are extracted north of Masham and at Well respectively. Otherwise the land is devoted to mixed agriculture. The local population services these undertakings but also includes a small commuter element.

The district may be divided into four topographically distinct units. Between Newton-le-Willows and Bedale and north of Thornton Watlass an upstanding hummocky landscape rises to over 475 ft at Ley Hill. The origin of this landscape is related by Johnson (1969, p. 137) to a minor readvance and subsequent stagnation of the Wensleydale glacier. South of this area, between Well and Masham, the Lower Magnesian Limestone forms a cuesta, rising to 500 ft near Halfpenny House. These two upland units separate the Ure and Swale valleys. The River Ure crosses the south-west corner of the district in a broad valley. The ground east of the upland area forms part of the Vale of Mowbray, the northward extention of the Vale of York.

Geology

The 'solid' and drift deposits found at or near surface in the district are listed in Table 1. Permian strata are

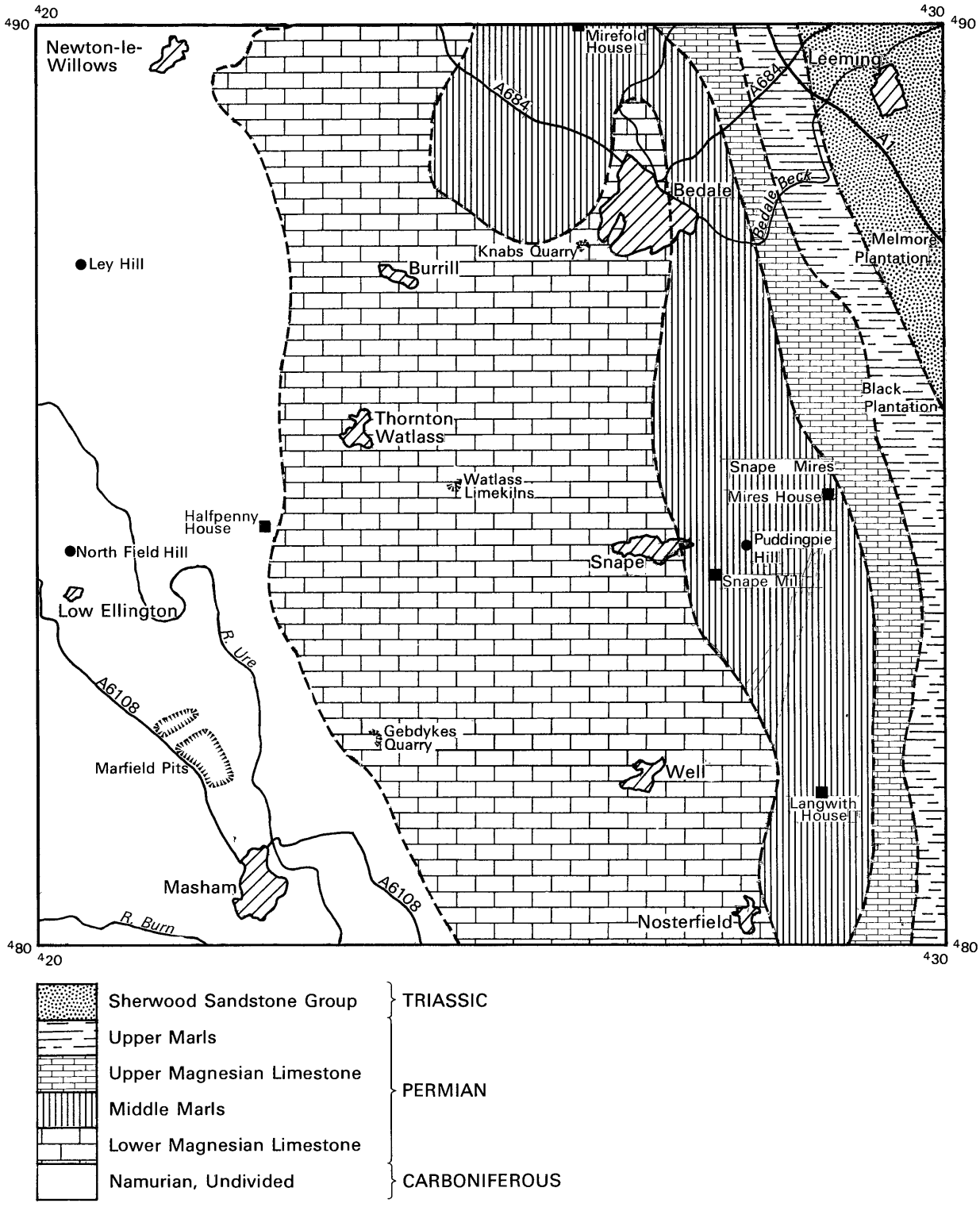


Figure 2 Sketch map showing 'solid' geology and principal localities referred to in the report.

Table 1 Stratigraphy

DRIFT	
Quaternary	Peat
	Calcareous Tufa
	Alluvium
	Alluvial Fan
	River Terrace Deposits, undifferentiated
	Head
	Fluvio-glacial Sand and Gravel
	Laminated Clay associated with fluvio-glacial sand and gravel
	Glacial Lake Deposits: Sand; Silt and Clay
	Laminated Clay associated with glacial deposits
	Glacial Sand and Gravel
	Till
SOLID	
Triassic	Sherwood Sandstone Group
Permian	Upper Marls
	Upper Magnesian Limestone
	Middle Marls
	Lower Magnesian Limestone
Carboniferous	
	Namurian, undivided

shown undivided on the resource map but the disposition of the tabulated subdivisions is indicated in Figure 2, which also shows the principal localities referred to in the report. The relationships between drift deposits proved by IMAU boreholes are illustrated in Figure 3.

SOLID

Namurian Beds of late Arnsbergian (E_2) to late Kinderscoutian (R_1) age comprise some 130 m of mudstones and sandstone. Exposures are restricted to the valleys due to the widespread cover of glacial drift. The most distinctive sandstone is the shelly, fine-grained Cayton Gill Shell Bed, some 6 metres in thickness. Coarser sandstones also occur, notable the feldspathic Lower Brimham Grit which is only seen at one small exposure [2250 8287].

Lower Magnesian Limestone This formation crops out as an escarpment with a well-defined dip-slope running south-south-eastwards from Burrill towards Well. Substantial areas north-east of Masham are drift free. The formation is 47 m thick at its maximum and consists mainly of grey and pale brownish cream dolomite underlain by a basal breccia 2.78 m thick in the Aiskew Bank Borehole (Pattison, 1978). The upper beds of the dolomite include groups of stellate calcite crystals after gypsum, whilst 'macro mottling' due to pressure solution occurs at lower levels. The dolomite is well exposed at Gybdykes Quarry [236 822] and Watlas Limekilns [246 850].

Middle Marls Reddish brown, thin-bedded calcareous mudstones comprise much of the Middle Marls, but it also contains appreciable thicknesses of gypsum and anhyd-rite, mainly at depth. The marls form a low-lying drift-covered tract parallel to the outcrop of the Lower Magnesian Limestone, and there are no exposures. The marls are variable in thickness (30-70 m), the variation being largely due to the removal of gypsum and anhyd-rite by groundwater solution, a process that has resulted in foundering of the overlying beds, including the bottom 30 m of the Sherwood Sandstone Group. Snape Mires is a topographic low, marking a large foundered area.

Upper Magnesian Limestone Throughout the area this formation is concealed by drift. It is between 7 and 11 m thick, and composed largely of light grey-buff, thin-bedded dolomitic limestone with vughs. As a result of evaporite solution in the underlying Middle Marls the Upper Magnesian Limestone is commonly foundered and brecciated.

Upper Marls There are no exposures of the Upper Marls, which comprise between 20 and 30 m of reddish brown silty, calcareous mudstone with gypsum and anhydrite at depth. These minerals have suffered groundwater solution and add to the foundering caused by the solution of the Middle Marls evaporites. A few thin sandstone beds are present near the top of the Upper Marls, where there is a passage by alternation into the overlying Sherwood Sandstone.

Sherwood Sandstone Group This group consists of reddish brown, fine- and medium-grained sandstone, the lowest 40 m of which crop out beneath drift in the north-eastern corner of the district. Near Melmore Plantation [2955 8796] red-brown, fine-grained micaceous sandstone is exposed in a drainage ditch and crops out in the adjacent field.

DRIFT

Althougth North Yorkshire was glaciated on several occasions during the Pleistocene, all the glacial deposits of the 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; Scottish ice, with Cheviot erratics, entered the Vale of York over the Tees lowland; and local Dales ice, containing Carboniferous and some Permian erratics, occupied the major dales. The west of the district was affected mainly by ice from the Wensleydale glacier, and Vale of York ice occupied the eastern part.

Till Much of the bedrock is concealed beneath deposits of till which in places are more than 18 m thick. The matrix of the till varies from clay to clayey sand and is commonly silty. Pebbles, cobbles and boulders in the till consist predominantly of Carboniferous sandstone and limestone with some chert. Fragments of Permian dolomitic limestone are scarce except near outcrops of the Lower and Upper Magnesian limestones. Lenses and discontinous beds of laminated clay, sand and gravel are present within and below the till. In the western ground north of the River Ure the till surface is commonly moundy.

Glacial Sand and Gravel These deposits range from fine- to medium-grained sand, with sporadic clay laminae, to coarse gravel with boulders in a sand or clayey sand matrix. The gravel is composed largely of pebbles of Carboniferous sandstone and limestone. The deposits occur above, within and below the till, and were probably laid bown by water on top of, adjacent to, or beneath a stagnating ice sheet. Some of the clayey gravels, however, are probably of morainic origin.

In the western ground glacial sand and gravel occur chiefly to the north of the River Ure in a series of mound-like hills of irregular, and in several cases sinuous, shape. The latter are likely to have been deposited by streams running within or under the ice sheet. The large spread west of Bedale is hummocky and is covered by sandy clay till which has not been separately mapped. The till is seen, together with the sand and gravel, in Knabs Quarry [260 876].

Laminated Clay closely associated with glacial deposits Small patches of laminated clay with beds of silt and sand occur above, within and below the till. Borehole SE 19 proved 7.2 m below till, and lesser thicknesses were proved in a similar position in boreholes SE 17 and SE 21. In borehole NE 19, 17 m of laminated

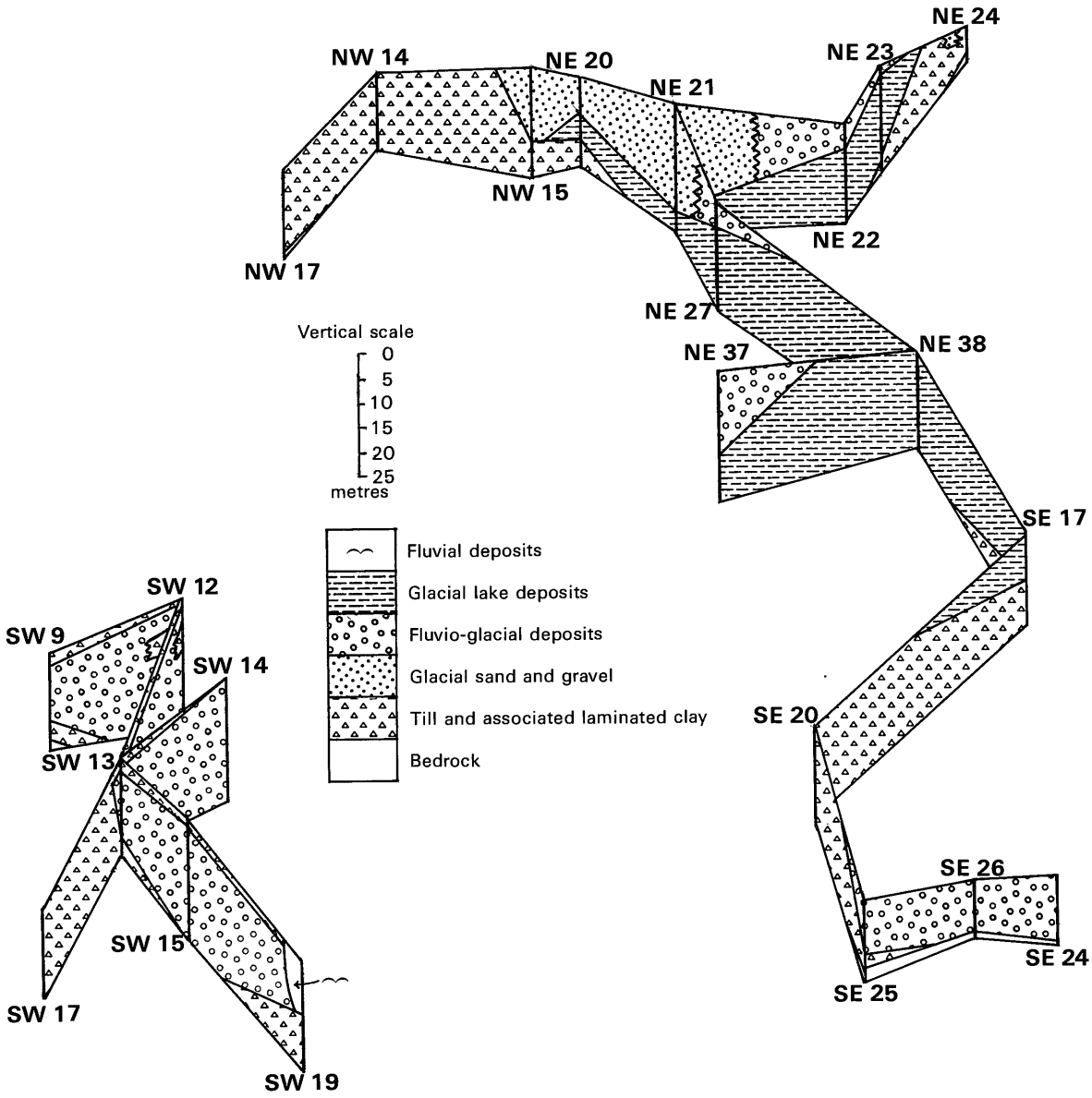


Figure 3 A simplified schematic fence diagram illustrating the relationship between the drift deposits proved in IMAU boreholes. Thin surface deposits of peat and alluvium have been omitted.

clay were proved under glacial sand and gravel. These deposits probably represent the distal equivalents of glacial sand and gravel.

Glacial Lake Deposits: Silt and Clay Silt and clay of lacustrine origin form flattish low areas around Mirefold House [260 890], Leeming [2960 8964] and Snape Mires [280 850]. These deposits are predominantly composed of stiff grey to brown, stoneless clay with laminae of silt and sand. At Snape Mires, and possibly at Mirefold House, the silt and clay partly fill large depressions produced by foundering after the underground solution of gypsum.

Glacial Lake Deposits: Sand Thin sands are interbedded with the lacustrine clays and are present at the surface near Leeming, where they form a marginal facies of the lake deposits. A borehole at Leeming (NE 1) proved 1.8 m of sand resting on clay.

Laminated Clay associated with fluvio-glacial sand and gravel Some 13 m of stoneless clays and silts occur deeply buried within the 45 m-thick glacial sequence in the Aiskew Bank Borehole (NE 9). These comprise both laminated and non-laminated deposits apparently associated with a north-south-trending buried valley through Bedale. The west-south-west to east-north-east-trending buried channel near Burrill (postulated by Johnson (1974)) probably does not exist. Johnson's geophysical evidence for this latter channel lies close to its westerly end and is now believed to relate only to a curve in the buried valley of the River Ure as it turns southwards towards Masham. Farther east, near Burill, a surface exposure of Lower Magnesian Limestone [2410 8690] and the occurrence of only 11.8 m of drift in borehole NE 25 close to Johnson's postulated channel centre line render its presence most unlikely.

Fluvio-glacial Sand and Gravel A gently undulating plain between Low Ellington and Masham lies at between 300 and 325 ft OD. It is underlain by fluvio-glacial deposits of the Ure Valley, masked in most places by clay commonly under 2 m in thickness and with a variable number of stones. The fluvio-glacial deposits consist of gravels with some sand lenses, ranging up to 13.9 m in thickness and in places overlying up to 12 m of pebbly sand resting on till. The stone content, commonly Carboniferous limestone and sandstone with some chert, points to local derivation. The gravels are best seen in Marfield Quarry of the Redland Co. north of Masham

Plate 1.1 Marfield Quarry and the fluvio-glacial terrace north of Masham: a north-north-eastwards view from near Mile House [214 823].

Plate 1.2 Marfield Quarry face: cobbles and boulders set in a matrix of coarse and fine gravel and sand, interbedded with lenses of 'clayey' sand showing cross-laminations.

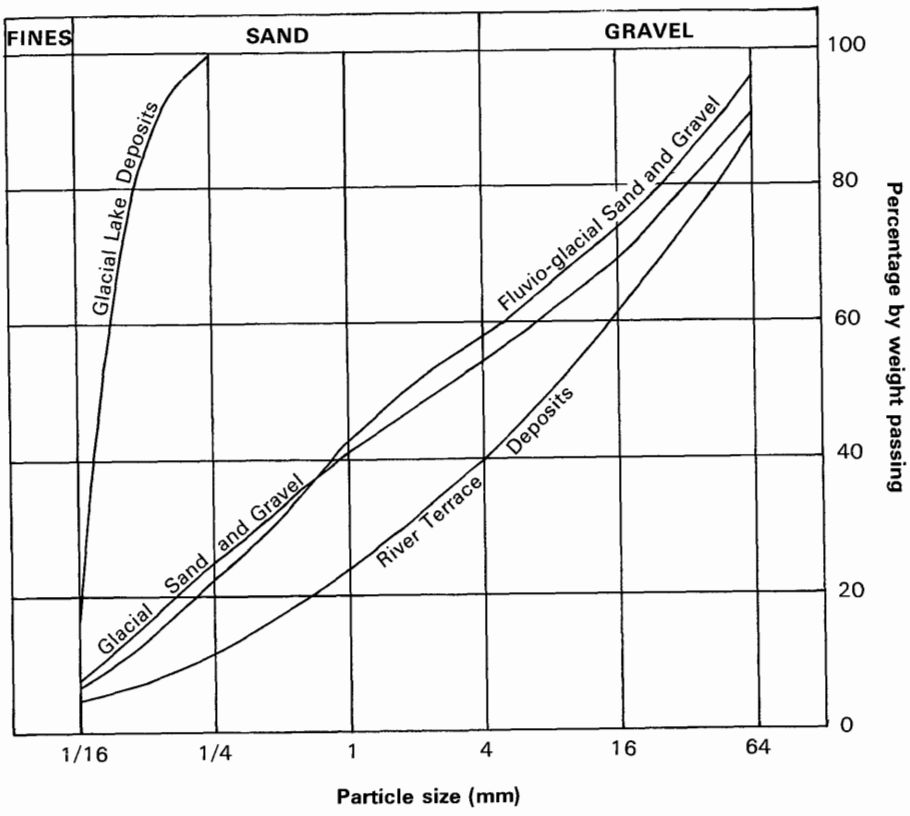


Figure 4 Cumulative curves showing mean particle size distributions of the potentially workable sand and gravel.

(Plate 1), where some 11 m are exposed. The best natural exposure on the banks of the River Ure [2164 8367] shows 10.8 m of gravel overlying up to 4.5 m of stony clay with a strongly undulating contact. These fluvio-glacial deposits marked a period of rapid stream flow in the main stages of the cutting of the Hack Fall Gorge.

Where the River Ure leaves the Hack Fall Gorge near West Tanfield, south of this resource area, there is an extensive fluvio-glacial terrace of sand and gravel which extends northwards into the area, almost to Well. This terrace is slightly undulating and has locally suffered slight subsidence after the underground solution of gypsum. Gravel in excess of 7 m thick was recently worked at Nosterfield and is currently being exploited just south of the area. This gravel is composed of approximately equal parts of Carboniferous sandstone and limestone with up to 20 per cent of Permian dolomite. Most of the gravel is pebble and cobble-sized and the matrix is composed of sand. Cross-bedding and channel structures are present in many places. These deposits have been proved to be up to 12.5 m thick by borehole SE 27.

Between Bedale and Snape there is a flat gravel terrace which skirts Snape Mires and extends, adjacent to Bedale Beck, north-eastwards almost to Leeming. This terrace, which rests on glacial lake silt and clay, probably once extended over most of Snape Mires, but much of the terrace has foundered due to gypsum solution and only small relict outliers remain at the surface. The resulting depressions are filled with lacustrine clay and peat.

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

River Terrace Deposits, undifferentiated River terraces occur along the valleys of the rivers Ure and Burn and form characteristic flat spreads with distinct back features. Boreholes show that the terraces consist of gravel up to 8 metres in thickness associated with silty clay up to 9.2 m thick. The thickest gravels occur from 8 to 12 metres above river level. The pebbles and cobbles in the gravels are typically of sandstone and limestone derived from the Ure catchment. Boreholes in terraces on both sides of the River Ure at Masham show from 7.3 to 9.2 m of silty clay underlying the gravel, in one case extending below river level.

Low terraces about 1-2 m higher than the alluvium occur adjacent to Bedale Beck to the east of Bedale. These terraces are of limited extent and are composed of gravelly and clayey sand.

Alluvium The alluvium of the rivers Ure and Burn typically consists of silt, up to 3.6 m of which are seen in many places along the river banks. The narrow belt of alluvium along Bedale Beck is composed of clay and silty clay.

Numerous ill-drained hollows contain alluvial clay and silt, commonly associated with peat. The majority of these hollows are situated in areas mantled by till or glacial sand and gravel, and some are typical kettle holes. Other hollows, largely confined to areas underlain by the Middle Marls, Upper Magnesian Limestone and Upper Marls, are subsidence features resulting from the solution of evaporites in the marl formation. Enclosed alluvium-filled depressions in the fluvio-glacial sand and gravel terrace to the east of Bedale have been produced by this mechanism.

Alluvial Fan At Well an alluvial fan composed of silt and fine gravel with calcareous tufa has formed where the water from a spring issuing from the Lower Magnesian Limestone debouches on to the drift-covered lowlands.

Calcareous Tufa At Snape Mill [2750 8409], near Mires House [2837 8499] and at the edge of Black Plantation [2906 8589] calcareous tufa forms slightly elevated mounds. These mounds are associated with spring activity and mark the escape of artesian water from the Permian rocks. Tufa is also present within the alluvial fan deposit at Well (see above) and is associated with peat deposits in various places (see below).

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

Deposit		Percentage by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian Limestone	Mudstone and shale	Quartz	Ironstone	Coal
River Terrace Deposits	Mean	66	31	2	trace	trace	trace	1	-
	Maximum	76	34	3	trace	trace	trace	1	-
	Minumum	64	21	1	-	trace	-	trace	-
Fluvio-glacial Sand and Gravel	Mean	56	40	1	2	trace	trace	1	-
	Maximum	85	67	4	41	1	1	2	-
	Minimum	30	15	trace	-	-	-	trace	-
Glacial Sand and Gravel	Mean	53	42	1	2	-	trace	2	trace
	Maximum	68	57	3	27	-	trace	4	trace
	Minimum	40	28	-	-	-	trace	-	trace

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

Borehole	Aggregate impact value	10 % fines value (kN)	Relative density		Water absorption (% of dry mass)
			oven dried basis	saturated and surface dried basis	
Glacial sand and gravel					
NW 11	27	170	2.52	2.58	2.2
NW 20	27	180	2.52	2.58	2.4
NE 17	23	-	2.55	2.60	1.9
NE 26	27	210	2.52	2.59	2.6
Fluvio-glacial sand and gravel					
SW 13	29	150	2.46	2.55	3.4
SW 14	22	200	2.58	2.61	1.3
SE 25	28	190	2.49	2.56	2.7

Peat This deposits, which is generally less than 1.5 m thick, occupies many areas of low-lying, ill-drained land, especially on Snape Mires. These depression have mainly been produced by subsidence following solution of underlying evaporites. The peat of Snape Mires is associated with numerous springs which issue from the Permian formations. These springs produce mounds of wet peat standing above the drained mire, the most extreme example being Puddingpie Hill [2784 8446]. Interbedded with the peat throughout the area are numerous beds of buff-coloured calcareous tufa and bog lime.

Composition of the Sand and Gravel Deposits

The main aggregate resources of the district consist of glacial and fluvio-glacial sand and gravel but subordinate amounts of mineral are found in the river terrace deposits of the Ure valley and in glacial lake deposits. Details of grading and composition are given in Appendix E; they are summarised below and in Figure 4 and Table 2. The results of a number of physical and mechanical tests carried out according to BS 812 (British Standards Institution, 1975) upon aggregates from selected boreholes in each of the main deposits are shown in Table 3.

Glacial and Fluvio-glacial Sand and Gravel Samples from the glacial and fluvio-glacial sand and gravel collected during this survey show that in mechanical and lithological composition the two deposits are indistinguishable from each other. Their mean gradings of fines 8 per cent, sand 46 per cent and gravel 46 per cent and of fines 7 per cent, sand 51 per cent and gravel 42 per cent, respectively, are virtually the same (see Figure 4). Both deposits have a similar range of variation in grade (see Figure 5), gravel and sandy gravel being the major classes of mineral represent. The sand fraction of the glacial sand and gravel contains approximately equal proportions of fine and medium grades: coarse sand is generally present in lesser amounts but, exceptionally, may predominate, as in NE 20. The medium grade is the most common in the fluvio-glacial deposits; it is accompanied by generally subordinate and approximately equal amounts of fine and coarse grades. The sand of both deposits is composed of roughly equal amounts of quartz and lithic grains; the latter dominate the coarse grade but become progressively less important with decreasing grain size. The sand is generally angular to rounded and equant in shape.

The gravel fraction of both deposits is mainly coarse. Carboniferous limestone and sandstone together normally represent more than 90 per cent of the gravel, the percentage of the former exceeding that of the latter (see Figure 5). Exceptionally, Magnesian Limestone may become a major component (see Table 2). Insignificant amounts of coal are present but up to 4 per cent of potentially deleterious ironstone may also occur. Other minor constituents include chert, mudstone and quartz. The pebbles are generally angular to rounded; they are normally equant in shape but may be tabular, bladed or prolate (see Figure 6).

The median grain size of the glacial and fluvio-glacial deposits associated with the readvance of the Wensleydale glacier becomes progressively finer eastwards away from the source of the ice (see Figure 7).

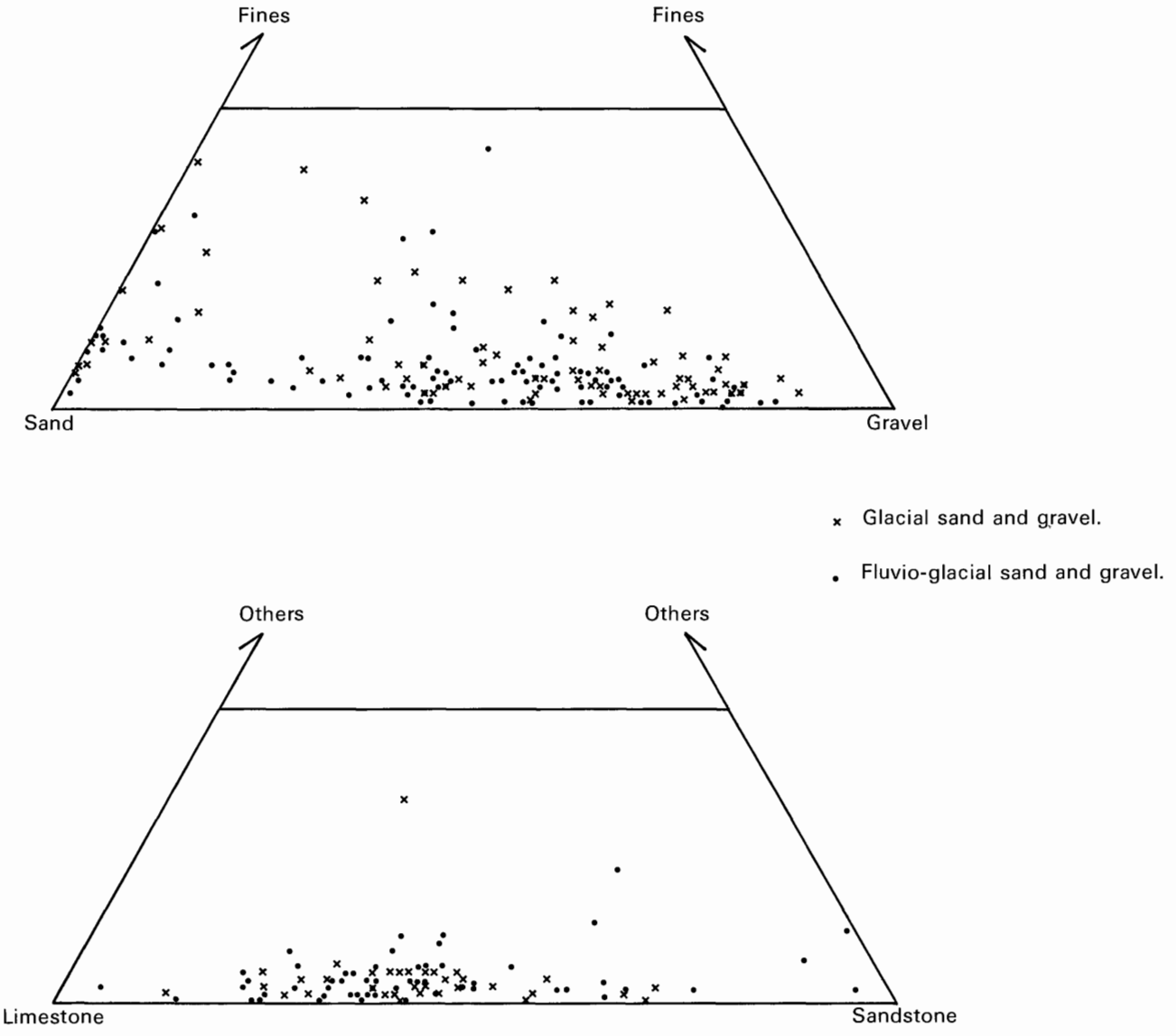


Figure 5 Variation of grading and of the composition of the gravel (+4 mm) fraction of individual samples from both glacial and fluvio-glacial sand and gravel deposits.

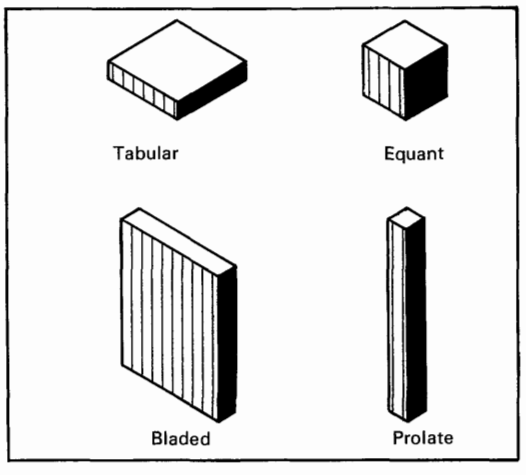


Figure 6 Classification of grain and pebble shapes (after Zingg, 1935).

Sand of the Glacial Lake Deposits The glacial lake deposits to the south and east of Bedale contain sporadic thin bands of sand. However, only IMAU borehole NE 32 found a potentially workable deposit; it consists almost entirely of fine-grained sand composed of quartz with lithic grains.

River Terrace Deposits Only three IMAU boreholes were drilled into river terraces, and these were sited in the valley of the River Ure. The terraces consist of reworked fluvio-glacial sand and gravel with a mean grading of fines 5 per cent, sand 35 per cent and gravel 60 per cent. The coarse sand always dominates the medium and fine and is composed of lithic grains and quartz. Coarse gravel content is greater than that of fine, which in turn exceeds that of the cobbles. The gravel consists mainly of Carboniferous limestone with subordinate sandstone, chert, mudstone and ironstone.

Small areas of terrace deposits associated with Bedale Beck have not been investigated.

The Map

The sand and gravel resource map is folded into the pocket at the end of this report. The base map is the

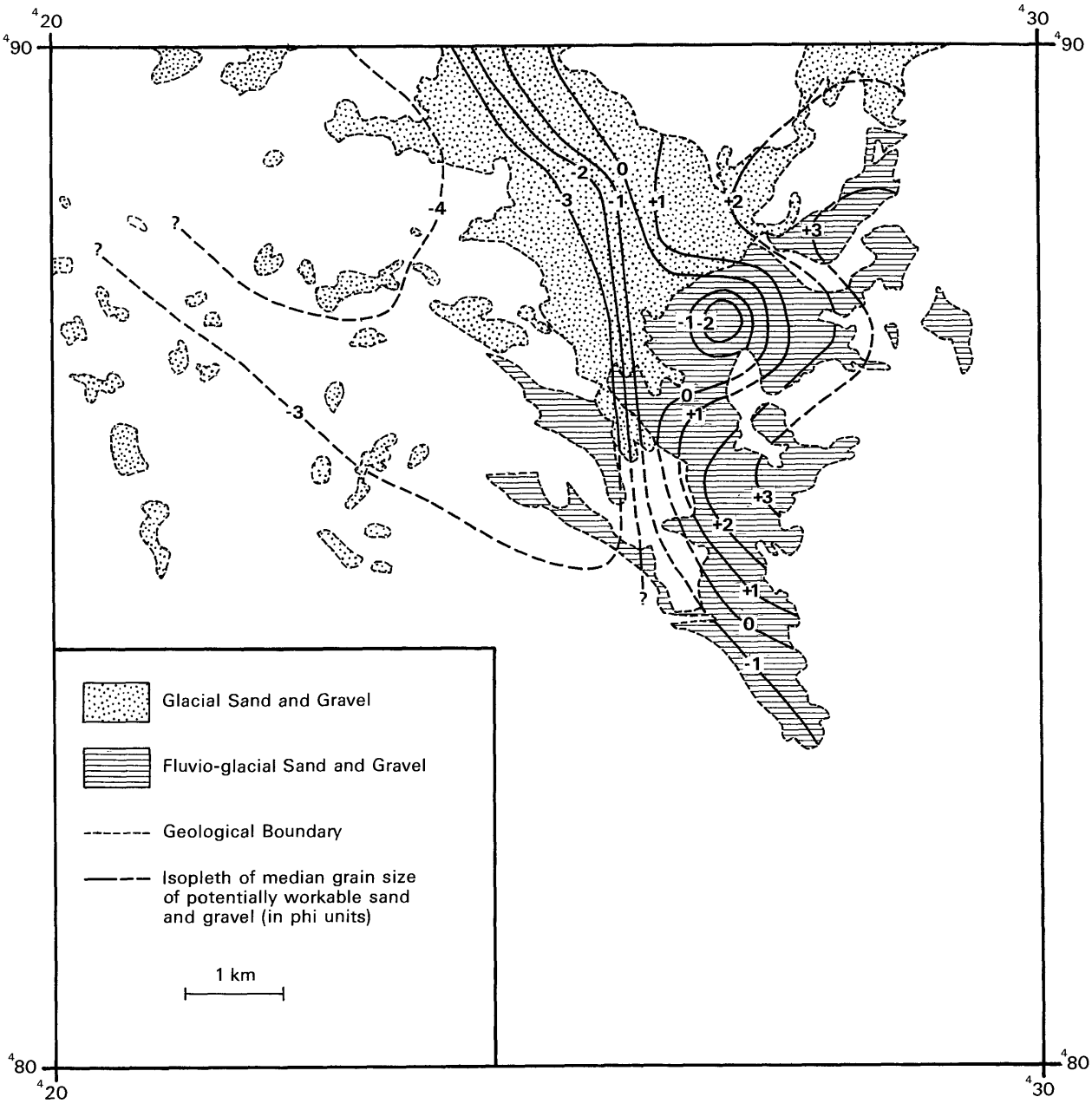


Figure 7 Isopleth diagram showing the median grain size of the mineral bearing deposits associated with the readvance of the Wensleydale glacier.

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 surveyeyd recently at the scale of 1:10 560. This infomation was obtained by detailed application of field mappping 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

Table 4 The sand and gravel resources of the district.

Block	Deposit	Area		Mean thickness			Volume of mineral			Mean grading percentages		
		Block	Mineral	Over-burden	Mineral	Waste		Limit at the 95 % probability		Fines $-\frac{1}{16}$	Sand $+\frac{1}{16}-4$	Gravel +4 mm
		km^2	km^2	m	m	m	$m^3 x 10^6$	± %	$\pm m^3 x 10^6$			
A	Glacial Sand and Gravel	24.7	2.0	0.6	6.4		13	speculative		6	30	64
B	Glacial Sand and Gravel	14.6	7.8	2.3	8.6	1.2	67	29	19	8	55	37
	Glacial Lake Deposits	14.6	0.8		1.6		1	speculative		No details available		
C	Fluvio-glacial Sand and Gravel	28.4	10.6	0.8	6.4	0.6	68	47	32	8	49	43
D	Fluvio-glacial Sand and gravel	12.1	5.9	1.7	13.0	2.0	77	25	19	6	53	41
	River Terrace Deposits	12.1	1.0	1.5	4.4		4	speculative		5	35	60

Table 5 Block A: data from the assessment boreholes.

Borehole	Recorded thickness (m)			Mean grading percentage						
	Over-burden	Mineral	Waste	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}-1$ mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles +64 mm
NW 11	9.0	8.2	-	4	4	8	15	19	23	27
NW 16	0.1	1.9	-	9	7	7	10	18	32	17
NW 18	7.0	7.0	-	4	4	4	12	19	46	11
NW 19	1.2	7.3+	-	9	10	11	12	14	25	19
NW 20	0.5	10.1	-	7	7	16	16	19	26	9

Boreholes NW 9, 10, 13, 14, 17, 21, 22, 23, 25, 26, 27 and 28 did not prove mineral.

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 results of the assessment are summarised in Table 4. Fuller grading particulars are shown in Figure 8 and Tables 5 to 8.

Accuracy of results The major sand and gravel resources of blocks B, C and D, namely glacial and fluvio-glacial sand and gravel, have been assesed statistically. For the glacial sand and gravel of block A, the glacial lake sands of block B and the river terrace deposits in block D only infered assessments have been attempted. For the statistical assessments, the accuracy of the results at the 95 per cent probability level (that is, on average nineteen out of every twenty sets of limits constructed in this way contain the true value for the volume of mineral) varies between 25 per cent and 47 per cent (Appendix B). However, the true volumes are more likely to be nearer the figure estimated than either of the limits. Moreover, it is probable that roughly the same percentage limits would apply for the statistical estimate of mineral volume within a very much smaller parcel of ground (say 100 hectares) containing similar sand and gravel deposits, if the results from the same number of sample points (as provided by, say, ten boreholes) were used in the calculation. Thus, if closer limits are needed for quotation of reserves, data from more sample points would be required, even if the area were quite small. This point can be illustrated by considering the whole of the statistically assessed potentially workable sand and gravel in Blocks B to D. The total volume (212 million m^3) can be estimated to limits of ± 20 per cent at the 95 per cent probability level by a calculation based on data from 35 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.

Table 6 Block B: data from the assessment boreholes and exposure records.

Borehole	Recorded thickness (m)			Mean grading percentage						
	Over-burden	Mineral	Waste	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles +64 mm
NW 12	2.0	4.0+		2	3	7	19	21	34	14
NW 15	5.0	8.3		5	7	13	14	17	32	12
NE 17	3.6	14.4	5.2	7	18	18	17	22	17	1
NE 19	1.6	6.4		7	37	54	2	0	0	0
NE 20	3.2	3.3		2	4	14	19	28	30	3
NE 21	6.7	13.0		6	36	25	11	11	8	3
NE 25	1.3	4.0		6	5	8	14	23	32	12
NE 26	1.0	10.0	2.9	17	19	12	15	14	16	7
NE 31	1.4	11.1	6.5	10	16	17	20	19	13	5
NE 35	2.0	7.0		12	50	9	5	4	14	6
NE E1	0.2	11.8		No data available						

Boreholes NE 18 and NE 24 did not prove potentially workable sand or gravel.

Notes on Resource Blocks

Geological criteria have been used to designate the boundaries of the resource blocks. Block A includes many, mainly small, isolated patches of glacial sand and gravel. Block B encompasses more continuous spreads of glacial mineral, largely beneath overburden, but also includes small areas of glacio-lacustrine sand. Fluvio-glacial sand and gravel constitutes the whole of the mineral in block C and most of that in block D. The latter also includes some glacial sand and gravel and potentially workable river terrace deposits.

The cuesta of the Lower Magnesian Limestone between Well and Masham is partly covered by till and head with only a few small patches of glacial sand and gravel. The whole area is assumed to be devoid of potentially workable material and has been excluded from the resource blocks.

Block A The area included in this block consists of an undulating upland which is mainly covered by till up to 22.9 m thick. Small areas of Namurian and Permian strata outcrop through the till. Glacial sand and gravel is present at the surface in numerous, mainly small, isolated patches. Borehole evidence suggests that in places sand and gravel exists beneath till but also indicates that it does not form extensive sheets, at least not within potentially workable depth. Without much more investigation, which could not be justified by an assessment at the indicative level, the distribution of mineral cannot be conjectured. The presence of glacial sand and gravel is therefore only indicated on the resource map where it has been mapped at surface.

Of the 17 boreholes drilled for IMAU, only five found potentially workable sand and gravel. Three of these, NW 16, 19, and 20, were sited on isloated hills of sand and gravel and proved 1.9 m, 7.3 m and 10.1 m of mineral respectively. Boreholes NW 11 and 18, sited on till, found 8.2 m and 7.0 m respectively of mineral beneath thick overburden but the lateral extent of the deposits is not known. All the potentially workable material proved consists of gravel, with a mean grading of fines 6 per cent, sand 30 per cent and gravel 64 per cent (including 16 per cent of cobbles).

Because of the lack of continuty across the block and lack of information about mineral distribution, an assessment of resources must be extremely speculative. The mineral volume is tentatively estimated at about 13 million m^3.

Block B The undulating scenery of block A is replaced eastwards by a landscape dominated by a series of sub-parallel drainage channels which trend from west-north-west to east-south-east, separated from each other by a group of similarly aligned drift ridges. Except for a small amount of sand deposited in a glacial lake near Leeming, the mineral consists of glacial sand and gravel. This ranges in thickness from 3.3 m to 14.4 m, with a mean thickness of 8.6 m. Its mean grading is fines 8 per cent, sand 55 per cent and gravel 37 per cent (including 5 per cent of cobbles) but there is considerable lateral variation (see Figure 8). Gravel normally predominates. However, borehole NE 19, north-east of Bedale, proved only sand and NE 35, in the south-east of the block, yielded sand, 'clayey' pebbly sand and gravel. A sandy till, which has not been mapped separately, overlies the mineral; it is up to 6.7 m thick but averages only 2.3 m. Waste partings totalling 5.2 m, 2.9 m and 6.5 m respectively were encountered in boreholes NE 17, 26 and 31. The estimated volume of glacial sand and gravel in the block is 67 million $m^3 \pm 29$ per cent.

The small area of glacial lake sand near Leeming is proved by two wells (NE 1 and 4) which recorded 1.8 m and 1.5 m of sand respectively. A speculative estimate of the volume of potentially workable mineral in this deposit is 1 million m^3.

Block C This block occupies the low lying area in the east of the district, and stretches from Bedale in the north to Nosterfield in the south. An elevated, featureless, till-covered tract around Langwith House separates the relatively low lying area of Snape Mires, which is fringed by sand and gravel on the north and west sides, from the flat sand and gravel terrace east of Nosterfield. All the potentially workable mineral in this block is classified as fluvio-glacial in origin but some of the sands at depth may have been deposited in a glacial lake. There are a number of small isolated deposits of glacial sand and gravel, glacio-lacustrine sand and river terrace deposits but they are deemed too small to be included in the assessment.

Potentially workable fluvio-glacial sand and gravel was proved by seven IMAU boreholes which were drilled into outwash fans and sandur deposits fringing Snape Mires. They range in thickness from 1.5 m to 14.6 m, with a mean of 5.4 m. Their mean grading is fines 11 per cent, sand 51 per cent and gravel 38 per cent (including 5 per cent of cobbles). However, there is a considerable variation in grade in this part of the block. Gravel totalling 14.6 m in thickness was found in borehole NE 30 near the western limit of the block but elsewhere it is much thinner and may be associated with sand and pebbly sand. Overburden is normally thin except at borehole NE 30 where 3.5 m of clay are present. Thin waste partings were found in boreholes NE 22 and 30 and

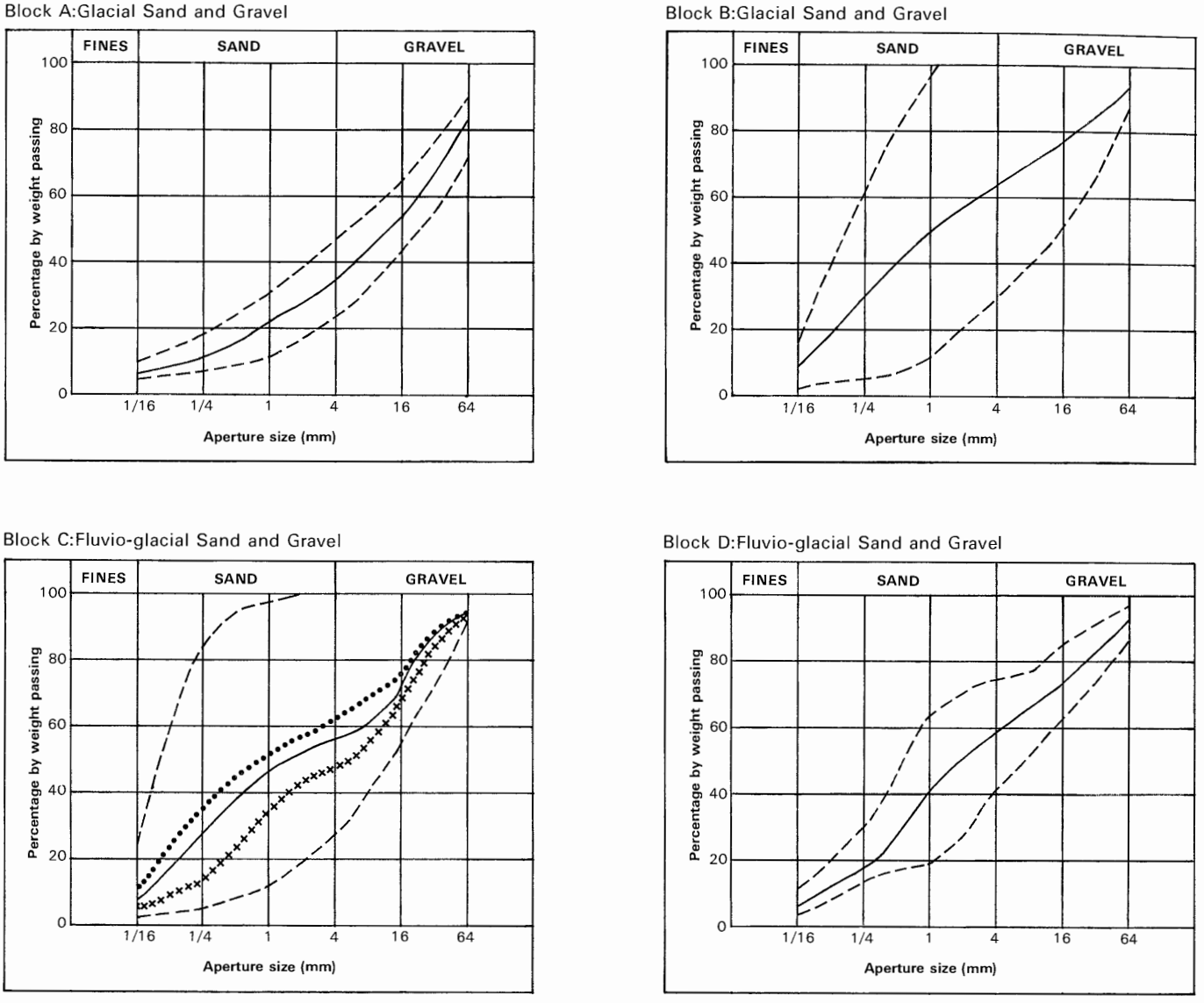


Figure 8 Grading characteristics of some of the mineral in the resource blocks.

a thicker, 3.9 m, parting was recorded in NE 37. Potentially workable sand and gravel occupies an area of 7.3 km^2 in this part of the block and has an estimated volume of 39 million m^3 ± 93 per cent. The large value for the confidence limits is a measure of the variability in thickness of these deposits.

The flat sand and gravel terrace east of Nosterfield was considered by Raistrick (1926) to be an outwash terrace related to a moraine across the Ure valley south of Masham. The terrace is more extensive to the south, where it has been included in the assessment of the West Tanfield district (Strong, *in prep.*). Four IMAU boreholes and information from the restored quarry west of Nosterfield have been used in the assessment of this terrace. The mean thickness of mineral is 7.7 m but a range between 3.8 m and 12.5 m was recorded. The mean grading is fines 4 per cent, sand 45 per cent and gravel 51 per cent (including 5 per cent of cobbles). Thin soil is the only overburden recorded. Waste partings 0.5 m and 1.6 m thick, composed of stony clay, were found in boreholes SE 26 and 27, respectively. In this district the terrace extends to 3.3 km^2 and it is estimated to contain 25 million m^3 ± 55 per cent of mineral.

Borehole NE 32 proved 2.8 m of 'clayey' sand within the lake clays. However, the lateral extension of this deposit is not known and consequently it has not been included in the assessment.

Assessed potentially workable sand and gravel in block C, when considered as a whole, has a mean thickness of 6.4 m, extends over an area of 10.6 km^2 and has an estimated volume of 68 million m^3 ± 47 per cent. Its mean grading is fines 8 per cent, sand 49 per cent and gravel 43 per cent (including 5 per cent of cobbles) but there is considerable lateral variation (see Figure 8).

Block D This block encompasses potentially workable fluvial and fluvio-glacial deposits in the valleys of the River Ure and its tributary the Burn, together with minor contiguous areas of glacial mineral. There are a number of patches of glacial sand and gravel west of Masham. These have limited extent at the surface and although, at least in places, the sand and gravel extends beneath till (see borehole SW 18) their distribution cannot be inferred with any confidence. They are therefore, not included in the assessment.

Fluvio-glacial sand and gravel fills a deeply incised channel which is at least partly till floored. Together with an overlying variably stony clay they form a broad undulating plain in the bottom of the Ure valley. The limit of this mineral deposit beneath cover in the west has been inferred on the basis of borehole evidence supplemented by topographic and outcrop information.

Eight IMAU boreholes proved fluvio-glacial sand and gravel; it is also recorded in two exposures. Mineral is generally between 10.8 m and 20.8 m thick but, exceptionally, in borehole SW 10 a total of only 4.8 m

Table 7 Block C: data from the assessment boreholes

Borehole	Recorded thickness (m)			Mean grading percentage						
	Over-burden	Mineral	Waste	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles +64 mm
NE 22	0.3	4.3	0.2	23	61	8	2	4	2	0
NE 23	0.5	1.5		24	50	24	2	0	0	0
NE 27	0.9	2.7		5	5	18	20	18	30	4
NE 30	3.5	14.6	0.1	4	6	12	16	20	31	11
NE 32	5.2	2.8		16	83	1	0	0	0	0
NE 36	1.2	2.4		2	3	8	14	34	37	2
NE 37	0.9	10.7	3.9	18	46	22	4	5	5	0
SE 18	0.3	1.7		9	12	20	18	24	17	0
SE 24	0.2	3.8		8	15	16	10	23	28	0
SE 25	0.3	6.2		6	11	24	13	29	17	0
SE 26	0.3	9.2	0.5	5	19	28	10	14	20	4
SE 27	0.4	12.5+	1.6	2	4	19	14	18	35	8

Additional information from the restored quarry near Nosterfield has been used in the assessment. Boreholes NE 28, 29, 33, 34, and 38, and SE 16, 17, 19, 20, 21, 22 and 23 did not prove mineral.

Table 8 Block D: data from the assessment boreholes and exposure records.

Borehole	Recorded thickness (m)			Mean grading percentage						
	Over-burden	Mineral	Waste	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles +64 mm
NW 24	2.5	8.0		4	7	12	17	22	25	13
SW 8	2.4	16.0	6.6	4	19	40	11	11	10	5
SW 9	2.1	10.8		10	5	13	24	21	20	7
SW 10	1.2	4.8	1.1	8	20	22	11	11	21	7
SW 11	4.3	12.9		4	10	16	19	19	24	8
SW 12	1.0	12.7	6.0	5	11	19	18	20	24	3
SW 13	1.2	12.6		5	5	10	22	20	26	12
SW 14	0.4	17.2	5.8	6	8	22	20	20	20	4
SW 15	1.7	20.8	0.5	7	23	31	11	10	14	4
SW 16	0.8	2.8		6	6	8	12	21	35	12
SW 18	2.8	2.6		16	17	15	6	9	20	17
SW 19	1.0	2.4		6	10	15	19	21	22	7
SW E1	0.9	11.6		No details available						
SW E2		10.8		No details available						

Borehole SW 17 did not prove mineral.

was recorded. The mean proved thickness of potentially workable fluvio-glacial sand and gravel is 13.0 m. The mean grading is fines 6 per cent, sand 53 per cent and gravel 41 per cent (including 6 per cent of cobbles). Gravel predominates but at a number of sites is underlain by sand and pebbly sand. Overburden ranges from 0.4 m to 4.3 m in thickness and waste partings up to 6.6 m thick are recorded in this deposit. The estimated volume of fluvio-glacial sand and gravel in the block is 77 million $m^3 \pm 25$ per cent.

River terraces flank the present course of the rivers Ure and Burn. Three IMAU boreholes drilled into the terraces of the Ure proved mineral 2.4 m, 2.8 m and 8.0 m thick, although the lower part of the last may in fact be of fluvio-glacial origin. A speculative estimate of the volume of sand and gravel in the river terraces is 4 million m^3 and the mean grading is fines 5 per cent, sand 35 per cent and gravel 60 per cent (including 12 per cent of cobbles). Overburden consisting of soil and sandy clay may be up to at least 2.5 m thick.

REFERENCES

ALLEN, V. T. 1936. Terminology of medium-grained sediments. **Rep. Natl. Res. Counc., Washington, 1935-1936, App. 1, Rep. Comm. Sediment.**, 18-47.

ARCHER, A. A. 1969. Background and problems of an assessment of sand and gravel resources in the United Kingdom. **Proc. 9th Commonw. Min. & Metall. Congr., 1969**, Vol. 2: Mining and petroleum geology, 495-508.

— 1970a. Standardisation of the size classification of naturally occurring particles. **Geotechnique**, Vol. 20, 103-107.

— 1970b. Making the most of metrication. **Quarry Managers' J.**, Vol. 54, No. 6, 223-227.

ATTERBERG, A. 1905. Die rationelle Klassifikation der Sande und Kiese. **Chem. Z.**, Vol. 29, 195-198.

BRITISH STANDARDS INSTITUTION. 1967. **B.S.1377: Methods of testing soils for civil engineering purposes.** (London: British Standards Institution.)

— 1975. **B.S. 812: Methods of testing for mineral aggregates, sands and fillers.** (London: British Standards Institution.)

BUREAU OF MINES AND GEOLOGICAL SURVEY. 1948. **Pp. 14-17** in **Mineral resources of the United States.** (Washington, DC: Public Affairs Press.)

HARRIS, P. M., THURRELL, R. G., HEALING, R. A., and ARCHER, A. A. 1974. Aggregates in Britain. **Proc. R. Soc.**, Ser. A, Vol. 339, 329-353.

HULL, J. H. 1981. Methods of calculating the volume of resources of sand and gravel. **Appendix** (pp. 192-193) to **THURRELL, R. G.** 1981. Quarry resources and reserves: the identification of bulk mineral resources: the contribution of the Institute of Geological Sciences. **Quarry Management**, for March 1981, 181-193.

JOHNSON, P. G. 1969. The glacial influence on the relief of part of the western side of the Vale of York. Unpub. PhD thesis, University of Leeds.

— 1974. Evidence for abandoned river courses in the west of the Vale of York. **Proc. Yorkshire Geol. Soc.**, Vol 40, 223-232

LANE, E. W., and others. 1947. Report of the sub-committee on sediment terminology. **Trans. Am. Geophys. Union**, Vol. 28, 936-938.

PATTISON, J. 1978. Upper Permian palaeontology of the Aiskew Bank Farm Borehole, north Yorkshire. **Rep. Inst. Geol. Sci.**, No 78/14.

PETTIJOHN, F. J. 1975. **Sedimentary rocks.** 3rd edition. (London: Harper and Row.)

RAISTRICK, A. 1926. The glaciation of Wensleydale, Swaledale and adjoining parts of the Pennines. **Proc. Yorkshire Geol. Soc.**, Vol 20, 366-411.

THURRELL, R..G. 1971. The assessment of mineral resources with particular reference to sand and gravel. **Quarry Managers' J.**, Vol. 55, 19-25.

— 1981. Quarry resources and reserves: the identification of bulk mineral resources: the contribution of the Institute of Geological Sciences. **Quarry Management**, for March 1981, 181-193.

TWENHOFEL, W. H. 1937. Terminology of the fine-grained mechanical sediments. **Rep. Natl. Res. Counc., Washington, 1936-37**, App. 1, Rep. Comm. Sediment., 81-104.

UDDEN, J. A. 1914. Mechanical composition of clastic sediments. **Bull. Geol. Soc. Am.**, Vol. 25, 655-744.

WENTWORTH, C. K. 1922. A scale of grade and class terms for clastic sediments. **J. Geol.**, Vol. 30, 377-392.

— 1935. The terminology of coarse sediments. **Bull. Natl. Res. Counc. Washington**, No. 98, 225-246.

WILLMAN, H. B. 1942. Geology and mineral resources of the Marseilles, Ottawa and Streator quadrangles. **Bull. Illinois State Geol. Surv.**, No. 66, 343-344.

ZINGG, TH. 1935. Beiträge zur Schotteranalyse. **Min. Petrog. Mitt. Schweiz.**, Vol 15, 39-140.

WP/KW/LKW.

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.

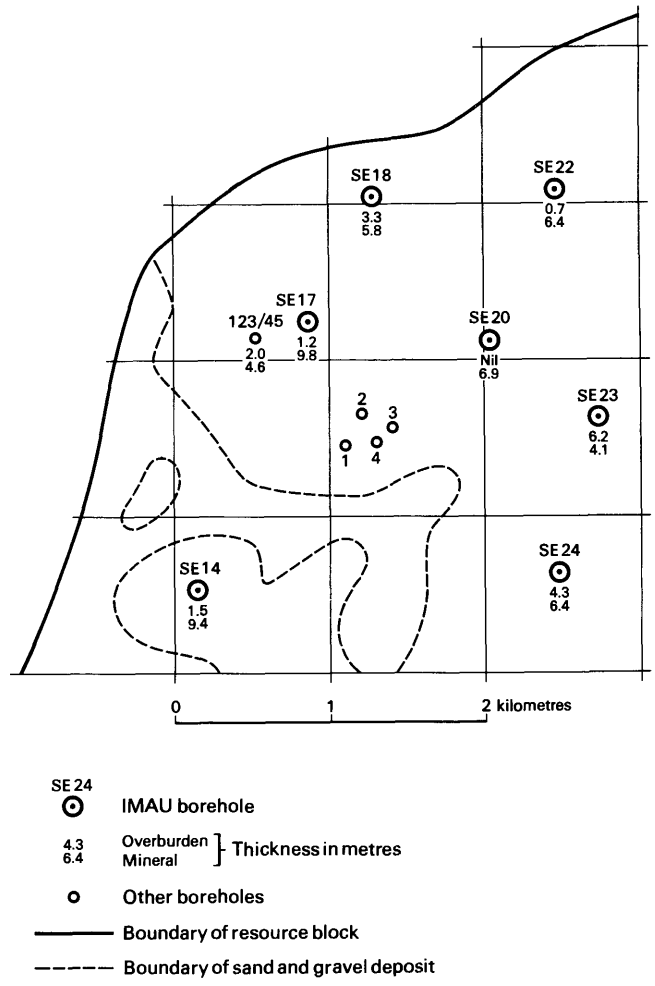
The drilling machine employed should be capable of providing a continuous sample representative of all unconsolidated deposits, so that the in-situ grading can be determined, if necessary, to a depth of 30 m (100 ft) at a diameter of about 200 mm (8 in), beneath different types of overburden. It should 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: not original faces, edges or corners left. The entire surface consists of broad curves; flat areas are absent. The original shape is suggested by the present form of the grain.

Classification of gravel, sand and fines

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

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

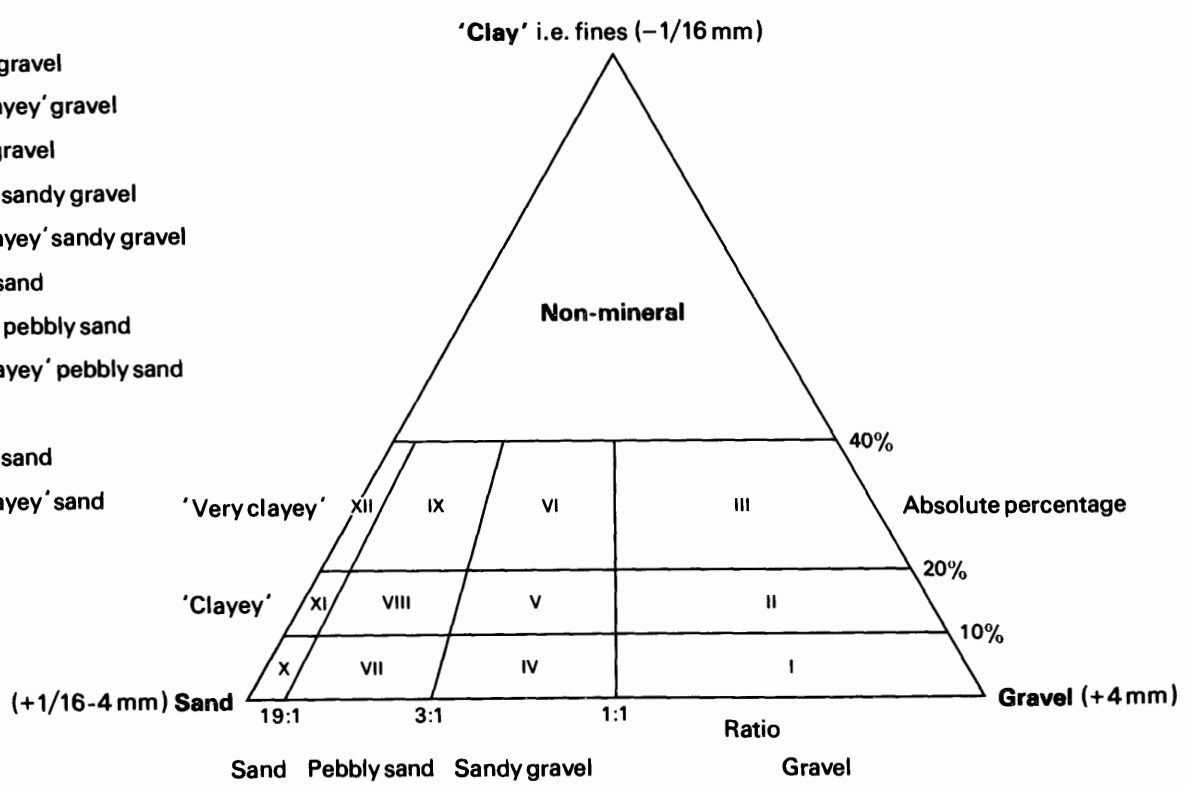


Diagram showing the descriptive categories used in the classification of sand and gravel

APPENDIX D

EXPLANATION OF THE BOREHOLE RECORDS

SE 28 NW 11[1] **2346 8951**[2] **Mudfield**[3] **Block A**

Surface level +64.5 m[4]
Water struck at +58.1 m[5]
November 1980[6]

Overburden[7] 9.0 m
Mineral 8.2 m
Waste 5.0 m+[8]

LOG

Geological classification	Lithology[9]	Thickness m	Depth m
	Soil	0.3	0.3
Till	Stony clay, yellowish brown changing to grey at 0.9 m, sandy, with pebbles and cobbles of Carboniferous limestone and sandstone	8.7	9.0
Glacial Sand and Gravel	Gravel Gravel: cobble, angular to rounded, equant, bladed and tabular; Carboniferous limestone and sandstone with some ironstone Sand: coarse, subangular to subrounded; lithic grains with quartz	8.2	17.2
Till	Stony clay, yellowish brown changing to light grey at 17.8 m, sandy, with pebbles of Carboniferous limestone and sandstone	5.0+	22.2

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
4	27	69	9.0-10.0*	2	2	4	12	23	36	21
			10.0-11.0*	2	4	9	18	17	22	28
			11.0-12.0*	13	4	5	12	24	17	25
			12.0-13.0*	6	11	21	14	14	16	18
			13.0-14.0*	2	3	5	13	18	30	29
			14.0-15.0*	1	4	8	13	17	29	28
			15.0-16.0*	2	4	8	17	20	20	29
			16.0-17.2*	2	4	8	17	18	19	32
			Mean	4	4	8	15	19	23	27

COMPOSITION[11]

Depth below surface (m)	Percentages by weight in +4 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
9.0-10.0	85	14	0	0	0	trace	1	0
10.0-11.0	69	28	0	0	0	0	3	0
11.0-12.0	73	23	trace	0	0	0	4	0
12.0-13.0	59	41	trace	0	0	0	trace	0
13.0-14.0	72	27	0	0	0	0	1	0
14.0-15.0	74	24	1	0	0	0	1	0
15.0-16.0	54	45	trace	0	0	0	1	0
16.0-17.2	60	39	trace	0	0	0	1	0
Mean	68	30	trace	0	0	trace	2	0

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 SE 28.
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 11.

Thus the full Registration Number is SE 28 NW 11.

2 National Grid Reference
All National Grid References fall in the 100 km square identified by the first two letters of the Registration Number. Grid references are given to eight figures, accurate to within 10 m.

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 250 mm casing. The month and year of completion of the borehole are stated.

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

8 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 gravel (+16-64 mm) and cobble gravel (+64 mm) are stated.

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

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
Lithological analyses were carried out on selected gravel samples. The categories recognised were:
Carboniferous limestone, varying from pure pale carbonate to dark muddy limestones, some of which are partly silicified.
Sandstone, mainly Carboniferous, fine- to coarse-grained quartzites, arkoses and greywackes.
Chert, Carboniferous, may include some silicified limestone.
Magnesian limestone, mainly dolomites of Upper Permian age.
Mudstone and shale, locally-derived Carboniferous material.
Quartz.
Ironstone.
Coal.

APPENDIX E

INDUSTRIAL MINERALS ASSESSMENT UNIT BOREHOLE AND EXPOSURE RECORDS

SE 28 NW S9 **2151 8980** **Newton le Willows** **Block A**

Surface level +67.8 m
Water not encountered
November 1980

Waste 12.1 m
Bedrock 1.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.7	0.7
Till	Stony clay, yellowish brown changing to dark grey at 5.8 m, sandy with pebbles, cobbles and boulders of Carboniferous limestone and sandstone	8.7	9.4
	Clay, dark grey, containing numerous fragments of weathered mudstone	2.7	12.1
Namurian	Mudstone, dark grey	1.9+	14.0

SE 28 NW 10 **2258 8915** **Hill Top East** **Block A**

Surface level +80.9 m
Water level not recorded
September 1980

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Stony clay, reddish brown changing to grey at 3.0 m, sandy, with pebbles, cobbles and sporadic boulders of Carboniferous limestone and sandstone: thin bands of 'very clayey' gravel below 5.5 m	17.9+	18.0

SE 28 NW 11 **2346 8951** **Mudfield** **Block A**

Surface level +64.5 m
Water struck at +58.1 m
November 1980

Overburden 9.0 m
Mineral 8.2 m
Waste 5.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Stony clay, yellowish brown changing to grey at 0.9 m, sandy, with pebbles and cobbles of Carboniferous limestone and sandstone	8.7	9.0
Glacial Sand and Gravel	Gravel Gravel: cobble, angular to rounded, equant, bladed and tabular; Carboniferous limestone and sandstone with some ironstone Sand: coarse, subangular to subrounded; lithic grains with quartz	8.2	17.2
Till	Stony clay, yellowish brown changing to light grey at 17.8 m, sandy, with pebbles of Carboniferous limestone and sandstone	5.0+	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
4	27	69	9.0-10.0*	2	2	4	12	23	36	21
			10.0-11.0*	2	4	9	18	17	22	28
			11.0-12.0*	13	4	5	12	24	17	25
			12.0-13.0*	6	11	21	14	14	16	18
			13.0-14.0*	2	3	5	13	18	30	29
			14.0-15.0*	1	4	8	13	17	29	28
			15.0-16.0*	2	4	8	17	20	20	29
			16.0-17.2*	2	4	8	17	18	19	32
			Mean	4	4	8	15	19	23	27

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
9.0-10.0	85	14	0	0	0	trace	1	0
10.0-11.0	69	28	0	0	0	0	3	0
11.0-12.0	73	23	trace	0	0	0	4	0
12.0-13.0	59	41	trace	0	0	0	trace	0
13.0-14.0	72	27	0	0	0	0	1	0
14.0-15.0	74	24	1	0	0	0	1	0
15.0-16.0	54	45	trace	0	0	0	1	0
16.0-17.2	60	39	trace	0	0	0	1	0
Mean	68	30	trace	0	0	trace	2	0

SE 28 NW 12 **2422 8944** **Great Crakehall** **Block B**

Surface level +56.0 m
Water not encountered
October 1980

Overburden 2.0 m
Mineral 4.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	Stony clay, yellowish brown, sandy, with pebbles and cobbles of Carboniferous limestone and sandstone	1.8	2.0
	Gravel Gravel: coarse, angular to subrounded, equant and tabular sandstone and subangular to rounded, equant, bladed and prolate Carboniferous limestone Sand: coarse, angular to rounded, equant; quartz and lithic grains	4.0+	6.0
	Borehole abandoned due to drilling difficulties		

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	29	69	2.0-3.0*	2	3	9	19	17	28	22
			3.0-4.0*	2	2	4	13	18	36	25
			4.0-6.0	2	4	8	22	23	37	4
			Mean	2	3	7	19	21	34	14

SE 28 NW 13 **2107 8838** **Ashley Hill** **Block A**

Surface level +131.0 m
Water struck at +127.1 m
November 1980

Waste 8.4 m
?Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Stony clay, yellowish brown changing to grey at 6.5 m, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone	8.3	8.4
Namurian	Sandstone, yellowish brown (bedrock or boulder?)	0.5+	8.9

SE 28 NW 14 **2344 8849** **Cowling Whins** **Block A**

Surface level +87.6 m
Water not encountered
November 1980

Waste 14.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, yellowish brown changing to grey at 1.0 m, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone; thin band of gravel at 8.7 m	14.3+	14.5
	Borehole abandoned because of boulder obstruction		

SE 28 NW 15 **2490 8854** **High Scroggs House** **Block B**

Surface level +55.6 m
Water struck at +49.1 m
November 1980

Overburden 5.0 m
Mineral 8.3 m
Waste 7.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	Clay, brown, sandy, pebbly below 1.3 m; thin band of 'clayey' sand at 1.2 m	4.8	5.0
	Gravel Gravel: coarse, angular to rounded, equant sandstone and subangular to rounded, equant and bladed Carboniferous limestone with some ironstone Sand: coarse, angular to rounded, equant; lithic grains and quartz	8.3	13.3
Till	Stony clay, grey, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone; seam of gravel between 16.5 m and 17.1 m	7.2+	20.5
	Borehole abandoned due to 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
5	34	61	5.0-7.0*	4	5	7	11	8	45	20
			7.0-8.0	3	4	12	19	21	34	7
			8.0-9.0	1	5	12	14	17	26	25
			9.0-10.0*	17	8	26	9	11	27	2
			10.0-11.0*	3	10	17	22	29	18	1
			11.0-13.3*	5	9	12	15	20	29	10
			Mean	5	7	13	14	17	32	12

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
8.0-9.0	43	56	0	0	0	0	1	0

SE 28 NW 16 **2148 8748** **High Pond House** **Block A**

Surface level c+124.5 m
Water struck at +122.5 m
September 1980

Overburden 0.1 m
Mineral 1.9 m
Waste 13.0 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial Sand and Gravel	Gravel Gravel: coarse, angular to rounded, equant and bladed Carboniferous limestone and subangular to rounded, equant sandstone with some ironstone Sand: coarse, subangular to rounded, equant; lithic grains and quartz	1.9	2.0
Till	Stony clay, grey, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone	13.0	15.0
Namurian	Sandstone	0.5+	15.5

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
9	24	67	0.1-1.1*	14	10	8	9	14	30	15
			1.1-2.0*	5	3	5	11	22	35	19
			Mean	9	7	7	10	18	32	17

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
1.1-2.0	55	43	0	0	0	trace	2	0

SE 28 NW 17 **2258 8758** **Low Pond House** **Block A**

Surface level +112.4 m
Water level not recorded
November 1980

Waste 16.3 m
?Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, yellowish brown changing to grey at 1.0 m, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone; bands of sandy gravel below 13.4 m	16.1	16.3
Namurian	Sandstone, brown (bedrock or boulder?)	0.5+	16.8

SE 28 NW 18 **2324 8778** **Cowling Manor House** **Block A**

Surface level +111.2 m
Water level not recorded
November 1980

Overburden 7.0 m
Mineral 7.0 m
Waste 2.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Stony clay, brown becoming grey at 1.6 m, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone	6.7	7.0
Glacial Sand and Gravel	Gravel, with band of stony clay between 11.3 m and 11.6 m Gravel: coarse, well rounded to subrounded, equant and bladed; Carboniferous limestone and sandstone with some ironstone and chert Sand: coarse; quartz with lithic grains	7.0	14.0
Till	Stony clay, dark grey, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone	2.0+	16.0
	Borehole abandoned due to 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
4	20	76	7.0-8.0*	6	6	6	14	14	32	22
			8.0-9.0*	7	5	4	13	24	46	1
			9.0-10.0*	2	4	3	4	12	59	16
			10.0-11.6*	4	4	3	5	24	51	9
			11.6-12.6*	3	4	4	9	18	50	12
			12.6-14.0*	5	5	5	23	21	32	9
			Mean	4	4	4	12	19	46	11

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
10.0-11.6	50	46	1	0	0	0	3	0

SE 28 NW 19 **2417 8719** **Burrill** **Block A**

Surface level +91.7 m
Water not encountered
September 1980

Overburden 1.2 m
Mineral 7.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	Stony clay, yellowish brown, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone	1.0	1.2
	Gravel Gravel: coarse, angular to subrounded tabular and equant; Carboniferous limestone, sandstone and Magnesian limestone Sand: coarse, medium and fine, angular to subrounded, equant; quartz and lithic grains	7.3+	8.5
	Borehole abandoned due to drilling difficulties		

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	1.2-2.2*	7	5	4	8	20	26	30	
			2.2-3.2*	4	3	6	15	21	24	27	
			3.2-5.2*	3	5	8	12	20	32	20	
			5.2-7.2*	17	19	19	15	6	16	8	
			7.2-8.5*	9	14	12	8	7	33	17	
			Mean	9	10	11	12	14	25	19	

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
3.2-5.2	45	28	trace	27	0	0	trace	0

SE 28 NW 20 **2076 8625** **Dun Hill** **Block A**

Surface level +110.6 m
Water struck at +102.1 m
August 1980

Overburden 0.5 m
Mineral 10.1 m
Waste 10.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	Clay, yellowish brown, sandy, pebbly	0.3	0.5
	a 'Clayey' gravel Gravel: coarse, subangular to well rounded, equant, bladed and prolate Carboniferous limestone and angular to rounded, equant sandstone with some chert and ironstone Sand: coarse, angular to rounded, equant; lithic grains and quartz	1.7	2.2
	b Gravel Gravel: as above Sand: medium and coarse, angular to rounded, equant, lithic grains and quartz	8.4	10.6
Laminated Clay associated with glacial deposits	Silt, yellowish brown becoming grey below 15.0 m, sandy; thin seam of laminated clay between 14.8 m and 15.0 m	6.5	17.1
Till	Stony clay, grey, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone	4.4+	21.5

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	35	50	0.5-1.5	16	10	13	15	17	29	0
				1.5-2.2*	13	6	10	16	18	30	7
				Mean	15	8	12	15	17	30	3
b	5	40	55	2.2-3.8*	4	4	12	24	22	28	6
				3.8-6.0*	4	6	15	20	19	19	17
				6.0-8.0*	4	4	15	17	23	27	10
				8.0-10.6*	7	12	23	9	16	25	8
				Mean	5	7	17	16	20	24	11
a+b	7	39	54	0.5-10.6	7	7	16	16	19	26	9

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
0.5-1.5	64	31	3	0	0	0	2	0
1.5-2.2	69	30	1	0	0	0	trace	0
Mean	66	31	2	0	0	0	1	0

SE 28 NW 21 **2178 8611** **Thirn** **Block A**

Surface level +117.9 m
Water struck at +109.2 m
September 1980

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Stony clay, yellowish brown changing to grey at 3.1 m, silty, with pebbles and cobbles of Carboniferous limestone and sandstone	14.4	14.5
Laminated Clay associated with glacial deposits	Clay, dark grey, laminated; sporadic pebbles	3.5+	18.0

SE 28 NW 22 **2285 8619** **Gospel Hill** **Block A**

Surface level +123.1 m
Water struck at +107.0 m
September 1980

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Stony clay, yellowish brown changing to olive grey at 4.0 m, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone	17.9+	18.0

SE 28 NW 23 **2379 8614** **Thornton Watlass** **Block A**

Surface level +103.2 m
Water not encountered
September 1980

Waste 14.5 m
Bedrock 1.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Stony clay, greyish brown changing to grey at 2.9 m, with pebbles, cobbles and sporadic boulders of Carboniferous limestone, Magnesian limestone and sandstone	14.2	14.5
Upper Permian (undivided)	Dolomitic limestone, brownish yellow	1.2+	15.7

SE 28 NW 24 **2026 8546** **Back Lane** **Block D**

Surface level c+96.0 m
Water level not recorded
August 1980

Overburden 2.5 m
Mineral 8.0 m
Waste 11.3 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
River Terrace Deposits, undifferentiated	Clay, greyish orange, sandy; sporadic pebbles	1.0	1.2
	Clay, yellowish orange with grey mottling, sandy, sporadic pebbles	1.3	2.5
	a Gravel Gravel: coarse, subrounded to rounded, equant Carboniferous limestone and subangular to rounded, equant sandstone with some chert and ironstone Sand: coarse, subangular to rounded, equant quartz and angular to rounded, equant lithic grains	6.5	9.0
	b Sandy gravel Gravel: fine, subangular to rounded, equant; Carboniferous limestone and sandstone Sand: medium, angular to rounded, equant; quartz and lithic grains	1.5	10.5
Till	Stony clay, medium grey, sandy, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone	6.0	16.5
	Clay, medium grey, silty with pebbles of light grey siltstone and sandstone	5.3	21.8
Namurian	Sandstone, light grey	0.2+	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
a	3	30	67	2.5-3.5*	1	1	2	9	23	36	28
				3.5-5.5*	2	3	6	13	22	47	7
				5.5-7.5*	5	11	10	16	14	16	28
				7.5-9.0*	4	8	15	22	31	20	0
				Mean	3	6	9	15	22	30	15
b	5	59	36	9.0-10.5*	5	10	26	23	23	13	0
a+b	4	36	60	2.5-10.5	4	7	12	17	22	25	13

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	2.5-3.5	47	50	2	0	trace	0	1	0
	3.5-5.5	68	30	1	0	0	0	1	0
	5.5-7.5	70	30	0	0	0	0	0	0
	7.5-9.0	68	32	trace	0	0	0	trace	0
	Mean	64	34	1	0	trace	0	1	0

SE 28 NW 25 **2056 8560** **Folly Bridge** **Block A**

Surface level +89.7 m
Water struck at +76.2 m
August 1980

Waste 17.5 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, yellowish brown, sandy, with pebbles of sandstone and Carboniferous limestone below 0.6 m	2.1	2.3
	Silt, dark grey, sandy	0.3	2.6
	Stony clay, grey, sandy, with pebbles of Carboniferous limestone and sandstone; thin bands of 'very clayey' gravel below 13.5 m	14.9	17.5
Namurian	Sandstone, light grey	0.5+	18.0

SE 28 NW 26 **2180 8527** **Clifton Grange Farm** **Block A**

Surface level +119.0 m
Water not encountered
August 1980

Waste 18.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, grey with yellowish brown mottling to 2.0 m; pebbles, cobbles and boulders of Carboniferous limestone sandstone	13.0	13.2
Laminated Clay associated with glacial deposits	Clay, dark brown, laminated, silty	2.4	15.6
Till	Stony clay, dark brown, with pebbles, cobbles and boulders of Carboniferous limestone sandstone and mudstone	3.2+	18.8

SE 28 NW 27 **2258 8567** **Thirn Moor House** **Block A**

Surface level +128.1 m
Water struck at +116.5 m
September 1980

Waste 11.6 m
Bedrock 1.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Stony clay, yellowish brown, sandy, with pebbles, cobbles and boulders of sandstone and Carboniferous limestone; thin band of 'clayey' gravel at 8.8 m	11.3	11.6
Namurian	Sandstone, yellow	1.4+	13.0

SE 28 NW 28 **2319 8533** **Village Farm** **Block A**

Surface level +122.8 m
Water not encountered
August 1980

Waste 5.3 m
Bedrock 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Stony clay, greyish brown changing to olive grey at 2.6 m, with pebbles, cobbles and boulders of Carboniferous limestone and sandstone	5.0	5.3
Upper Permian (Undivided)	Dolomite, yellow	1.5+	6.8

SE 28 NE 17 **2516 8921** **Casling Hill** **Block B**

Surface level +55.3 m
Water level not recorded
October 1980

Overburden 3.6 m
Mineral 2.3 m
Waste 2.6 m
Mineral 2.6 m
Waste 2.6 m
Mineral 9.5 m
Waste 1.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	Clay, yellowish brown, sandy; pebbles and cobbles of Carboniferous limestone and sandstone between 0.2 m and 1.7 m	2.7	2.9
	'Very clayey' gravel Gravel: coarse, angular to subrounded, equant; Carboniferous limestone and sandstone Sand: medium, subangular to rounded, equant; quartz and lithic grains	0.5	3.4
	Clay, yellowish brown, sandy, pebbly	0.2	3.6

a 'Very clayey' pebbly sand Gravel: coarse, angular to subrounded, equant; Carboniferous limestone and sandstone Sand: fine, subrounded to rounded, equant; quartz and lithic grains	2.3	5.9
Clay, yellowish brown, silty, laminated	2.6	8.5
b Gravel Gravel: fine and coarse, angular to subrounded, equant, prolated and bladed; Carboniferous limestone with sandstone and some ironstone and shale Sand: coarse, subangular to rounded, equant; quartz and lithic grains	2.6	11.1
Clay, dark grey, sandy, pebbly, with thin bands of gravel	2.6	13.7
c Sandy gravel Gravel: fine, angular to rounded, equant and bladed; Carboniferous limestone and sandstone with some ironstone and chert Sand: medium, angular to rounded, equant; lithic grains and quartz Fines: sporadic thin bands of laminated clay between 13.7 m and 15.7 m and at 21.4 m and 22.9 m	9.5	23.2
Clay, grey, sandy, pebbly	1.8+	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	21	71	8	3.6-5.9*	21	59	8	4	2	6	0
b	4	32	64	8.5-9.5	No grading data available						
				9.5-11.1*	4	5	7	20	29	28	7
				Mean	4	5	7	20	29	28	7
c	4	54	42	13.7-15.7	3	6	18	28	26	19	0
				15.7-17.7	2	7	17	18	26	27	3
				17.7-19.7	2	16	24	14	25	18	1
				19.7-21.7	6	11	27	18	22	16	0
				21.7-23.2	5	16	31	20	23	5	0
				Mean	4	11	23	20	23	18	1
a+b+c	7	53	40	Mean	7	18	18	17	22	17	1

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
c	13.7-15.7	57	39	trace	0	0	0	4	0
	15.7-17.7	52	45	2	trace	0	0	1	0
	17.7-19.7	61	37	1	0	0	0	1	0
	19.7-21.7	51	47	1	0	0	0	1	0
	21.7-23.2	44	56	trace	0	0	0	trace	0
	Mean	54	43	1	trace	0	0	2	0

SE 28 NE 18 **2658 8954** **Sand Hill House** **Block B**

Surface level c+36.0 m
Water stuck at +15.5 m
October 1980

Waste 22.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Lake Deposits	Clay, dark brown, silty to sandy, with sporadic pebbles, weathered to 2.5 m	8.2	8.5
Till	Stony clay, yellowish brown, pebbles and cobbles of Carboniferous limestone and sandstone	5.0	13.5
	'Very clayey' sand, with thin bands of silt and sporadic pebbles	2.5	16.0
Laminated Clay associated with glacial deposits	Clay brown, silty, weakly laminated	6.0+	22.0

SE 28 NE 19 **2789 8977** **Micklebrack** **Block B**

Surface level +60.7 m
Water struck at +56.1 m
October 1980

Overburden 1.6 m
Mineral 6.4 m
Waste 17.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Glacial Sand and Gravel	Sand: medium, quartz and lithic grains	0.8	1.3
	Clay, grey, silty	0.3	1.6
	Sand: medium, well rounded to subangular, equant; quartz and lithic grains	6.4	8.0
Laminated Clay associated with glacial deposits	Clay, brownish grey, laminated, sandy in part	17.0+	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
7	93	0	1.6-2.6	6	29	58	6	1	0	0
			2.6-3.6	6	29	60	4	1	0	0
			3.6-4.6	6	31	61	2	0	0	0
			4.6-5.6	16	30	52	2	0	0	0
			5.6-6.6	5	46	48	1	0	0	0
			6.6-8.0	6	52	42	0	0	0	0
			Mean	7	37	54	2	0	0	0

SE 28 NE 20 **2537 8845** **Keepers Wood** **Block B**

Surface level c+51.0 m
Water level not recorded
October 1980

Overburden 3.2 m
Mineral 3.3 m
Waste 10.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	Stony clay, yellowish brown, sandy, with pebbles and cobbles of Carboniferous limestone and sandstone	3.0	3.2
	Gravel Gravel: coarse, angular to rounded, equant Carboniferous limestone and angular to subrounded, equant, bladed and prolate sandstone with some ironstone Sand: coarse, subangular to rounded, equant; quartz and lithic grains	3.3	6.5
Glacial Lake Deposits	Silt, olive grey, laminated, sandy	4.5	11.0
	Clay, olive grey, laminated, sandy	0.6	11.6
Till	Stony clay, grey, sandy, with pebbles and cobbles of sandstone and Carboniferous limestone	4.9+	16.5
	Borehole abandoned due to drilling difficulties		

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	37	61	3.2-4.2*	1	3	10	19	28	37	2
			4.2-5.2*	2	2	11	15	25	38	7
			5.2-6.5*	2	7	19	21	31	20	0
			Mean	2	4	14	19	28	30	3

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
4.2-5.2	55	43	trace	trace	0	0	2	0

SE 28 NE 21 **2627 8821** **Bedale** **Block B**

Surface level +51.6 m
Water struck at +42.6 m
September 1980

Overburden 6.7 m
Mineral 13.0 m
Waste 4.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Glacial Sand and Gravel	Clay, mainly yellowish brown but olive grey from 4.2 m to 6.0 m, sandy, with sporadic pebbles and cobbles of Carboniferous limestone and sandstone	6.1	6.7
	a Sandy gravel Gravel: fine, angular to rounded, equant and tabular; sandstone and Carboniferous limestone with some ironstone Sand: coarse, subangular to rounded, equant; quartz and lithic grains Fines: thin band of stony clay at 13.4 m; sporadic bands of laminated silt between 13.6 m and 14.5 m	8.0	14.7
	b Sand: fine, subrounded to rounded, equant; quartz and lithic grains	5.0	19.7
Glacial Lake Deposits	Silt, yellowish brown, sandy	2.0	21.7
	Clay, pale brown, laminated	2.3+	24.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	2	51	47	6.7-10.7	No grading data available						
				10.7-12.7	1	4	11	28	28	18	10
				12.7-14.7	3	14	24	21	19	16	3
				Mean	2	9	17	25	23	17	7
b	9	90	1	14.7-16.7	9	69	22	0	0	0	0
				16.7-19.7	9	51	36	2	2	0	0
				Mean	9	58	31	1	1	0	0
a+b	6	72	22	10.7-19.7	6	36	25	11	11	8	3

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	10.7-12.7	40	57	0	0	0	trace	3	0

SE 28 NE 22 **2788 8804** **Aiskew Farm** **Block c**

Surface level c+34.0 m
Water level not recorded
October 1980

Overburden 0.3 m
Mineral 2.0 m
Waste 0.2 m
Mineral 2.3 m
Waste 13.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvio-glacial Sand and Gravel	**a** 'Clayey' sandy gravel Gravel: fine and coarse, rounded, equant; Carboniferous limestone and sandstone Sand: fine, rounded, equant; quartz and lithic grains	0.5	0.8
	b 'Very clayey' pebbly sand Gravel: fine, as above Sand: fine, as above	1.5	2.3
	Clay, reddish brown, sandy	0.2	2.5
	c 'Very clayey' sand: fine, subangular to rounded, equant; lithic grains and quartz	2.3	4.8
Glacial Lake Deposits	Clay, pale brown, silty, laminated	13.2+	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
a	11	47	42	0.3-0.8	11	21	14	12	21	21	0
b	26	70	4	0.8-2.3	26	59	9	2	4	0	0
c	24	76	0	2.5-4.8	24	69	7	0	0	0	0
a+b+c	23	71	6	Mean	23	61	8	2	4	2	0

SE 28 NE 23 **2824 8856** **Floodbridge Farm** **Block C**

Surface level c+32.0 m
Water struck at +17.0 m
October 1980

Overburden 0.5 m
Mineral 1.5 m
Waste 17.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Fluvio-glacial Sand and Gravel	'Very clayey' sand: fine, subrounded, equant; quartz and lithic grains	1.5	2.0
Glacial Lake Deposits	Silt, brown	1.0	3.0
	Clay, brown, silty	14.0	17.0
Till	Stony clay, grey, sandy, with pebbles and cobbles of Carboniferous limestone and sandstone	2.5+	19.5

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
24	76	0	0.5-2.0	24	50	24	2	0	0	0

SE 28 NE 24 **2906 8894** **Cowfold Grange** **Block B**

Surface level +35.0 m
Water not encountered
October 1980

Waste 6.2 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Clay, yellowish brown, silty	3.1	3.5
	Stony clay, dark brown; pebbles, cobbles and sporadic boulders of Carboniferous limestone, sandstone and mudstone	2.7	6.2
Sherwood Sandstone Group	Siltstone, dark red	0.9+	7.1

SE 28 NE 25 **2552 8703** **Ashbank House** **Block B**

Surface level +54.0 m
Water struck at +42.2 m
September 1980

Overburden 1.3 m
Mineral 4.0 m
Waste 6.5 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	Stony clay, light brown to 1.0 m then yellowish brown, sandy, with pebbles of Carboniferous limestone and sandstone	1.1	1.3
	Gravel Gravel: coarse, subangular to subrounded equant and bladed Carboniferous limestone and angular to subrounded, equant, tabular and bladed sandstone with some ironstone Sand: coarse, subangular to rounded, equant; lithic grains and quartz Fines: sporadic thin bands of stony clay between 3.9 m and 4.3 m	4.0	5.3
Till	Stony clay, yellowish brown becoming olive grey at 5.5 m, sandy, with pebbles of Magnesian limestone, Carboniferous limestone and sandstone	4.7	10.0
	Stony clay, yellowish brown, sandy, with pebbles mainly of Magnesian limestone	1.8	11.8
Upper Permian (undivided)	Dolomite, yellowish orange	0.5+	12.3

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
6	27	67	1.3-2.3	3	4	5	14	30	32	12
			2.3-3.3	3	3	5	11	20	37	21
			3.3-5.3	8	6	10	15	20	32	9
			Mean	6	5	8	14	23	32	12

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
2.3-3.3	58	38	0	0	0	0	4	0

SE 28 NE 26 **2609 8740** **Knabs Quarry** **Block B**

Surface level +48.7 m
Water struck at +43.2 m
November 1980

Overburden	1.0 m
Mineral	5.3 m
Waste	2.7 m
Mineral	3.0 m
Waste	0.2 m
Mineral	1.7 m
Waste	6.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	Clay, yellowish brown, sandy, pebbly	0.8	1.0
	a Gravel Gravel: coarse, subangular to rounded, equant and bladed Carboniferous limestone and angular to subrounded, equant, bladed and prolate sandstone with some ironstone Sand: coarse, angular to rounded, equant, lithic grains and quartz	5.3	6.3
	Clay, grey, sandy, with sporadic pebbles	2.7	9.0
	b Gravel Gravel: coarse, subangular to rounded, equant Carboniferous limestone and angular to subrounded, equant and tabular sandstone with some Magnesian limestone and ironstone Sand: coarse, angular to subrounded, equant, lithic grains and quartz	1.2	10.2
	c 'Very clayey' pebbly sand Gravel: fine, angular to rounded, equant; Carboniferous limestone and sandstone Sand: fine, subangular to rounded, equant; quartz and lithic grains	1.8	12.0
	Clay, grey, laminated	0.2	12.2
	d 'Very clayey' sand: fine subangular to rounded, equant; quartz and lithic grains	1.7	13.9

Glacial Lake Deposits	Clay, grey, laminated, with sporadic thin bands of silt and 'very clayey' sand	5.9	19.8
Till	Stony clay, grey, sandy, with pebbles and cobbles of Carboniferous limestone and sandstone	0.7+	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	9	43	48	1.0-2.0*	2	3	8	16	18	29	24
				2.0-3.0*	2	5	11	13	11	29	29
				3.0-4.0*	4	7	14	29	17	17	12
				4.0-5.0*	6	8	16	29	22	18	1
				5.0-6.3*	28	8	20	21	14	9	0
				Mean	9	6	14	23	16	20	12
b	2	22	76	9.0-10.2	2	5	7	10	28	43	5
c	33	58	9	10.2-12.0	33	35	11	11	8	2	0
d	33	66	1	12.2-13.9	34	52	10	3	1	0	0
a-d	17	46	37	Mean	17	19	12	15	14	16	7

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	1.0-2.0	No compositional data available							
	2.0-3.0	59	40	trace	1	0	0	trace	0
	3.0-4.0	59	40	trace	0	0	0	1	0
	4.0-5.0	55	43	0	0	0	0	2	0
	5.0-6.3	56	40	2	1	0	0	1	0
	Mean	58	41	trace	trace	0	0	1	0

SE 28 NE 27 **2667 8728** **Benkhill House** **Block C**

Surface level +45.0 m
Water struck at +25.5 m
October 1980

Overburden 0.9 m
Mineral 2.7 m
Waste 16.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvio-glacial Sand and Gravel	Clay, yellowish brown, silty	0.5	0.9
	a Gravel Gravel: coarse, subrounded to rounded, equant; Carboniferous limestone and sandstone with some Magnesian limestone, ironstone and chert Sand: coarse, subrounded to well rounded, equant; lithic grains and quartz	1.1	2.0

	b Sandy gravel Gravel: coarse, subrounded to rounded, equant; Carboniferous limestone and sandstone with some ironstone and chert Sand: medium, subrounded to well rounded, equant; lithic grains and quartz	1.6	3.6
Glacial Lake Deposits	Clay, brown, silty, weakly laminated below 5.0 m	16.4+	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	1	20	79	0.9-2.0	1	3	6	13	23	47	7
b	7	59	34	2.0-3.6	7	7	27	25	14	18	2
a+b	5	43	52	0.9-3.6	5	5	18	20	18	30	4

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	0.9-2.0	63	33	1	2	0	0	1	trace
b	2.0-3.6	56	41	2	trace	0	trace	1	trace
a+b	Mean	61	36	1	1	0	trace	1	trace

SE 28 NE 28 **2775 8733** **Bridge Grange Farm** **Block C**

Surface level +34.2 m
Water level not recorded
October 1980

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial Lake Deposits	Clay, dark grey, laminated, silty, with sand partings	5.9	6.0
	Clay, brown, laminated, silty in part	12.0+	18.0

SE 28 NE 29 **2881 8779** **Bromaking Grange** **Block C**

Surface level +35.2 m
Water struck at +21.7 m
October 1980

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Lake Deposits	Silt, brown, sandy	1.3	1.5
	Clay, reddish brown, slightly silty	12.0	13.5
	Clay, olive grey, sandy, pebbly	0.5	14.0
	Clay, olive grey, laminated, with bands of silt and sand	4.0+	18.0

SE 28 NE 30 **2541 8629** **Mile House** **Block C**

Surface level +58.7 m
Water struck at +46.2 m
June 1980

Overburden 3.5 m
Mineral 10.3 m
Waste 0.1 m
Mineral 4.3 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvio-glacial Sand and Gravel	Clay, yellowish brown, sandy, pebbly below 2.6 m with sporadic cobbles	3.3	3.5
	a 'Clayey' gravel Gravel: coarse, subangular to rounded, equant and bladed, Carboniferous limestone and sandstone with some chert Sand: fine, medium and coarse, subangular to rounded, equant; quartz and lithic grains	2.0	5.5
	b Gravel Gravel: coarse, subangular to rounded, equant and bladed, Carboniferous limestone and sandstone with some chert, Magnesian limestone and ironstone Sand: coarse, as above	8.3	13.8
	Clay, greyish orange, laminated	0.1	13.9
	c Gravel Gravel: coarse, subangular to well rounded, equant and bladed, Carboniferous limestone and sandstone with some Magnesian limestone, chert, and ironstone Sand: coarse, as above	4.3	18.2
Upper Permian (undivided)	Dolomite, greyish orange	1.0+	19.2

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	11	33	56	3.5-4.5	10	9	11	9	21	38	2
				4.5-5.5	12	12	12	12	20	25	7
				Mean	11	11	11	11	20	32	4
b	2	34	64	5.5-7.5*	1	3	11	23	20	31	11
				7.5-10.5*	1	6	12	18	20	33	10
				10.5-13.8	3	7	11	13	21	26	19
				Mean	2	6	11	17	20	30	14
c	4	34	62	13.9-16.9	4	6	11	17	21	33	8
				16.9-18.2	3	7	13	13	21	29	14
				Mean	4	6	12	16	21	31	10
a+b+c	4	34	62	Mean	4	6	12	16	20	31	11

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	3.5-4.5	50	48	2	0	0	trace	0	0
	4.5-5.5	No compositional data available							
	Mean	50	48	2	0	0	trace	0	0
b	5.5-7.5	49	49	2	trace	trace	0	trace	0
	7.5-10.5	59	36	3	1	trace	trace	1	0
	10.5-13.8	58	40	trace	1	trace	trace	1	0
	Mean	56	41	1	1	trace	trace	1	0
c	13.9-16.9	54	41	2	2	trace	trace	1	0
	16.9-18.2	68	27	0	5	0	0	0	0
	Mean	58	37	1	3	trace	trace	1	0
a+b+c	Mean	56	41	1	1	trace	trace	1	0

SE 28 NE 31 **2599 8669** **Manley Cottage** **Block B**

Surface level +46.4 m
Water struck at +43.4 m
September 1980

Overburden 1.4 m
Mineral 4.1 m
Waste 6.5 m
Mineral 7.0 m
Waste 1.2 m
Bedrock 0.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	Clay, yellowish brown changing to dark grey at 1.2 m, sandy, pebbly to 1.2 m	1.2	1.4
	a Gravel Gravel: fine, angular to rounded, equant and bladed Carboniferous limestone and angular to rounded, equant, bladed and tabular sandstone with some Magnesian limestone, chert and ironstone Sand: coarse, angular to rounded, equant; lithic grains and quartz	2.0	3.4

	b 'Very clayey' pebbly sand Gravel: coarse, subangular to rounded, equant; sandstone and Carboniferous limestone Sand: fine, subrounded to rounded, equant; quartz and lithic grains Fines: sproadic thin bands of laminated clay below 5.0 m	2.1	5.5
	Clay, pale red, silty, laminated	0.5	6.0
	Silt, yellowish brown, sandy, sporadic pebbles	3.0	9.0
	'Clayey' sandy gravel Gravel: coarse, as above Sand: medium, as above	0.9	9.9
Till	Clay, olive grey, sandy, pebbly	2.1	12.0
Glacial Sand and Gravel	**c** Gravel Gravel: fine, angular to rounded, equant Carboniferous limestone and angular to subangular, equant and bladed sandstone with some Magnesian limestone, chert and ironstone Sand: coarse, subangular to rounded, equant; quartz and lithic grains	4.0	16.0
	d Pebbly sand Gravel: fine, as above Sand: medium, as above	3.0	19.0
Till	Clay, dark grey, sandy, pebble	1.2	20.2
Upper Permian (undivided)	Dolomite, yellowish orange	0.6+	20.8

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	5	38	57	1.4-2.4*	2	4	9	17	22	33	13
				2.4-3.4	8	7	6	32	31	14	2
				Mean	5	6	8	24	26	24	7
b	32	54	14	3.4-5.5	32	40	5	9	6	8	0
c	3	37	60	12.0-14.0*	3	3	7	24	27	19	17
				14.0-16.0*	4	5	11	24	32	23	1
				Mean	3	4	9	24	30	21	9
d	9	84	7	16.0-19.0	9	21	42	21	6	1	0
a-d	10	53	37	Mean	10	16	17	20	19	13	5

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	1.4-2.4	56	42	1	trace	0	0	1	0
	2.4-3.4	53	43	trace	3	0	0	1	0
	Mean	54	42	1	2	0	0	1	0
c	14.0-16.0	60	36	1	2	0	0	1	0

SE 28 NE 32 **2681 8652** **Firby House** **Block C**

Surface level +41.1 m
Water struck at +37.3 m
June 1980

Overburden 5.2 m
Mineral 2.8 m
Waste 13.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Glacial Lake Deposits	Clay, brown, sandy, laminated below 1.2 m	3.3	3.8
	Sandy silt, olive grey	1.4	5.2
	'Clayey' sand: fine, subangular to subrounded, equant; quartz with lithic grains	2.8	8.0
	Clay, brownish grey, laminated, interbedded with seams of 'very clayey' sand and sandy silt	7.0	15.0
	'Very clayey' gravel Gravel: fine, angular to rounded, equant and tabular; sandstone and Carboniferous limestone Sand: fine; quartz with lithic grains	1.1	16.1
Till	Stony clay, dark grey, sandy, with pebbles and cobbles of Carboniferous limestone and sandstone	3.4	19.5
	Sandy silt, olive grey	1.5+	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	
16	84	0	5.2-8.0	16	83	1	0	0	0	0	

SE 28 NE 33 **2776 8602** **Hollins House** **Block C**

Surface level +32.3 m
Water not encountered
June 1980

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Lake Deposits	Clay, grey, laminated, with sand partings	1.3	1.5
	Clay, reddish brown, laminated, silty in part	14.6	16.1
Till	Stony clay, dark grey, sandy, with pebbles of Carboniferous limestone and sandstone	1.9+	18.0

SE 28 NE 34 **2828 8644** **Lord's Moor Farm** **Block C**

Surface level +29.3 m
Water struck at 27.6 m
July 1980

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Lake Deposits	'Very clayey' sand: fine; quartz with lithic grains	0.1	0.4
	Clay, mainly yellowish brown, laminated	1.3	1.7
	Clay, grey changing to pale brown at 8.0 m, sandy, laminated	16.3+	18.0

SE 28 NE 35 **2950 8680** **Exelby** **Block B**

Surface level +37.1 m
Water struck at +33.6 m
October 1980

Overburden 2.0 m
Mineral 7.0 m
Waste 0.2 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial Sand and Gravel	Sandy silt, yellowish brown	1.6	2.0
	a 'Very clayey' sand: fine, angular to rounded, equant; quartz and lithic grains	1.5	3.5
	b 'Clayey' pebbly sand Gravel: coarse, subangular to rounded, equant and tabular sandstone and angular to rounded, equant and bladed Carboniferous limestone Sand: fine, subangular to rounded, equant; quartz and lithic grains including coal	3.3	6.8
	c Gravel Gravel: as above Sand: as above	2.2	9.0
	Clay, moderate red, sandy, pebbly	0.2	9.2
Sherwood Sandstone Group	Sandstone, moderate red	1.0+	10.2

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	24	75	1	2.0-3.5	24	69	5	1	1	0	0
b	11	76	13	3.5-6.8	11	61	11	4	1	12	0
c	6	38	56	6.8-9.0*	6	20	10	8	10	27	19
a+b+c	12	64	24	2.0-9.0	12	50	9	5	4	14	6

SE 28 NE 36 **2543 8523** **West Park** **Block C**

Surface level +57.3 m
Water not encountered
July 1980

Overburden 1.2 m
Mineral 2.4 m
Waste 0.4 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvio-glacial Sand and Gravel	Clay, yellowish brown, sandy, pebbly	0.8	1.2
	Gravel Gravel: coarse, angular to rounded, mainly equant; Magnesian limestone and Carboniferous limestone with sandstone and some quartz Sand: coarse, angular to rounded, equant; quartz and lithic grains	2.4	3.6
	Clay, yellowish brown, sandy, pebbly	0.4	4.0
Upper Permian (undivided)	Dolomite, greyish orange	1.0+	5.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
2	25	73	1.2-2.2	2	4	7	12	33	40	2
			2.2-3.6	1	3	8	15	35	37	1
			Mean	2	3	8	14	34	37	2

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
1.2-2.2	34	24	trace	41	0	1	trace	0

SE 28 NE 37 **2669 8571** **Throp Perrow** **Block C**

Surface level +43.3 m
Water struck at +43.0 m
July 1980

Overburden 0.9 m
Mineral 2.2 m
Waste 3.9 m
Mineral 8.5 m
Waste 9.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvio-glacial Sand and Gravel	Clay, yellowish brown, sandy	0.7	0.9
	a Gravel Gravel: coarse, angular to well rounded, equant and bladed Carboniferous limestone and angular to rounded, equant, bladed and tabular sandstone with some chert, Magnesian limestone and mudstone Sand: medium, subangular to rounded, equant; quartz with lithic grains	1.1	2.0
	b 'Clayey' sand: fine, angular to subrounded, equant; quartz with lithic grains	1.1	3.1
	Clay, yellowish brown, pebbly to 3.6 m, silty below	2.2	5.3
	'Clayey' sandy gravel Gravel: coarse, subangular to rounded, equant; Carboniferous limestone and sandstone Sand: fine, subangular to rounded, equant; quartz with lithic grains	0.6	5.9
	Clay, dark grey, silty, pebbly, with thin bands of 'very clayey' pebbly sand towards the base	1.1	7.0
	c Pebbly sand Gravel: fine, subangular to rounded, equant; Carboniferous limestone and sandstone with some chert Sand: medium, subangular to rounded, equant; quartz with lithic grains	1.0	8.0
	d Sandy gravel Gravel: fine and coarse, subangular to rounded, equant, Carboniferous limestone and sandstone with some Magnesian limestone, ironstone and chert Sand: medium, subangular to rounded, equant; quartz with lithic grains	1.0	9.0
	e 'Very clayey' sand: fine, subangular to rounded, equant; quartz with lithic grains	6.5	15.5
Glacial Lake Deposits	Laminated clay, yellowish brown, silty, with thin beds of 'very clayey' sand	9.5+	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	3	39	58	0.9-2.0	4	6	20	13	24	33	0
b	17	79	4	2.0-3.1	17	47	26	6	3	1	0
c	7	87	6	7.0-8.0	7	25	52	10	4	2	0
d	3	70	27	8.0-9.0	3	15	41	14	14	13	0
e	24	76	0	9.0-11.0	17	59	22	1	1	0	0
				11.0-13.0	15	64	20	1	0	0	0
				13.0-15.5	37	60	3	0	0	0	0
				Mean	24	62	14	trace	trace	0	0
a-e	18	72	10	Mean	18	46	22	4	5	5	0

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	0.9-2.0	54	43	1	1	1	trace	trace	0
c	7.0-8.0	54	45	1	trace	0	trace	0	0
d	8.0-9.0	49	42	1	4	0	trace	4	0
a+c+d	Mean	52	43	1	2	1	trace	1	0

SE 28 NE 38 **2858 8588** **Main Cut** **Block C**

Surface level c+29.5 m
Water not encountered
June 1980

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Lake Deposits	Clay, grey, laminated, with sand partings	1.2	1.5
	Clay, reddish brown, laminated, silty	16.5+	18.0

SE 28 NE E1 **2598 8762** **Knabs Quarry** **Block B**

Surface level c+56.0 m

Overburden 0.2 m
Mineral 11.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	'Clayey' sandy gravel Gravel: coarse, subangular to rounded, equant Carboniferous limestone and angular to subrounded, equant and tabular sandstone Sand: medium, angular to rounded, equant; lithic grains and quartz	11.8+	12.0

SE 28 SW 8 **2063 8435** **North Field Hill** **Block D**

Surface level c+112.0 m
Water struck at +109.6 m
August 1980

Overburden 2.4 m
Mineral 5.5 m
Waste 6.6 m
Mineral 10.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, yellowish brown, sandy, with sporadic pebbles	1.0	1.2
	Sand: fine, subangular to subrounded; quartz with lithic grains	0.8	2.0
	Clay, yellowish brown, sandy, pebbly at base	0.4	2.4
Fluvio-glacial Sand and Gravel	**a** Gravel Gravel: coarse, angular to subrounded equant and bladed Carboniferous limestone with subangular to rounded, equant sandstone and some chert and ironstone Sand: coarse, angular to rounded, equant; quartz and lithic grains	5.5	7.9
	Clay, olive grey, silty, laminated in part	6.6	14.5
	b Pebbly sand Gravel: fine, subangular to rounded, equant; sandstone and Carboniferous limestone with some chert Sand: medium, angular to rounded, equant; quartz and lithic grains	5.5	20.0
	c Sand: medium, subangular to rounded, equant; quartz and lithic grains	5.0+	25.0

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
a	1	26	73	2.4-3.4*	1	2	4	8	26	52	7
				3.4-4.4*	1	3	8	18	22	20	28
				4.4-6.0*	1	5	10	15	18	26	25
				6.0-7.9	No grading data available						
				Mean	1	4	8	14	21	31	21
b	5	78	17	14.5-16.0	6	11	53	14	10	6	0
				16.0-18.0	4	14	49	14	13	6	0
				18.0-20.0	6	19	38	19	17	1	0
				Mean	5	15	47	16	13	4	0
c	6	93	1	20.0-22.0	8	51	40	1	0	0	0
				22.0-25.0	4	25	63	7	1	0	0
				Mean	6	35	53	5	1	0	0
a+b+c	4	70	26	Mean	4	19	40	11	11	10	5

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	2.4-3.4	93	5	1	0	0	0	1	0
	3.4-4.4	No compositional data available							
	4.4-6.0	61	37	1	0	trace	0	1	0
	6.0-7.9	No compositional data available							
	Mean	75	23	1	0	trace	0	1	0
b	14.5-16.0	58	42	trace	0	0	0	0	0
	16.0-18.0	31	67	1	0	1	0	0	0
	18.0-20.0	55	42	2	1	0	trace	0	0
	Mean	45	54	1	trace	trace	trace	0	0
a+b	Mean	66	32	1	0	0	0	1	0

SE 28 SW 9 **2039 8304** **Wind Hills** **Block D**

Surface level c+111.0 m
Water not encountered
September 1980

Overburden 2.1 m
Mineral 10.8 m
Waste 3.4 m
Bedrock 1.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Clay, brown, sandy; pebbles becoming increasingly common with depth	1.7	2.1
Fluvio-glacial Sand and Gravel	**a** Gravel Gravel: fine, subangular to well rounded; Carboniferous limestone and sandstone with some ironstone Sand: coarse, subangular to rounded, equant; lithic grains and quartz	3.9	6.0

	b 'Very clayey' gravel Gravel: coarse, subangular to rounded, equant, Carboniferous limestone with sandstone, and some chert and ironstone Sand: as above	2.0	8.0
	c Sandy gravel Gravel: fine and coarse, subangular to rounded, equant, Carboniferous limestone and sandstone with some ironstone Sand: as above	4.9	12.9
Till	Stony clay, grey, sandy, with pebbles, cobbles and sporadic boulders of Carboniferous limestone and sandstone	3.4	16.3
Namurian	Sandstone, grey	1.4+	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	4	33	63	2.1-4.0*	5	4	7	23	26	31	4
				4.0-6.0*	3	2	7	24	30	30	14
				Mean	4	3	7	23	29	25	9
b	35	31	34	6.0-8.0*	35	3	10	18	12	15	7
c	5	53	42	8.0-11.8	5	7	17	28	16	21	6
				11.8-12.9	3	10	21	30	28	8	0
				Mean	5	7	18	28	19	18	5
a+b+c	10	42	48	2.1-12.9	10	5	13	24	21	20	7

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	4.0-6.0	63	36	trace	0	0	0	1	0
b	6.0-8.0	75	22	2	0	0	0	1	0
c	8.0-11.8	70	28	trace	0	0	0	2	0

SE 28 SW 10 **2046 8377** **Low Ellington** **Block D**

Surface level +99.8 m
Water struck at +95.8 m
August 1980

Overburden 1.2 m
Mineral 1.8 m
Waste 1.1 m
Mineral 3.0 m
Waste 13.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Stony clay, yellowish brown	1.0	1.2

Fluvio-glacial Sand and Gravel	**a** Gravel Gravel: coarse, angular to rounded, equant Carboniferous limestone and angular to subrounded equant sandstone, with some ironstone Sand: coarse, subangular to rounded, equant; quartz and lithic grains	1.8	3.0
	Clay, medium grey, sandy, pebbly	1.1	4.1
	b Sandy gravel Gravel: coarse, subangular to subrounded, equant Carboniferous limestone with angular to rounded, equant sandstone Sand: medium, subangular to subrounded, equant; quartz and lithic grains	1.0	5.1
	c 'Clayey' pebbly sand Gravel: coarse, subangular to subrounded, equant; Carboniferous limestone and sandstone Sand: medium and fine, subangular to subrounded, equant; quartz and lithic grains	2.0	7.1
Laminated clay associated with fluvio-glacial sand and gravel	Laminated clay, olive grey, with partings of silt and sand	13.9+	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	4	27	69	1.2-2.2	4	8	9	13	21	30	15
				2.2-3.0	4	6	7	11	17	39	16
				Mean	4	7	8	12	19	35	15
b	6	53	41	4.1-5.1*	6	17	24	12	14	25	2
c	12	79	9	5.1-7.1	12	34	35	10	1	5	3
a+b+c	8	53	39	Mean	8	20	22	11	11	21	7

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	2.2-3.0	67	32	trace	0	0	0	1	0
c	5.1-7.1	75	25	trace	0	0	0	0	0

SE 28 SW 11 **2117 8306** **Inner Hills** **Block D**

Surface level c+105.0 m
Water not encountered
August 1980

Overburden 4.3 m
Mineral 12.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Silt, brown	0.4	0.6
	Stony clay, light brown, sandy, pebbly	3.7	4.3

Fluvio-glacial Sand and Gravel	Gravel Gravel: coarse, subangular to rounded, equant and tabular; Carboniferous limestone and sandstone with some chert and quartz Sand: coarse, angular to subrounded, equant, prolate and bladed; lithic grains and quartz	12.9+	17.2

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
4	45	51	4.3-5.3*	4	9	13	12	13	32	17
			5.3-6.5*	6	14	21	18	14	18	9
			6.5-8.0*	5	11	17	23	18	19	7
			8.0-10.0*	3	6	11	19	22	29	10
			10.0-12.0	No grading data available						
			12.0-15.0	No grading data available						
			15.0-17.2*	4	11	21	19	24	19	2
			Mean	4	10	16	19	19	24	8

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
8.0-10.0	66	32	1	0	0	1	trace	0

SE 28 SW 12 2161 8354 High Mains Block D

Surface level c+101.0 m
Water struck at +82.7 m
August 1980

Overburden 1.0 m
Mineral 2.7 m
Waste 6.0 m
Mineral 10.0 m
Waste 4.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, yellowish brown, pebbly	0.8	1.0
Fluvio-glacial Sand and Gravel	**a** Gravel Gravel: coarse, angular to rounded, tabular, prolate and equant; Carboniferous limestone and sandstone with some chert and ironstone Sand: coarse, angular to rounded, equant; lithic grains and quartz	2.7	3.7
Laminated clay associated with fluvio-glacial sand and gravel	Clay, dark brown, laminated; sporadic pebbles	1.5	5.2
Till	Stony clay, brownish grey, silty	4.5	9.7
Fluvio-glacial Sand and Gravel	**b** Sandy gravel Gravel: coarse and fine, angular to well rounded, equant and tabular; Carboniferous limestone and sandstone with some chert and Magnesian limestone Sand: medium, angular to well rounded, equant; lithic grains and quartz	10.0	19.7

Laminated clay associated with fluvio-glacial sand and gravel	Clay, greyish brown, pebbly, becoming laminated towards base	4.3+	24.0

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	6	39	55	1.0-2.0*	4	6	17	18	14	30	11
				2.0-3.7*	7	9	10	18	29	25	2
				Mean	6	8	13	18	23	27	5
b	5	51	44	9.7-11.1*	3	9	24	19	26	19	0
				11.1-14.3*	3	9	17	15	20	31	5
				14.3-15.6*	5	15	19	17	17	23	4
				15.6-17.0*	7	21	28	18	9	15	2
				17.0-18.3*	7	14	19	19	24	17	0
				18.3-19.7*	3	8	25	24	24	14	2
				Mean	5	12	21	18	20	21	3
a+b	5	48	47	Mean	5	11	19	18	20	24	3

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	1.0-2.0	50	42	5	0	0	0	3	0
	2.0-3.7	64	35	1	0	trace	0	0	0
	Mean	59	38	2	0	trace	0	1	0
b	9.7-11.1	61	38	trace	1	trace	0	trace	0
	11.1-14.3	60	37	2	1	0	0	trace	0
	14.3-15.6	65	32	3	trace	0	0	trace	0
	15.6-17.0	74	25	trace	1	trace	trace	0	0
	17.0-18.3	60	37	3	0	trace	trace	trace	0
	18.3-19.7	56	37	7	0	trace	0	trace	0
	Mean	61	36	2	1	trace	trace	trace	0
a+b	Mean	60	37	2	1	trace	trace	trace	0

SE 28 SW 13 **2104 8210** **Mile House** **Block D**

Surface level +101.2 m
Water struck at +89.5 m
October 1980

Overburden 1.2 m
Mineral 12.6 m
Waste 2.6 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, brown, sandy, pebbly	1.0	1.2
Fluvio-glacial Sand and Gravel	Gravel Gravel: coarse, subangular to rounded, equant and tabular; Carboniferous limestone and sandstone with some ironstone and chert Sand: coarse, subangular to rounded, equant; lithic grains and quartz	12.6	13.8

Till	Stony clay, brown, sandy, with pebbles and cobbles of Carboniferous limestone and sandstone	2.6	16.4
Namurian	Sandstone, light grey	1.0+	17.4

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
5	37	58	1.2-2.5*	7	3	5	11	18	43	13
			2.5-4.0*	3	6	16	31	20	20	4
			4.0-6.0*	4	6	12	28	23	21	6
			6.0-8.0*	6	6	10	23	21	24	10
			8.0-10.0	5	4	8	23	13	29	18
			10.0-12.0*	8	7	14	25	22	16	8
			12.0-13.8*	4	4	6	10	21	31	24
			Mean	5	5	10	22	20	26	12

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
1.2-2.5	76	22	1	0	0	0	1	0
2.5-4.0	No compositional data available							
4.0-6.0	75	21	2	0	0	0	2	0
6.0-8.0	76	22	trace	0	0	tra e	2	0
8.0-10.0	58	40	1	0	0	0	1	0
10.0-12.0	38	60	trace	0	1	trace	1	0
12.0-13.8	39	59	trace	0	0	0	2	0
Mean	59	38	1	0	trace	trace	2	0

SE 28 SW 14 **2203 8281** **Low Mains** **Block D**

Surface level +92.5 m
Water struck at +74.3 m
August 1980

Overburden 0.4 m
Mineral 13.9 m
Waste 5.8 m
Mineral 3.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvio-glacial Sand and Gravel	**a** Gravel Gravel: fine and coarse, subangular to rounded, equant and bladed, Carboniferous limestone and angular to rounded, equant, bladed and prolate sandstone, with some chert Sand: coarse, angular to rounded, equant; lithic grains and quartz	13.9	14.3
	Clay, grey, silty	5.0	19.3
	Sandy silt, olive grey	0.8	20.1
	b 'Clayey' gravel Gravel: as above Sand: medium, subangular to rounded, equant; quartz and lithic grains	1.3	21.4

c	Sand: medium, subangular to rounded, equant; quartz and lithic grains	2.0+	23.4

Borehole abandoned due to drilling difficulties

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	6	44	50	0.4-1.4*	4	5	16	24	15	34	2
				1.4-4.0*	4	5	11	26	30	22	2
				4.0-6.0*	5	5	10	23	25	24	8
				6.0-7.8*	2	4	10	18	23	37	6
				7.8-9.0*	No grading data available						
				9.0-10.0*	4	12	23	24	16	19	2
				10.0-11.5*	1	8	17	21	19	22	12
				11.5-14.3*	14	5	17	26	25	13	0
				Mean	6	6	14	24	23	23	4
b	10	35	55	20.1-21.4	10	12	17	7	21	21	12
c	2	97	1	21.4-23.4	2	17	73	7	1	0	0
a+b+c	6	50	44	Mean	6	8	22	20	20	20	4

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	0.4-1.4	64	33	3	0	trace	0	trace	0
	1.4-4.0	76	24	trace	0	0	trace	trace	0
	4.0-6.0	63	36	trace	0	0	0	1	0
	6.0-7.8	67	32	1	0	0	0	trace	0
	7.8-9.0	No compositional data available							
	9.0-10.0	68	32	trace	0	0	0	trace	0
	10.0-11.5	62	37	1	0	0	0	trace	0
	11.5-14.3	72	27	1	0	0	0	trace	0
	Mean	68	31	1	0	trace	trace	trace	0
b	20.1-21.4	72	27	1	0	0	0	trace	0
a+b	Mean	68	31	1	0	trace	trace	trace	0

SE 28 SW 15 **2166 8152** **Stony Bottoms Plantations** **Block D**

Surface level +94.1 m
Water struck at +83.1 m
July 1980

Overburden 1.7 m
Mineral 4.7 m
Waste 0.5 m
Mineral 16.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Clay, yellowish brown, with sporadic pebbles	1.3	1.7

Fluvio-glacial Sand and Gravel	**a** Gravel Gravel: coarse, angular to subrounded, equant Carboniferous limestone with angular to rounded, equant and tabular sandstone Sand: coarse, angular to rounded, equant; lithic grains and quartz		4.7	6.4
	Silt, brown, sandy		0.5	6.9
	b Pebbly sand Gravel: fine and coarse, subangular to subrounded, equant; sandstone and Carboniferous limestone with some chert Sand: medium, subangular to subrounded, equant; lithic grains and quartz		16.1+	23.0

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	5	36	59	1.7-2.7*	6	8	15	19	17	30	5
				2.7-4.4*	4	7	14	18	14	32	11
				4.4-6.4*	5	6	10	16	15	38	10
				Mean	5	7	12	17	15	35	9
b	8	73	19	6.9-8.5*	4	7	9	15	27	29	9
				8.5-9.9	No grading data available						
				9.9-11.0	23	24	15	8	12	17	1
				11.0-12.0	9	28	44	15	3	1	0
				12.0-13.0	2	5	24	28	34	7	0
				13.0-13.9*	1	10	27	19	11	24	8
				13.9-15.5	5	31	37	8	8	8	3
				15.5-17.0	8	40	38	3	4	4	3
				17.0-19.0	10	43	43	3	1	0	0
				19.0-21.0	8	37	48	5	1	1	0
				21.0-23.0	10	37	53	0	0	0	0
				Mean	8	29	36	8	9	8	2
a+b	7	65	28	Mean	7	23	31	11	10	14	4

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	2.7-4.4	85	15	trace	0	0	0	trace	0
b	13.0-13.9	34	65	1	0	0	trace	trace	0

SE 28 SW 16 **2305 8127** **North Cote** **Block D**

Surface level +78.7 m
Water struck at +76.2 m
July 1980

Overburden 0.8 m
Mineral 2.8 m
waste 19.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.8	0.8
River Terrace Deposits, undifferentiated	Gravel Gravel: coarse, subrounded, equant Carboniferous limestone and subangular, equant sandstone with some chert Sand: coarse, subangular to subrounded, equant; lithic grains with quartz	2.8	3.6
	Clay, brownish grey, sandy, laminated in part	9.2	12.8
	Gravel Gravel: coarse, subangular to subrounded, equant; Carboniferous limestone and sandstone Sand: coarse; lithic grains and quartz	1.6	14.4
Till	Stony clay, greyish brown, sandy, laminated in part	9.0+	23.4

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
6	26	68	0.8-2.0*	3	4	6	11	18	36	22
			2.0-3.0	10	9	9	11	21	33	7
			3.0-3.6	4	6	13	16	30	30	1
			Mean	6	6	8	12	21	35	12

COMPOSITION

Depth below surface (m)	Percentages by weight in +4 mm fraction							
	Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
0.8-2.0	68	31	1	trace	trace	trace	0	
2.0-3.0	64	32	3	0	0	0	1	0
3.0-3.6	72	28	trace	0	trace	trace	trace	0
Mean	67	31	2	trace	trace	trace	trace	0

SE 28 SW 17 **2026 8063** **Micklebury Lane** **Block D**

Surface level +124.6 m
Water not encountered
July 1980

Waste 17.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Stony clay, yellowish brown changing to dark brown at 6.1 m, sandy, with pebbles of sandstone and Carboniferous limestone	17.2+	17.5

SE 28 SW 18 **2138 8075** **Micklebury Lodge** **Block D**

Surface level +102.5 m
Water struck at+97.1 m
July 1980

Overburden 2.8 m
Mineral 2.6 m
Waste 13.3 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Silt, reddish brown, sandy, with sporadic pebbles	2.6	2.8
Glacial Sand and Gravel	**a** 'Clayey' sandy gravel Gravel: cobble, subangular, equant sandstone and subrounded, equant Carboniferous limestone and sandstone with some chert Sand: fine, subrounded, equant; quartz with lithic grains	1.0	3.8
Till	Stony clay, brown, sandy	13.3	18.7
Namurian	Sandstone, yellowish brown	0.9+	19.6

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	18	48	34	2.8-3.8	18	24	20	4	4	11	19
b	14	32	54	3.8-4.8	12	14	11	5	11	24	23
				4.8-5.4	17	13	10	9	15	32	4
				Mean	14	14	11	7	12	27	15
a+b	16	38	46	2.8-5.4	16	17	15	6	9	20	17

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	2.8-3.8	30	70	trace	0	0	0	trace	trace
b	3.8-4.8	50	47	3	0	trace	0	trace	0
	4.8-5.4	56	43	1	trace	trace	0	trace	0
	Mean	52	46	2	trace	trace	0	trace	0
a+b	Mean	46	52	2	trace	trace	0	trace	trace

SE 28 SW 19 **2271 8018** **Badger Lane** **Block D**

Surface level +82.0 m
Water struck at +77.6 m
July 1980

Overburden 1.0 m
Mineral 2.4 m
Waste 16.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
River Terrace Deposits, undifferentiated	Stony clay, brown, sandy	0.6	1.0
	a Gravel Gravel: coarse, subangular to subrounded, equant; Carboniferous limestone with sandstone and some chert Sand: coarse; lithic grains and quartz	1.1	2.1
	b Sandy gravel Gravel: fine, as above Sand: as above	1.3	3.4
	Clay, grey, silty, laminated, with sporadic pebbles	7.3	10.7
Till	Stony clay, grey	1.5	12.2
	Silt, grey, sandy	1.4	13.6
	Stony clay, greyish brown, sandy	6.5+	20.1

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	4	35	61	1.0-2.1*	4	7	12	16	17	30	14
b	9	52	39	2.1-3.4*	9	12	18	22	23	16	0
a+b	6	44	50	1.0-3.4	6	10	15	19	21	22	7

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	1.0-2.1	76	21	3	0	trace	0	trace	0

SE 28 SW 20 **2387 8014** **Upbank Wood**

Surface level c+93.0 m
Water struck at +89.0 m
October 1980

Waste 21.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Stony clay, brown changing to grey at 4.0 m, sandy, initially only sporadic pebbles but below 0.9 m pebbles, cobbles and sporadic boulders of Carboniferous limestone and sandstone with some Magnesian limestone are common	11.1	11.5
	'Clayey' pebbly sand Gravel: fine, subangular to subrounded, equant; sandstones and Carboniferous limestone with some Magnesian limestone	2.0	13.5
	Stony clay, dark brown, sandy, with pebbles and cobbles of Carboniferous limestone and sandstone with some Magnesian limestone	2.9	16.4
	'Clayey' gravel Gravel: coarse, subrounded to rounded, equant; sandstone and Carboniferous limestone Sand: coarse, subrounded to rounded, equant; lithic grains and quartz	4.6+	21.0

SE 28 SW E1 **2157 8241** **Marfield Plantation** **Block D**

Surface level c+95.0 m

Overburden 0.9 m
Mineral 11.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Stony clay, brown, sandy	0.8	0.9
Fluvio-glacial Sand and Gravel	Gravel Gravel: coarse, subangular to rounded, equant; Carboniferous limestone and sandstone Sand: coarse, angular to rounded, equant; lithic grains and quartz	11.6+	12.5

SE 28 SE 16 **2825 8441** **Mires Lane** **Block C**

Surface level +28.1 m
Water struck at +27.6 m
July 1980

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Peat	0.2	0.2
Glacial Lake Deposits	Clay, grey changing to greyish brown at 7.5 m, laminated, with sand partings	16.1	16.3
Till	Stony clay, dark grey, silty, with pebbles and cobbles at Carboniferous limestone and sandstone	1.7+	18.0

SE 28 SE 17 **2964 8418** **Rowmy Hill** **Block C**

Surface level +29.3 m
Water not encountered
July 1980

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Peat	Peat, reddish grey, fibrous	0.6	0.9
Glacial Lake Deposits	Silt, grey, peaty, with numerous bivalve shells	0.2	1.1
	Clay, olive grey changing to brownish grey at 3.0 m	7.7	8.8
Till	Stony clay, dark grey, sandy, with pebbles and cobbles of sandstone and Carboniferous limestone	5.2	14.0
Laminated Clay associated with glacial deposits	Clay, olive grey, laminated, with sand partings	4.0+	18.0

SE 28 SE 18 **2730 8360** **Salmon House** **Block C**

Surface level +43.2 m
Water struck at +41.2 m
August 1980

Overburden 0.3 m
Mineral 1.7 m
Waste 17.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvio-glacial Sand and Gravel	Sandy gravel Gravel: fine, angular to rounded, equant, bladed and prolate sandstone and subangular to well rounded, equant and prolate, Carboniferous and Magnesian limestones with some quartz Sand: medium, subrounded to rounded, equant and bladed; lithic grains and quartz	1.7	2.0

Glacial Lake Deposits	Laminated clay, brown, silty	7.1	9.1
Till	Clay, grey, sandy, pebbly	5.6	14.7
Laminated Clay associated with glacial deposits	Clay, grey, laminated, silty	1.9	16.6
	Clay, grey, sandy, pebbly	2.4+	19.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
9	50	41	0.3-1.3	13	13	19	14	25	16	0
			1.3-2.0	5	9	21	22	25	18	0
			Mean	9	12	20	18	24	17	0

SE 28 SE 19 **2938 8349** **Brickyard Farm** **Block C**

Surface level +29.7 m
Water not encountered
July 1980

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial Lake Deposits	Clay, grey, silty, laminated, with sand partings	4.0	4.1
Till	Stony clay, dark grey, sandy, with pebbles of sandstone and Carboniferous limestone	6.7	10.8
Laminated Clay associated with glacial deposits	Clay, yellowish brown, laminated, with sporadic sand partings	7.2+	18.0

SE 28 SE 20 **2758 8242** **Oak Tree Farm** **Block C**

Surface level +46.3 m
Water not encountered
July 1980

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Till	Clay, yellowish brown changing to olive grey at 10.0 m, initially pebbly but becoming less so with depth	17.5+	18.0

SE 28 SE 21 **2861 8219** **House Close Wood** **Block C**

Surface level +48.3 m
Water level not recorded
July 1980

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Clay, olive grey, silty, pebbly	12.0	12.1
Laminated Clay associated with glacial deposits	Sandy silt, olive grey, laminated	0.9	13.0
Till	Clay, as above	2.3	15.3
Laminated Clay associated with glacial deposits	Sandy silt, as above	2.7+	18.0

SE 28 SE 22 **2981 8270** **Carthorpe Moor** **Block C**

Surface level +41.9 m
Water struck at +30.4 m
July 1980

Waste 16.5 m
Bedrock 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Stony clay, dark grey changing to reddish brown at 12.0 m, sandy, with pebbles of sandstone and Carboniferous limestone; thin seam of dark grey laminated clay at 3.0 m	16.4	16.5
Upper Permian (undivided)	Mudstone, red with greenish grey calcareous patches	1.5+	18.0

SE 28 SE 23 **2764 8166** **Oak Tree Farm** **Block C**

Surface level c+45.0 m
Wate struck at +41.8 m
November 1980

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, grey, silty to 3.2 m, becoming sandy below, pebbly	4.4	4.6
	Silt, grey, sandy, interbedded with 'clayey' sand	13.4+	18.0

SE 28 SE 24 **2990 8109** **Upsland** **Block C**

Surface level c+37.0 m
Water level not recorded
July 1980

Overburden 0.2 m
Mineral 3.8 m
Waste 9.0 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvio-glacial Sand and Gravel	**a** 'Very clayey' sandy gravel Gravel: fine and coarse, subangular to rounded, equant, bladed and tabular, sandstone with chert and some Magnesian limestone and Carboniferous limestone Sand: fine, subangular to rounded, equant; quartz and lithic grains	1.0	1.2
	b Gravel Gravel: coarse, subangular to rounded, equant; Carboniferous limestone and sandstone with some chert and mudstone Sand: medium, subangular to rounded, equant; quartz and lithic grains	2.8	4.0
	Silt, olive grey, sandy	1.5	5.5
	Clay, olive grey, silty	1.0	6.5
	Clay, yellowish brown, sandy, pebbly	6.5	13.0
Upper Permian (undivided)	Siltstone, light grey	0.5+	13.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4	+4 -16	+16 -64	+64 mm
a	24	43	33	0.2-1.2	24	25	13	5	17	16	0
b	3	41	56	1.2-2.2	0	2	10	9	35	44	0
				2.2-4.0	4	17	22	14	20	23	0
				Mean	3	11	18	12	25	31	0
a+b	8	41	51	0.2-4.0	8	15	16	10	23	28	0

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	0.2-1.2	1	89	7	2	0	0	1	0
b	1.2-2.2	51	44	3	trace	2	0	0	0
	2.2-4.0	52	45	3	0	0	0	0	0
	Mean	52	44	3	trace	1	0	0	0
a+b	Mean	43	52	4	trace	1	0	trace	0

SE 28 SE 25 **2805 8078** **Flask Lane** **Block C**

Surface level +42.8 m
Water struck at +29.3 m
September 1980

Overburden 0.3 m
Mineral 6.2 m
Waste 7.0 m
Bedrock 2.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvio-glacial Sand and Gravel	**a** Gravel Gravel: fine, subangular to rounded, equant and tabular; Carboniferous limestone and sandstone with some Magnesian limestone, chert and ironstone Sand: medium and coarse, subrounded to rounded, equant; quartz and lithic grains	2.2	2.5
	b Sandy gravel Gravel: fine, subangular to rounded equant; sandstone and Carboniferous limestone with Magnesian limestone and some chert Sand: medium, subrounded to rounded, equant; quartz and lithic grains	4.0	6.5
	Silt, grey, laminated; sporadic pebbles below 8.0 m; thin band of pebbly sand between 7.1 m and 8.0 m	4.0	10.5
Till	Stony clay, reddish brown, silty; with pebbles of Carboniferous limestone and sandstone	3.0	13.5
Upper Permian (undivided)	Dolomite, yellow	2.5+	16.0

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	6	34	60	0.3-1.5	7	5	18	17	22	31	0
				1.5-2.5	6	7	10	10	66	1	0
				Mean	6	6	14	14	43	17	0
b	6	56	38	2.5-3.5	12	14	28	12	18	16	0
				3.5-4.5	3	11	32	13	27	14	0
				4.5-5.5	1	12	27	16	24	20	0
				5.5-6.5	7	17	31	12	16	17	0
				Mean	6	13	30	13	21	17	0
a+b	6	48	46	0.3-6.5	6	11	24	13	29	17	0

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	0.3-1.5	53	42	3	2	0	0	trace	0
	1.5-2.5	68	25	trace	5	0	0	2	0
	Mean	61	33	1	4	0	0	1	0
b	2.5-3.5	30	59	3	8	0	trace	0	0
	3.5-4.5	54	37	1	8	0	0	trace	0
	4.5-5.5	43	51	1	5	0	0	trace	0
	5.5-6.5	50	39	1	10	0	trace	0	0
	Mean	45	47	1	7	0	trace	trace	0
a+b	Mean	52	41	1	6	0	trace	trace	0

SE 28 SE 26 **2911 8099** **Lady Bridge** **Block C**

Surface level +41.8 m
Water struck at +37.8 m
July 1980

Overburden 0.3 m
Mineral 6.0 m
Waste 0.5 m
Mineral 3.2 m
Bedrock 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvio-glacial Sand and Gravel	**a** Gravel Gravel: fine, subangular to well rounded, equant and bladed Carboniferous limestone and subangular to rounded, equant sandstone with some chert and Magnesian limestone Sand: medium, subangular to rounded, equant; quartz and lithic grains	2.0	2.3
	b Pebbly sand Gravel: fine, angular to rounded, equant sandstone with subrounded to well rounded, equant Carboniferous limestone, and angular to subangular, equant chert and some Magnesian limestone Sand: medium, subangular to rounded, equant; quartz and lithic grains	2.0	4.3
	c 'Clayey' sand: fine, subangular to rounded, equant; quartz and lithic grains	2.0	6.3
	Clay, yellowish brown, sandy; thin bands of gravel	0.5	6.8
	d Gravel Gravel: coarse, angular to rounded, equant and tabular sandstone with subangular to rounded, equant Carboniferous limestone and some chert and Magnesian limestone Sand: medium, angular to subrounded, equant; quartz with lithic grains	3.2	10.0
Upper Permian (undivided)	Mudstone, reddish brown	1.5+	11.5

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	45	54	0.3-1.3	1	4	24	18	26	27	0
				1.3-2.3	1	3	20	20	32	22	2
				Mean	1	4	22	19	29	24	1
b	6	84	10	2.3-4.3	6	22	49	13	9	1	0
c	11	89	0	4.3-6.3	11	49	38	2	0	0	0
d	3	28	69	6.8-7.8	3	4	9	4	13	55	12
				7.8-8.8	2	4	10	5	18	48	13
				8.8-10.0*	5	10	22	10	19	28	6
				Mean	3	7	14	7	17	42	10
a-d	5	57	38	Mean	5	19	28	10	14	20	4

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	0.3-1.3	61	37	2	0	0	0	0	0
	1.3-2.3	56	40	2	2	0	0	trace	0
	Mean	58	39	2	1	0	0	trace	0
b	2.3-4.3	24	58	15	3	0	trace	trace	0
d	6.8-7.8	8	86	3	3	trace	trace	trace	0
	7.8-8.8	23	75	2	0	0	trace	0	0
	8.8-10.0	33	64	2	0	0	1	trace	0
	Mean	21	76	2	1	trace	trace	trace	0
a+b+d	Mean	33	63	3	1	trace	trace	trace	0

SE 28 SE 27 **2917 8014** **Three Hills** **Block C**

Surface level +42.3 m
Water not encountered
September 1980

Overburden 0.4 m
Mineral 5.2 m
Waste 1.6 m
Mineral 7.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvio-glacial Sand and Gravel	**a** Gravel Gravel: coarse, subrounded to well rounded, equant and tabular; Carboniferous limestone and sandstone with some chert and Magnesian limestone Sand: medium and coarse; lithic grains and quartz	5.2	5.6
	Stony clay, reddish brown, sandy; pebbles of Carboniferous limestone and sandstone	1.6	7.2
	b Gravel Gravel: coarse, subangular to well rounded, equant; sandstone with some Carboniferous limestone, chert and Magnesian limestone Sand: medium, lithic grains and quartz	7.3+	14.5
	Borehole abandoned due to drilling difficulties		

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	40	58	0.4-1.4	1	1	4	11	32	48	3
				1.4-2.4	2	2	12	16	29	39	0
				2.4-3.4	1	2	15	19	28	31	4
				3.4-4.4	1	3	25	22	25	24	0
				4.4-5.6	2	7	37	20	19	15	0
				Mean	2	3	19	18	26	31	1
b	2	34	64	7.2-8.2	2	6	7	5	17	49	14
				8.2-9.2*	4	5	16	11	14	44	6
				9.2-10.2*	3	3	9	6	10	36	33
				10.2-11.2*	1	2	9	12	17	36	23
				11.2-12.2*	2	4	29	22	13	24	6
				12.2-14.5*	1	5	29	10	8	41	6
				Mean	2	4	19	11	12	39	13
a+b	2	37	61	Mean	2	4	19	14	18	35	8

COMPOSITION

	Depth below surface (m)	Percentages by weight in +4 mm fraction							
		Carboniferous limestone	Sandstone	Chert	Magnesian limestone	Mudstone and shale	Quartz	Ironstone	Coal
a	2.4-3.4	62	34	3	1	0	trace	trace	0
b	9.2-10.2	4	94	1	1	0	trace	0	0
a+b	Mean	30	67	2	1	0	trace	trace	0

The following reports of the Institute relate particularly to bulk mineral resources

Reports of the Institute of Geological Sciences

Assessment of British Sand and Gravel Resources

1 The sand and gravel resources of the country south-east of Norwich, Norfolk: Resource sheet TG 20.
E. F. P. Nickless.
Report 71/20 ISBN 0 11 880216 X £1.15

2 The sand and gravel resources of the country around Witham, Essex: Resource sheet TL 81. H. J. E. Haggard.
Report 72/6 ISBN 0 11 880588 6 £1.20

3 The sand and gravel resources of the area south and west of Woodbridge, Suffolk: Resource sheet TM 24.
R. Allender and S. E. Hollyer.
Report 72/9 ISBN 0 11 880596 7 £1.70

4 The sand and gravel resources of the country around Maldon, Essex: Resource sheet TL 80. J. D. Ambrose.
Report 73/1 ISBN 0 11 880600 9 £1.20

5 The sand and gravel resources of the country around Hethersett, Norfolk: Resource sheet TG 10.
E. F. P. Nickless.
Report 73/4 ISBN 0 11 880606 8 £1.60

6 The sand and gravel resources of the country around Terling, Essex: Resource sheet TL 71. C. H. Eaton.
Report 73/5 ISBN 0 11 880608 4 £1.20

7 The sand and gravel resources of the country around Layer Breton and Tolleshunt D'Arcy, Essex: Resource sheet TL 91 and part of TL 90. J. D. Ambrose.
Report 73/8 ISBN 0 11 880614 9 £1.30

8 The sand and gravel resources of the country around Shotley and Felixstowe, Suffolk: Resource sheet TM 23.
R. Allender and S. E. Hollyer.
Report 73/13 ISBN 0 11 880625 4 £1.60

9 The sand and gravel resources of the country around Attlebridge, Norfolk: Resource sheet TG 11.
E. F. P. Nickless.
Report 73/15 ISBN 0 11 880658 0 £1.85

10 The sand and gravel resources of the country west of Colchester, Essex: Resource sheet TL 92. J. D. Ambrose.
Report 74/6 ISBN 0 11 880671 8 £1.45

11 The sand and gravel resources of the country around Tattingstone, Suffolk: Resource sheet TM 13. S. E. Hollyer.
Report 74/9 ISBN 0 11 880675 0 £1.95

12 The sand and gravel resources of the country around Gerrards Cross, Buckinghamshire: Resource sheet SU 99, TQ 08 and TQ 09. H. C. Squirrell.
Report 74/14 ISBN 0 11 880710 2 £2.20

Mineral Assessment Reports

13 The sand and gravel resources of the country east of Chelmsford, Essex: Resource sheet TL 70. M. R. Clarke.
ISBN 0 11 880744 7 £3.50

14 The sand and gravel resources of the country east of Colchester, Essex: Resource sheet TM 02. J. D. Ambrose.
ISBN 0 11 880745 5 £3.25

15 The sand and gravel resources of the country around Newton on Trent, Lincolnshire: Resource sheet SK 87.
D. Price.
ISBN 0 11 880746 3 £3.00

16 The sand and gravel resources of the country around Braintree, Essex: Resource sheet TL 72. M. R. Clarke.
ISBN 0 11 880747 1 £3.50

17 The sand and gravel resources of the country around Besthorpe, Nottinghamshire: Resource sheet SK 86 and part of SK 76. J. R. Gozzard.
ISBN 0 11 880748 X £3.00

18 The sand and gravel resources of the Thames Valley, the country around Cricklade, Wiltshire: Resource sheet SU 09/19 and parts of SP 00/10. P. R. Robson.
ISBN 0 11 880749 8 £3.00

19 The sand and gravel resources of the country south of Gainsborough, Lincolnshire: Resource sheet SK 88 and part of SK 78. J. H. Lovell.
ISBN 0 11 880750 1 £2.50

20 The sand and gravel resources of the country east of Newark upon Trent, Nottinghamshire: Resource sheet SK 85.
J. R. Gozzard.
ISBN 0 11 880751 X £2.75

21 The sand and gravel resources of the Thames and Kennet Valleys, the country around Pangbourne, Berkshire: Resource sheet SU 67. H. C. Squirrell.
ISBN 0 11 880752 8 £3.25

22 The sand and gravel resources of the country north-west of Scunthorpe, Humberside: Resource sheet SE 81.
J. W. C. James.
ISBN 0 11 880753 6 £3.00

23 The sand and gravel resources of the Thames Valley, the country between Lechlade and Standlake: Resource sheet SP 30 and parts of SP 20, SU 29 and SU 39. P. Robson.
ISBN 0 11 881252 1 £7.25

24 The sand and gravel resources of the country around Aldermaston, Berkshire: Resource sheet SU 56 and SU 66. H. C. Squirrell.
ISBN 0 11 881253 X £5.00

25 The celestite resources of the area north-east of Bristol: Resource sheet ST 68 and parts of ST 59, 69, 79, 58, 78, 68 and 77. E. F. P. Nickless, S. J. Booth and P. N. Mosley.
ISBN 0 11 881262 9 £5.00

26 The limestone and dolomite resources of the country around Monyash, Derbyshire: Resource sheet SK 16.
F. C. Cox and D. McC. Bridge.
ISBN 0 11 881263 7 £7.00

27 The sand and gravel resources of the country west and south of Lincoln, Lincolnshire: Resource sheets SK 95, SK 96 and SK 97. I. Jackson.
ISBN 0 11 884003 7 £6.00

28 The sand and gravel resources of the country around Eynsham, Oxfordshire: Resource sheet SP 40 and part of SP 41. W. J. R. Harries.
ISBN 0 11 884012 6 £3.00

29 The sand and gravel resources of the country south-west of Scunthorpe, Humberside: Resource sheet SE 80.
J. H. Lovell.
ISBN 0 11 884013 4 £3.50

30 Procedure for the assessment of limestone resources.
F. C. Cox, D. McC. Bridge and J. H. Hull.
ISBN 0 11 884030 4 £1.25

31 The sand and gravel resources of the country west of Newark upon Trent, Nottinghamshire: Resource sheet SK 75.
D. Price and P. J. Rogers.
ISBN 0 11 884031 2 £3.50

32 The sand and gravel resources of the country around Sonning and Henley, Berkshire, Oxfordshire and Buckinghamshire: Resource sheet SU 77 and SU 78.
H. C. Squirrell.
ISBN 0 11 884032 0 £5.25

33 The sand and gravel resources of the country north of Gainsborough, Lincolnshire: Resource sheet SK 89.
J. R. Gozzard and D. Price
ISBN 0 11 884033 9 £4.50

34 The sand and gravel resources of the Dengie Peninsula, Essex: Resource sheet TL 90, etc. M. B. Simmons.
ISBN 0 11 884081 9 £5.00

35 The sand and gravel resources of the country around Darvel, Strathclyde: Resource sheet NS 53, 63, etc.
E. F. P. Nickless, A. M. Aitken and A. A. McMillan.
ISBN 0 11 884082 7 £7.00

36 The sand and gravel resources of the country around Southend-on-Sea, Essex: Resource sheets TQ 78, 79 etc. S. E. Hollyer and M. B. Simmons.
ISBN 0 11 884083 5 £7.50

37 The sand and gravel resources of the country around Bawtry, South Yorkshire: Resource sheet SK 69. A. R. Clayton
ISBN 0 11 884053 3 £5.75

38 The sand and gravel resources of the country around Abingdon, Oxfordshire: Resource sheet SU 49, 59, SP 40, 50. C. E. Corser.
ISBN 0 11 884084 5 £5.50

39 The sand and gravel resources of the Blackwater Valley (Aldershot) area: Resource sheet SU 85, 86, parts SU 84, 94, 95, 96. M. R. Clarke, A. J. Dixon and M. Kubala.
ISBN 0 11 884085 1 £7.00

40 The sand and gravel resources of the country west of Darlington, County Durham: Resource sheet NZ 11, 21. A. Smith.
ISBN 0 11 884086 X £5.00

41 The sand and gravel resources of the country around Garmouth, Grampian Region: Resource sheet NJ 36. A. M. Aitken, J. W. Merritt and A. J. Shaw.
ISBN 0 11 884090 8 £8.75

42 The sand and gravel resources of the country around Maidenhead and Marlow: Resource sheet SU 88, parts SU 87, 97, 98. P. N. Dunkley.
ISBN 0 11 884091 6 £5.00

43 The sand and gravel resources of the country around Misterton, Nottinghamshire: Resource sheet SK 79. D. Thomas and D. Price.
ISBN 0 11 884092 4 £5.25

44 The sand and gravel resources of the country around Sedgefield, Durham: Resource sheet NZ 32. M. D. A. Samuel.
ISBN 0 11 884093 2 £5.75

45 The sand and gravel resources of the country around Brampton, Cumbria: Resource sheet NY 55, part 56. I. Jackson.
ISBN 0 11 884094 0 £6.75

46 The sand and gravel resources of the country around Harlow, Essex: Resource sheet TL 41. P. M. Hopson.
ISBN 0 11 884107 6 £9.50

47 The limestone and dolomite resources of the country around Wirksworth, Derbyshire: Resource sheet SK 25, part 35. F. C. Cox and D. J. Harrison.
ISBN 0 11 884108 4 £15.00

48 The sand and gravel resources of the Loddon Valley area: Resource sheet SU 75, 76, parts 64, 65, 66 and 74. M. R. Clarke, E. J. Raynor and R. A. Sobey.
ISBN 0 11 884109 2 £8.75

49 The sand and gravel resources of the country around Lanark, Strathclyde Region: Resource sheet NS 94, part 84. J. L. Laxton and E. F. P. Nickless.
ISBN 0 11 884112 2 £11.00

50 The sand and gravel resources of the country around Fordingbridge, Hampshire: Resource sheet SU 11 and parts of SU 00, 01, 10, 20 and 21. M. Kubala.
ISBN 0 11 884111 4 £7.75

51 The sand and gravel resources of the country north of Bournemouth, Dorset: Resource sheet SU 00, 10, 20, SZ 09, 19 and 29. M. R. Clarke.
ISBN 0 11 884110 6 £9.75

52 The sand and gravel resources of the country between Hatfield Heath and Great Waltham, Essex: Resource sheet TL 51 and 61. R. J. Marks.
ISBN 0 11 884113 0 £8.00

53 The sand and gravel resources of the country around Cottenham, Cambridgeshire: Resource sheet TL 46 and 47. A. J. Dixon.
ISBN 0 11 884114 9 £9.25

54 The sand and gravel resources of the country around Huntingdon and St Ives. Cambridgeshire: Resource sheets TL 16, 17, 26, 27, 36 and 37. R. W. Gatliff.
ISBN 0 11 884115 7 £8.75

55 The sand and gravel resources of the country around Ipswich, Suffolk: Resource sheet TM 14. R. Allender and S. E. Hollyer.
ISBN 0 11 884116 5 £10.00

56 Procedure for the assessment of the conglomerate resources of the Sherwood Sandstone Group. D. P. Piper and P. J. Rogers.
ISBN 0 11 884143 2 £1.25

57 The conglomerate resources of the Sherwood Sandstone Group of the country around Cheadle, Staffordshire: Resource sheet SK 04. P. J. Rogers, D. P. Piper and T. J. Charsley.
ISBN 0 11 884144 0 £7.75

58 The sand and gravel resources of the country west of Peterhead, Grampian Region: Resource sheet NK 04 and parts of NJ 94 and 95, NK 05, 14 and 15. A. A. McMillan and A. M. Aitken.
ISBN 0 11 884145 9 £12.00

59 The sand and gravel resources of the country around Newbury, Berkshire: Resource sheet SU 46 and 57, parts of SU 36, 37 and 47. J. R. Gozzard.
ISBN 0 11 884146 7 £11.50

60 The sand and gravel resources of the country south-west of Peterborough, in Cambridgeshire and east Northamptonshire: Resource sheet TL 09 and 19 and SP 98 and TL 08. A. M. Harrisson.
ISBN 0 11 884147 5 £15.50

61 The sand and gravel resources of the country north of Wrexham, Clwyd: Resource sheet SJ 35 and part of SJ 25. P. N. Dunkley.
ISBN 0 11 884148 3 £11.75

62 The sand and gravel resources of the country around Dolphinton, Strathclyde Region, and West Linton, Borders Region: Resource sheet NT 04 and 14, parts of NT 05 and 15. A. A. McMillan, J. L. Laxton and A. J. Shaw.
ISBN 0 11 884149 1 £8.00

63 The sand and gravel resources of the valley of the Douglas Water, Strathclyde Region: Resource sheet NS 83 and parts of NS 82, 92 and 93. A. J. Shaw and E. F. P. Nickless.
ISBN 0 11 884150 5 £11.50

64 The sand and gravel resources of the country between Wallingford and Goring, Oxfordshire: Resource sheet SU 68 and part of SU 58. C. E. Corser.
ISBN 0 11 884151 3 £11.50

65 The sand and gravel resources of the country around Hexham, Northumberland: Resource sheet NY 86 and 96. J. H. Lovell.
ISBN 0 11 884152 1 £7.50

66 The sand and gravel resources of the country west of Chelmsford, Essex: Resource sheet TL 60. P. M. Hopson.
ISBN 0 11 884153 X £8.50

67 The sand and gravel resources of the country around Hatfield and Cheshunt, Hertfordshire: Resource sheet TL 20 and 30, and parts of TQ 29 and 39. J. R. Gozzard.
ISBN 0 11 884167 X £10.00

68 The sand and gravel resources of the country north-east of Halstead, Essex: Resource sheet TL 83. R. J. Marks and J. W. Merritt.
ISBN 0 11 884168 8 £13.25

69 The sand and gravel resources of the country around Welwyn Garden City. Hertfordshire: Resource sheet TL 11 and 21. J. R. Gozzard.
ISBN 0 11 884169 6 £10.50

70 The sand and gravel resources of the country east of Harrogate, North Yorkshire: Resource sheet SE 35. D. L. Dundas.
ISBN 0 11 884170 7 £15.50

71 The sand and gravel resources of the country around Hemel Hempstead, St Albans and Watford: Resource sheet TL 00, 10, and parts TQ 09, 19.
W. J. R. Harries, S. E. Hollyer and P. M. Hopson.
ISBN 0 11 884171 8 £12.00

72 The sand and gravel resources of the country around Bury St Edmunds, Suffolk: Resource sheet TL 86.
M. P. Hawkins.
ISBN 0 11 884172 6 £10.50

73 The sand and gravel resources of the country between Ely and Cambridge, Cambridgeshire: Resource sheet TL 56, 57. A. R. Clayton.
ISBN 0 11 884173 4 £9.50

74 The sand and gravel resources of the country around Blaydon, Tyne and Wear: Resource sheet NZ 06, 16.
J. R. A. Giles.
ISBN 0 11 884174 2 £10.50

75 The sand and gravel resources of the country around Stokesley, North Yorkshire: Resource sheet NZ 40, 50 and parts 41, 51. R. G. Crofts.
ISBN 0 11 884175 0 £11.50

76 The sand and gravel resources of the country around Ellon, Grampian Region: Resource sheets NJ 93 with parts 82, 83, 92, and NK 03 with parts 02, 13. J. W. Merrit.
ISBN 0 11 884176 9 £15.00

77 The limestone and dolomite resources of the country around Buxton, Derbyshire: Resource sheet SK 07 and parts 06, 08. D. J. Harrison.
ISBN 0 11 884177 7 £13.50

78 The sand and gravel resources of the country west of Boroughbridge, North Yorkshire: Resource sheet SE 36.
D. A. Abraham.
ISBN 0 11 884178 5 £12.75

79 The limestone and dolomite resources of the country around Bakewell, Derbyshire: Resource sheet SK 26 and part 27. D. McC. Bridge and J. R. Gozzard.
ISBN 0 11 884179 3 £10.50

80 The sand and gravel resources of the country between Stamford, Lincolnshire, and Peterborough, Cambridgeshire: Resource sheet TF 00, 10. S. J. Booth.
ISBN 0 11 884180 7 £14.50

81 The sand and gravel resources of the country of the Thames and Thame valleys, the country around Dorchester and Watlington, Oxfordshire: Resource sheet SU 69 and part 59. C. E. Corser.
ISBN 0 11 884204 8 £14.25

82 The sand and gravel resources of the country around Sible Hedingham, Essex: Resource sheet TL 73.
R. J. Marks and D. W. Murray.
ISBN 0 11 884205 6 £10.75

83 The sand and gravel resources of the country around Hollesley, Suffolk: Resource sheet TM 34.
S. E. Hollyer and R. Allender.
ISBN 0 11 884206 4 £13.25

84 The sand and gravel resources of the country around Kirk Hammerton, North Yorkshire: Resource sheet SE 45.
J. R. A. Giles.
ISBN 0 11 884207 2 £10.00

85 The sand and gravel resources of the country around Nayland, Suffolk: Resource sheet TL 93. P. M. Hopson.
ISBN 0 11 884208 0 £11.25

86 The sand and gravel resources of the country around Wem, Shropshire: Resource sheet SJ 42, 52.
B. Cannell and W. J. R. Harries.
ISBN 0 11 884209 9 £15.50

87 The sand and gravel resources of the country around Ranskill and East Retford, Nottinghamshire: Resource sheet SK 68 and part 78. D. Thomas.
ISBN 0 11 884210 2 £8.50

88 The sand and gravel resources of the country around Tholthorpe, North Yorkshire: Resource sheet SE 46.
R. Stanczyszyn.
ISBN 0 11 884211 0 £13.00

89 The sand and gravel resources of the country around Newport-on-Tay, Fife Region: Resource sheet NO 42 and parts 32, 52. J. L. Laxton and D. L. Ross.
ISBN 0 11 887413 6 £12.75

90 The sand and gravel resources of the country around Shrewsbury, Shropshire: Resource sheet SJ 41, 51.
B. Cannell.
ISBN 0 11 884213 7 £17.00

91 The conglomerate resources of the Sherwood Sandstone Group of the country east of Stoke-on-Trent, Staffordshire: Resource sheet SJ 94. D. Piper.
ISBN 0 11 884214 5 £7.00

92 The sand and gravel resources of the country around Armthorpe, South Yorkshire: Resource sheet SE 60. D. Price and D. P. Best.
ISBN 0 11 884215 3 £10.00

93 The sand and gravel resources of the country around Whittlesey, Cambridgeshire: Resource sheet TF 20, TL 29.
S. J. Booth.
ISBN 0 11 884216 1 £12.50

94 The sand and gravel resources of the country north and west of Woodhall Spa, Lincolnshire: Resource sheet TF 16 and part 17. I. Jackson.
ISBN 0 11 884217 X £14.75

95 The sand and gravel resources of the country around Biggar, Strathclyde Region: Resource sheet NS 93, NT 03, and parts NS 92, NT 02. A. J. Shaw and J. W. Merritt.
ISBN 0 11 887414 4 £15.00

96 The sand and gravel resources of the country around Potter Hanworth and Reepham, Lincolnshire: Resource sheet TF 06, 07. R. G. Crofts.
ISBN 0 11 884216 6 £9.75

97 The sand and gravel resources of the country around Clare, Suffolk: Resource sheet TL 74. R. Marks.
ISBN 0 11 884297 8 £10.00

98 The limestone and dolomite resources of the country around Tideswell, Derbyshire: Resource sheet SK 17 and parts 18, 27. R. W. Gatliff.
ISBN 0 11 884298 6 £14.50

99 The sand and gravel resources of the country north and west of Billingham, Cleveland: Resource sheet NZ 42 and part 52. J. W. C. James.
ISBN 0 11 884299 4 £10.50

100 The sand and gravel resources of the country around Billinghay, Lincolnshire: Resource sheet TF 15 and part 05.
J. B. L. Wild.
ISBN 0 11 884300 1 £13.75

101 The sand and gravel resources of the country around Glenrothes, Fife Region: Resource sheet NO 20 and parts 21, 30, 31. A. M. Aitken.
ISBN 0 11 887415 2 £15.00

102 The sand and gravel resources of the country around Coggeshall, Essex: Resource sheet TL 82. S. J. Booth and J. W. Merrit.
ISBN 0 11 887416 0 £16.00

103 The sand and gravel resources of the country between Dorchester and Wareham, Dorset: Resource sheets comprising parts of SY 68, 69, 78, 79, 88, 89, 98, 99.
S. J. Mathers.
ISBN 0 11 884303 6 £17.00

104 The sand and gravel resources of the country around Stansted Mountfitchet, Essex: Resource sheet TL 52.
P. M. Hopson.
ISBN 0 11 884304 4 £11.75

105 The sand and gravel resources of the Welshampton area, Shropshire and Clwyd: Resource sheet SJ 43. Institute of Geological Sciences.
ISBN 0 11 884305 2 £12.00

106 The sand and gravel resources of the country south of Wrexham, Clwyd: Resource sheet SJ 34 and part 24. D. F. Ball.
ISBN 0 11 884306 0 £11.00

107 The sand and gravel resources of the country between Rugby and Northampton, Warwickshire and Northamptonshire: Resource sheet SP 66 and parts 56, 57, 65, 67, 75 and 76. M. R. Clarke and E. R. Moczarski.
ISBN 0 11 884307 9 £20.00

108 The sand and gravel resources of the country south of Horncastle, Lincolnshire: Resource sheet TF 26. G. Power and J. B. L. Wild.
ISBN 0 11 884308 7 £9.75

109 The sand and gravel resources of the country around Great Dunmow, Essex: Resource sheet TL 62. C. W. Thomas.
ISBN 0 11 884309 5 £12.75

110 The sand and gravel resources of the country north of Newmarket, Cambridgeshire and Suffolk: Resource sheet TL 67 and part 66. C. E. Corser.
ISBN 0 11 884310 9 £14.50

111 The sand and gravel resources of the country east and south-east of Darlington, Durham: Resource sheet NZ 30, 31. J. R. Gozzard and D. Price.
ISBN 0 11 884311 7 £14.25

112 The sand and gravel resources of the country around Hertford, Hertfordshire: Resource sheet TL 31. P. M. Hopson and M. D. A. Samuel.
ISBN 0 11 884312 5 £11.75

113 The sand and gravel resources of the country around Mold, Clwyd: Resource sheet SJ 26 and part 16. D. F. Ball and K. A. McL. Adlam.
ISBN 0 11 884313 3 £12.00

114 The sand and gravel resources of the country around Kettering and Wellingborough, in parts of Northamptonshire, Cambridgeshire and Bedfordshire: Resource sheets SP 86, 96, and SP 97 and parts SP 87, TF 07. A. M. Harrisson.
ISBN 0 11 884314 1 *not yet priced*

115 The sand and gravel resources of the country east of Solihull, Warwickshire: Resource sheet comprising parts of SP 17, 18, 27, 28. B. Cannell.
ISBN 0 11 884315 X £10.75

116 The limestone resources of the Craven Lowlands: Resource sheet comprising parts of 1:50000 geological sheets 59, 69, 61, 67, 68 and 69. D. J. Harrison.
ISBN 0 11 884316 8 £15.00

117 The sand and gravel resources of the country around Redgrave, Suffolk: Resource sheet TM 07 and part 08. C. A. Auton.
ISBN 0 11 884317 6 *not yet priced*

118 The sand and gravel resources of the country around Sudbury, Suffolk: Resource sheet TL 84. P. M. Hopson.
ISBN 0 11 884318 4 £12.50

119 The sand and gravel resources of the country around Bedale, North Yorkshire: Resource sheet SE 28. J. R. A. Giles.
ISBN 0 11 884319 2 £11.75

Reports of the Institute of Geological Sciences

Other Reports

69/9 Sand and gravel resources of the Inner Moray Firth. A. L. Harris and J. D. Peacock.
ISBN 0 11 880106 6 35p

70/4 Sands and gravels of the southern counties of Scotland. G. A. Goodlet.
ISBN 0 11 880105 8 90p

72/8 The use and resources of moulding sand in Northern Ireland. R. A. Old.
ISBN 0 11 881594 0 30p

73/9 The superficial deposits of the Firth of Clyde and its sea lochs. C. E. Deegan, R. Kirby, I. Rae and R. Floyd.
ISBN 0 11 880617 3 95p

77/1 Sources of aggregate in Northern Ireland (2nd edition). I. B. Cameron.
ISBN 0 11 881279 3 70p

77/2 Sand and gravel resources of the Grampian Region. J. D. Peacock and others.
ISBN 0 11 881282 3 80p

77/5 Sand and gravel resources of the Fife Region. M. A. E. Browne.
ISBN 0 11 884004 5 60p

77/6 Sand and gravel resources of the Tayside Region. I. B. Paterson.
ISBN 0 11 884008 8 £1.40

77/8 Sand and gravel resources of the Strathclyde Region. I. B. Cameron and others.
ISBN 0 11 884028 2 £2.50

77/9 Sand and gravel resources of the Central Region, Scotland. M. A. E. Browne.
ISBN 0 11 884016 9 £1.35

77/19 Sand and gravel resources of the Borders Region, Scotland. A. D. McAdam.
ISBN 0 11 884025 8 £1.00

77/22 Sand and gravel resources of the Dumfries and Galloway Region of Scotland. I. B. Cameron.
ISBN 0 11 884021 5 £1.20

78/1 Sand and gravels of the Lothian Region of Scotland. A. D. McAdam.
ISBN 0 11 884042 8 £1.00

78/8 Sand and gravel resources of the Highland Region. W. Mykura, D. L. Ross and F. May.
ISBN 0 11 884050 9 £3.00

Dd 717419 C10

Printed in England for Her Majesty's Stationery Office by Commercial Colour Press, London E7

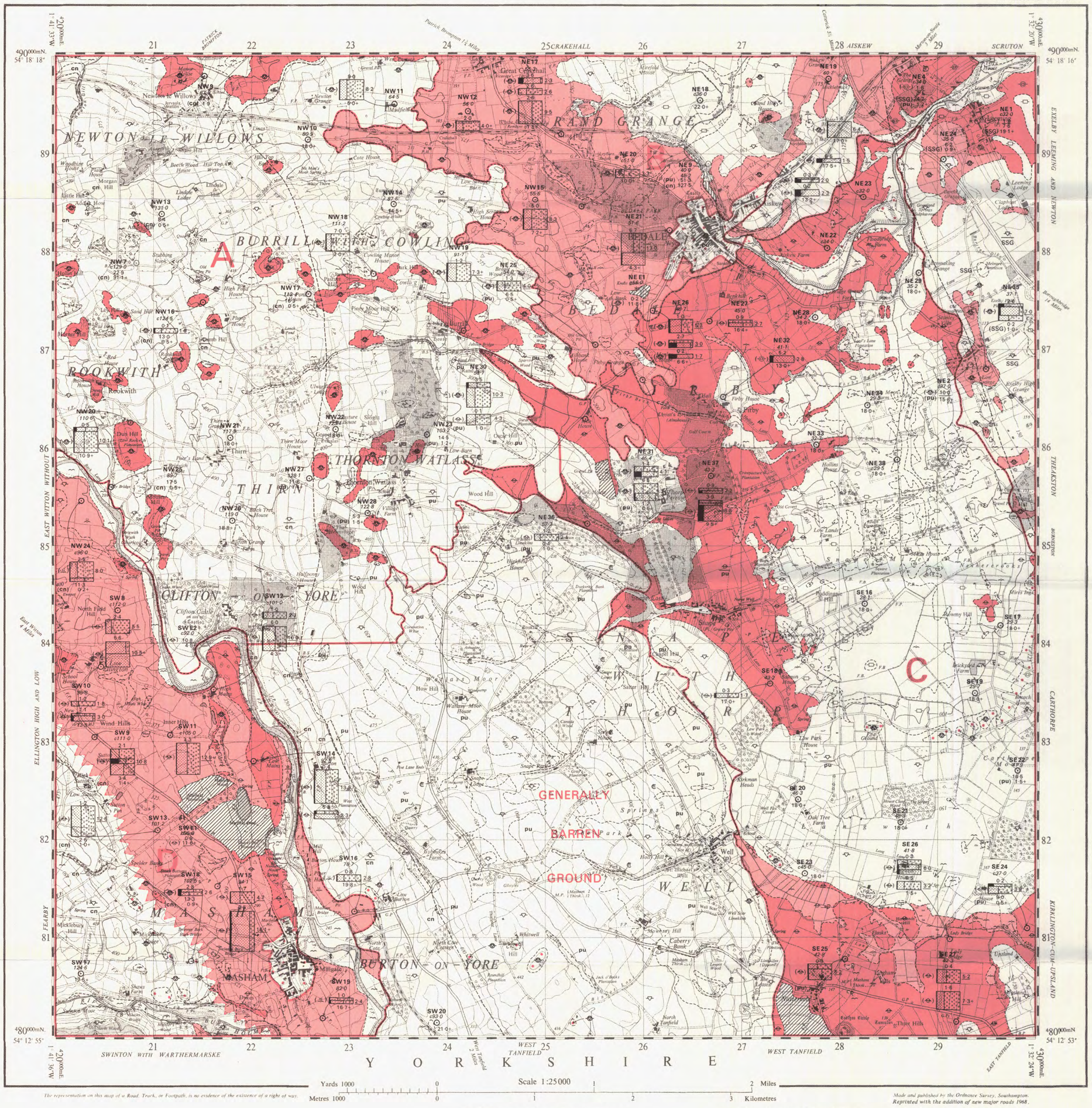
INSTITUTE OF GEOLOGICAL SCIENCES

INDUSTRIAL MINERALS ASSESSMENT UNIT

THE SAND & GRAVEL RESOURCES OF SHEET SE 28 (BEDALE, NORTH YORKSHIRE.)

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

ORDNANCE SURVEY
SHEET SE 28
PROVISIONAL EDITION



THE SAND & GRAVEL RESOURCES OF SHEET SE 28 (BEDALE, NORTH YORKSHIRE.)

119

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

EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Landslip L-1

DRIFT

RECENT AND PLEISTOCENE

- **Peat** P-1
- **Calcareous Tufa** CT-2
- **Alluvium** -clay and silt A-35
- **Alluvial Fan** AF-4
- **River Terrace Deposits, undifferentiated** -gravel, silt and clay RT-28
- **Head** H-12
- **Fluvio-glacial Sand and Gravel** -clean to 'very clayey' sand and gravel with clay and silt partings FL-22
- **Glacial Lake Deposits**
  - **Sand** -'clayey' sand S-4
  - **Silt and Clay** -laminated clay with silt and sand SI-6
- **Laminated Clay associated with glacial deposits** -laminated clay LC-3
- **Glacial Sand and Gravel** -clean to 'very clayey' sand and gravel with clay partings GS-58
- **Till** -stony clay TL-9

SOLID

PERMO-TRIASSIC / CARBONIFEROUS

- **SSG** **Sherwood Sandstone Group** -reddish brown, fine-to coarse-grained sandstone
- **pu** **Upper Permian (undivided)** -dolomite, dolomitic limestone and mudstone with gypsum
- **cn** **Namurian** -sandstone, shale, siltstone and limestone

Areas worked for sand and gravel WO-20

BOUNDARY LINES

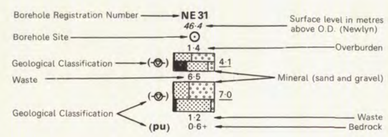
- Geological boundary, Drift.
- Geological boundary, Solid.
- Resource Block boundary.
- Inferred boundary between recognised categories of deposits.
  Broken line denotes uncertainty.

BOREHOLE DATA

SITE LOCATIONS

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

I.M.A.U. BOREHOLES



Note:
(i) Figures underlined denote thicknesses used in the assessment of resources.
(ii) The + sign indicates that the base of the deposit was not reached.
(iii) The 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 31** The letters refer to the quarter sheet and the figures to the I.G.S serial number for that quarter. The unique designation for borehole **NE 31** is **SE 28 NE 31**

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 ✳. Reference number and deatils of thickness are shown.

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, Keyworth, Nottingham. NG12 5GG.

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

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

Geological lines from 1:10 560 surveys by A. H. Cooper, J. G. O. Smart and A. A. Wilson in 1978-1980. J. G. O. Smart and E. G. Smith, District Geologists.

Sand and Gravel Survey by J. R. A. Giles assisted by C. Corser, J. H. Lovell, R. Stanczyszyn and J. B. L. Wild in 1980. R. G. Thurrell, Head, Industrial Minerals Assessment Unit.

1:25 000 Sand and Gravel Resource Sheet published 1982. G. M. Brown, D.Sc., F.R.S., Director, Institute of Geological Sciences. 1100/82

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.

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.

Compiled from 6" sheets last fully revised 1911 – 28. Other partial systematic revision 1950 – 51 has been incorporated.

Major roads revised 1967.

Made and published by the Ordnance Survey, Southampton. Reprinted with the addition of new major roads 1968.

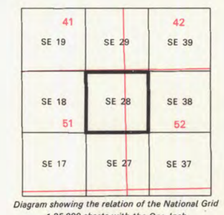


Diagram showing the relation of the National Grid 1:25 000 sheets with the One-Inch Geological Sheets 41, 42, 51 and 52.