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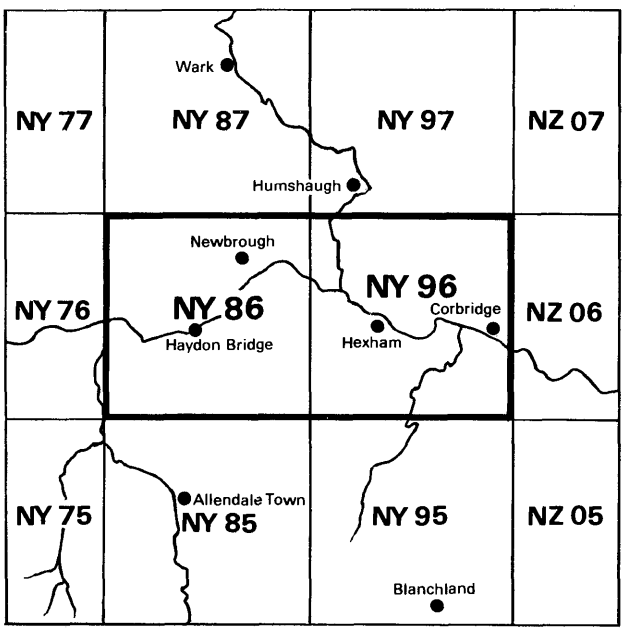

The sand and gravel resources of the country around Hexham, Northumberland

Description of 1:25 000 resource sheet NY 86 and 96

J. H. Lovell

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The first twelve reports on the assessment of British sand and gravel resources appeared in the Report series of the Institute of Geological Sciences as a subseries. Report 13 and subsequent reports appear as Mineral Assessment Reports of the Institute.

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

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PREFACE

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

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

This report describes the sand and gravel resources of 200 km^2 of country around Hexham and Corbridge. The survey was conducted by Mr J. H. Lovell; Miss L. M. Cooper and Messrs R. G. Crofts, J. R. A. Giles and I. Jackson assisted in the drilling programme and data preparation. The work is based on the original one-inch scale geological survey by Institute Field Staff and published in 1881, with partial revision on the six-inch scale between 1929–49 and 1968–78. The geological lines are now presented at the 1:25 000 scale. The account of the geology of the district includes a contribution by Dr D. W. Holliday, formerly of the North-Eastern England and Cumbria Unit.

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

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J. H. LOVELL

SUMMARY

The geological maps of the Institute of Geological Sciences, pre-existing borehole information and 56 boreholes drilled for the Industrial Minerals Assessment Unit form the basis of the assessment of sand and gravel resources in the district around Hexham, Northumberland.

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

The 1:25 000 map is divided into three resource blocks, containing between 6.2 and 14.3 km^2 of sand and gravel. For each block the geology of the deposits is described. The mineral bearing area, the mean thicknesses of overburden and mineral and the mean gradings are also stated. Detailed borehole data are also given. The geology, the positions of the boreholes and the outlines of the resource blocks are shown on the accompanying map.

Note

All National Grid references in this report lie within the 100-km square NY

Bibliographic reference

LOVELL, J. H. 1981. The sand and gravel resources of the country around Hexham, Northumberland: Description of 1:25 000 resource sheet NY 86 and 96. *Miner. Assess. Rep. Inst. Geol. Sci.*, No. 65.

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INTRODUCTION

The survey is concerned with the estimation of resources, which include deposits that are not currently exploitable but have a foreseeable use, rather than reserves, which can only be assessed in the light of current, locally prevailing economic considerations. Clearly, both the economic and the social factors used to decide whether a deposit may be workable in the future cannot be predicted; they are likely to change with time. Deposits not currently economically workable may be exploited as demand increases, as higher grade or alternative materials become scarce, or as improved processing techniques are applied to them. The improved knowledge of the main physical properties of the resource and their variability, which this survey seeks to provide, will add significantly to the factual background against which planning policies can be decided (Archer, 1969; Thurrell, 1971; Harris and others, 1974).

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

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

The following arbitrary physical criteria have been adopted:

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

A deposit of sand and gravel which 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.

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 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).

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

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

DESCRIPTION OF THE DISTRICT

GENERAL

The district, Figure 1, is one of high relief, lying between 30 and 61 m (100 and 200 ft) above Ordnance Datum in the river valleys and rising to almost 305 m (1000 ft) on the fells in the north and south. It is drained eastwards by the rivers North and South Tyne which form the River Tyne below their confluence, together with numerous small tributaries.

The small market town of Hexham is the main centre of habitation and industry, with Haydon Bridge and Corbridge as the only other major settlements. Lines of communication follow the river valleys, and the Tyne Valley carries major east-west communication routes.

Agriculture and associated service industries are the major sources of employment in the area, with light industry confined to Hexham. Locally, forestry and stone-quarrying are important. Gravel is dredged occasionally from the bed of the River Tyne, but extraction for local purposes was formerly widespread. Coal and metalliferous mining, formerly important, are now defunct. Tourists are drawn to the area in summer by numerous important Roman remains, for example Hadrian's Wall.

GEOLOGY

Carboniferous strata together with associated intrusive igneous rocks and mineral veins underlie the district, and crop out intermittently. The geological sequence is summarised in Table 1. No detailed description of the local geology has been published, but general accounts may be found in Dunham (1948) and Taylor and others (1971).

Table 1 Geological sequence

DRIFT	
Recent and Pleistocene	Peat Alluvium River Terrace deposits Glacial Sand and Gravel Boulder Clay
SOLID	
Carboniferous	Coal Measures (Westphalian) Stainmore Group, with Great Limestone at base (Namurian) Upper Liddesdale Group (Viséan)
Permo-Carboniferous intrusive igneous rocks	Whin Sill and associated dyke

SOLID

Upper Liddesdale Group

Southwards-dipping rocks of this group form high ground in the north-west, but are poorly exposed. They

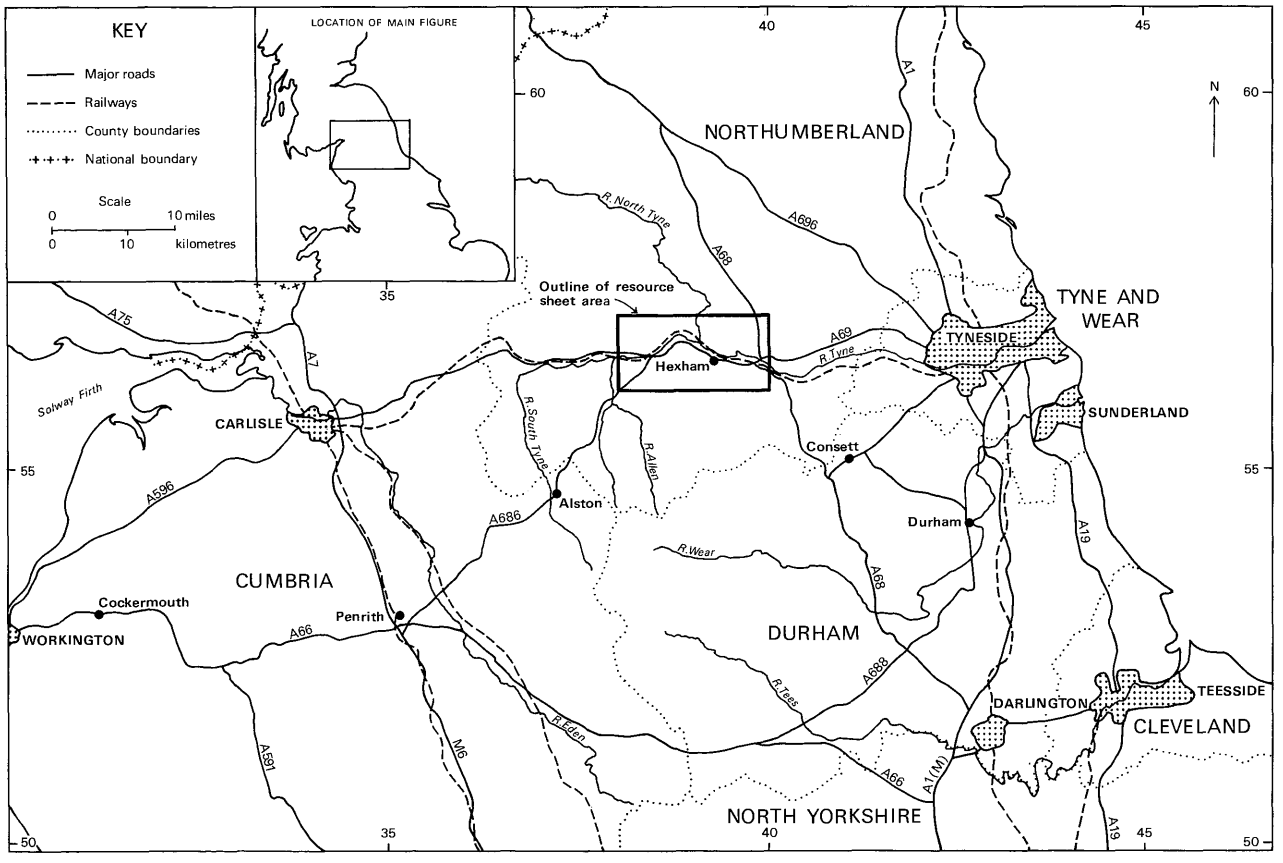


Figure 1 Sketch map showing the location of the resource sheet area (Ordnance Survey 1:25 000 sheets NY 86 and 96).

consist of interbedded limestones, sandstones, shales and thin coals, and were deposited in a marine and deltaic environment.

Stainmore Group
Rocks of the Stainmore Group (which broadly includes the Upper Limestone Group and Millstone Grit of earlier classifications) crop out throughout the area. Their base is taken at the base of the Great Limestone (Johnson and others, 1962), a thick and persistent member which crops out in the north and west. The rocks are largely deltaic in origin, but they do contain marine strata and, towards the top, beds of probable fluvial origin. Two facies can be recognised; a lower sequence of limestones, shales and thin sandstones (Hedley and Waite, 1929) and an upper, more arenaceous facies consisting of coarse-grained, massive sandstones with intercalations of mudstones and flaggy sandstones. Thin coal seams occur in both facies.

Coal Measures
Lower Coal Measures rocks are poorly exposed on high ground in the south of the area and they have also been identified but not mapped south of Corbridge. The rocks consist of a cyclic sequence of shales, sandstones and coals, and represent deposition in a coastal swamp environment, with rare marine incursions.

Igneous
The Whin Sill crops out intermittently in the north and north-west of the area and forms the highest ground (Holmes and Harwood, 1928; Frost and Holliday, *in press*). It is intruded into rocks of the Liddesdale Group, and consists of black, fine- to medium-grained quartz dolerite. Its thickness is variable, with 45 m proved in old mine shafts near Settlingstones [846 682]; it thickens north-eastwards to a maximum of 67 m just north of this district.

The Haydon Bridge or St Oswald's Church Dyke crosses the district with an east-north-easterly trend, and is petrologically similar to the Whin Sill.

DRIFT

Boulder Clay
During the late Devensian, a thick ice sheet containing locally-derived material and erratics from southern Scotland and the Lake District moved eastwards across the area (Taylor and others, 1971). Consequently much of the district is mantled with Boulder Clay, which ranges in thickness from a thin veneer to about 60 m in old mine workings near Settlingstones [846 682]. Generally it is a tough, grey or brown clay containing sand lenses and pebbles and boulders of sandstone, limestone, greywacke, acid igneous rock and dolerite. Locally, the Boulder Clay as mapped contains clays of late- or post-glacial age. Clays of this type may be found overlying Glacial Sand and Gravel and are thought to result from solifluxion or from fluvial or lacustrine reworking of Boulder Clay. In the north, the clays are dark grey, silty and relatively pebble-free.

Glacial Sand and Gravel
Coarse gravels occur in the Tyne valley, chiefly along the south bank. West of Greenshaw Plain [893 662] the deposits are thin, discrete and intimately associated with Boulder Clay. Farther east they are thicker, coarser grained and continuous, forming prominent features which resemble moraines, but they become patchy again east of Hexham. A patch of hummocky sand and gravel occurs north of Corbridge, while in the south-east, around Houtley Bank [941 611] thick sequences of fine gravel and 'very clayey' sand are thought to resemble delta-front sands. Small, thin patches of sand and gravel also occur elsewhere.

River Terrace deposits
These deposits infill the major river valleys and are also associated with tributaries throughout the area.

Two terraces (First and Second) have been mapped along the rivers South Tyne, Tyne and its tributary, with tops between 30–78 and 34–87 metres above Ordnance Datum respectively. They comprise sands, 'clayey' sands and gravels, ranging up to at least 20 metres thick and resting locally on Boulder Clay. More recent mapping in the North Tyne valley has recognised terraces, but has not differentiated them. These Undifferentiated terraces lie between 50 and 67 metres above Ordnance Datum and the deposits are generally much thinner and less gravelly than the First or Second terraces.

Alluvium
The Alluvium of the Tyne Valley infills a deep channel cut into pre-existing deposits. Its top falls from about 77 m above Ordnance Datum in the west to about 25 m above Ordnance Datum in the east. The upper facies is thin and consists of silt, clay and some peat, with sand lenses. The thicker lower facies exhibits great lateral variation and contains sand and gravel in varying proportions with some silt bands. Elsewhere thin alluvium is associated with streams and with peaty Boulder Clay on higher ground.

Peat
Peat occurs on high ground in the north-west and south-west, and commonly rests in hollows which mark the position of former late- and post-glacial lakes (Frost and Holliday, *in press*). It is also associated with the Alluvium.

COMPOSITION OF THE SAND AND GRAVEL DEPOSITS

The potentially workable sand and gravel deposits in the district are the Glacial Sand and Gravel, the First, Second and Undifferentiated terraces and the Alluvium, together with lenses of sand and gravel which occur with Boulder Clay. Pebble counts for specified samples are shown in Table 2.

Glacial Sand and Gravel
These deposits (including those in borehole 96 SW 17, where Glacial Sand and Gravel occurs beneath Boulder Clay) have a mean grading of fines 12 per cent, sand 56 per cent and gravel 32 per cent, but show considerable lateral variation. Along the Tyne valley, gravels predominate, but in the south-west around Newbiggin [944 608] the deposits are much more sandy. The gravel fraction, which reaches a maximum of 79 per cent in borehole 96 SW 14, consists mainly (Table 2) of subrounded to well rounded yellowish brown Carboniferous sandstones, with some dark grey and green Lower Palaeozoic greywackes and greenish grey acid igneous rocks of Borrowdale Volcanic Group type. Carboniferous limestone and mudstone, together with pink granites from the Lake District or south-west Scotland, dolerite pebbles and quartzites constitute the remainder. The sand fraction reaches a maximum of 88 per cent in the basal parts of borehole 96 SE 17, and consists of rounded to well rounded quartz grains and rock fragments, with a small percentage of coal fragments. Fines reach a maximum of 22 per cent in borehole 86 NE 28, although up to 40 per cent has been recorded for individual samples, for example in borehole

Table 2 Pebble counts (by weight and number) for the gravel (+4 mm) fractions of selected samples from the Tyne Valley

Borehole number	Sample depth	Geological classification	Method of calculation	Constituent rocks types (percentages)					
				Quartz	Quartzite	Sandstone	Limestone Mudstone	Igneous	Other
	m								
NY 96 NW 29	1.2–2.3	Glacial Sand and gravel	by weight	trace	1	77	10	12	–
			by number	2	3	65	13	17	–
NY 96 SW 18	5.4–6.4	Glacial Sand and Gravel	by weight	trace	6	78	5	11	–
			by number	1	5	75	8	11	–
NY 96 SE 17	3.5–4.8	Glacial Sand and Gravel	by weight	trace	4	90	1	5	–
			by number	6	4	72	8	10	–
NY 96 NW 26	3.1–4.3	Undifferentiated Terrace	by weight	1	5	65	18	10	1
			by number	trace	6	69	19	2	4
NY 96 NW 30	5.4–6.4	First Terrace	by weight	trace	3	87	2	8	–
			by number	1	5	81	7	6	–
NY 86 NE 26	1.2–2.2	Alluvium	by weight		19	60	7	14	–
			by number		1	94	3	2	–
NY 96 SE 16	6.2–7.2	Alluvium	by weight	1	6	74	9	10	–
			by number	3	4	69	10	14	–

96 SW 16. The fines consist of greyish and reddish brown micaceous silt.

River Terraces (First, Second and Undifferentiated)
The First and Second terraces differ little in grading or composition; the mean figures are fines 8 per cent, sand 52 per cent, gravel 40 per cent and fines 11 per cent, sand 46 per cent and gravel 43 per cent respectively. The gravel fraction consists mainly of well rounded Carboniferous sandstones with some Lower Palaeozoic greywackes, and some limestone, pink granite and green acid igneous rocks. The Second Terrace contains a higher percentage of limestone and igneous rocks than the First. The sand fraction consists of subangular to well rounded quartz grains and rock fragments, and the fines consist of reddish brown and grey micaceous and clayey silts.

The Undifferentiated terraces have a mean grading of fines 8 per cent, sand 32 per cent and gravel 60 per cent, based on samples from 3 boreholes. The composition is similar to the First and Second terraces, although a higher limestone content has been recorded.

Alluvium
This deposit has a mean grading of fines 8 per cent, sand 53 per cent and gravel 39 per cent, although it exhibits considerable vertical and lateral variations. Gravel percentages of up to 82 per cent occur, for example in borehole 96 NW 32, and the sand and fines factions reach maxima of 93 and 24 per cent in boreholes 96 NW 28 and 96 NW 32 respectively. The lithological composition is similar to that of the river terraces.

Note on former workings
Throughout the area small pits bear witness to the former extraction of sand and gravel for local purposes. Gravel was dredged from the bed of the River South Tyne at Haydon Bridge until terminated by scour problems, and is occasionally dredged from the bed of the River Tyne at Hexham. Otherwise, no large workings are known.

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

Geological data: The geological boundary lines are taken from the sources shown at the foot of the map. The boundaries are the best interpretation of the information available at the time of survey. However, it is inevitable, particularly with glacial deposits (such as those included in this area) which change rapidly vertically and laterally, that local irregularities or discrepancies will be revealed by some boreholes (as, for example, at borehole 96 SW17). These are taken into account in the assessment of resources. Borehole data, which include the stratigraphical relations and mean particle size distributions of the sand and gravel samples collected during the assessment survey, are also shown.

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

On this sheet the mineral is subdivided into areas where it crops out and areas where it is present in continuous spreads beneath over-burden. However, within these areas there may be small patches where sand and gravel is absent or not potentially workable, for example, around borehole 96 NW 27. Areas where bedrock crops out, where superficial deposits are classified as non-mineral and where sand and gravel is deemed to be not potentially workable are shown uncoloured. Areas of unassessed sand and gravel are indicated by a red stipple.

For the most part, the distribution of categories of deposits is based on the mapped geological boundaries. Where there is a transition from one category to another which cannot be related to the geological lines and which could not be delineated accurately during the survey, inferred boundaries, shown by a distinctive symbol, have been inserted. The symbol is intended to signify an approximate location within a likely zone of occurrence rather than to represent the breadth of the zone, its size being limited only by cartographic considerations. For the purpose of measuring areas the centre-line of the symbol is used.

Table 3 Statistical assessment of the sand and gravel resources

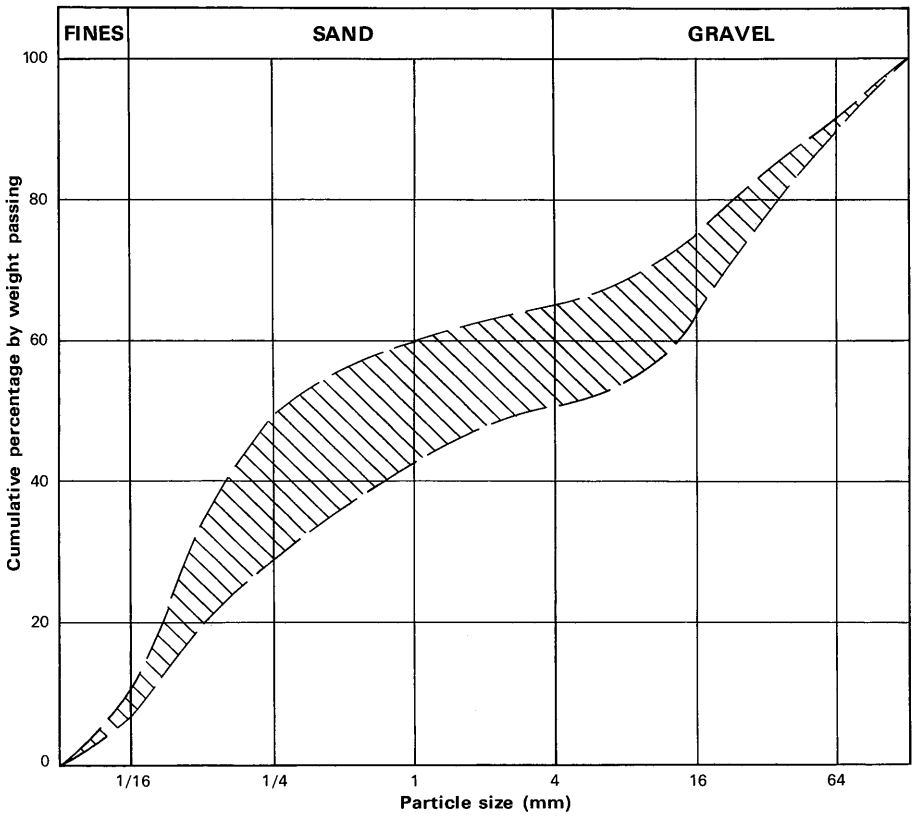
Resource Block	Area		Mean thickness			Volume of mineral			Mean grading percentage			
	Block	Mineral	Over-burden	Mineral	Waste		Limits at the 95% confidence level		Fines $\frac{1}{16}$	Sand $+\frac{1}{16}-4$	Gravel $+4-64$	Cobbles $+64$
	km^2	km^2	m	m	m	$10^6\ m^3$	± %	± $10^6\ m^3$	mm	mm	mm	mm
A	6.3	6.2	1.3	6.9	2.0	43	50	21	7	44	38	11
B	9.9	9.6	1.7	5.4	1.1	52	60	31	11	54	26	9
C	14.7	14.3	1.4	11.7	2.0	167	26	43	9	55	30	6
	0.3*											
	1.9†											
	166.9‡											
Sheet	200	30.1	1.5	8.7	1.7	262	23	60	9	52	29	8

* Haydon Bridge urban area, not assessed.
† Hexham urban area, not assessed.
‡ Barren area.

RESULTS

The statistical results are summarised in Table 3 and Figure 2. Fuller grading particulars are shown in Tables 4 to 6 and Figures 3 to 5. Up to 11 data points have been used in plotting each grading curve.

For the 3 resource blocks on this sheet the confidence limits at the 95 per cent probability level vary between 26 and 60 per cent (that is, it is probable that nineteen times out of twenty the true volumes present will be within the stated limits). However, the true values are more likely to be nearer the figure estimated than the limits. Moreover, it is probable that in each block, approximately the same percentage limits would apply for the estimate of volume of a very much smaller parcel of ground (say 1 km^2) containing similar sand and gravel deposits if the results from the same number of sample points (as provided by, say, ten boreholes) were used in the calculation. Thus, if closer limits are needed for the quotation of reserves of part of a block, it can be expected that data from more than ten sample points will be required, even if the area is quite small. This point can be illustrated by considering the whole of the potentially workable sand and gravel in



Envelope within which the mean grading curves for the blocks fall.

RESOURCE BLOCK	Cumulative percentage by weight passing					
	1/16mm	1/4mm	1mm	4mm	16mm	64mm
A	7	29	43	51	64	89
B	11	49	60	65	75	91
C	9	41	57	64	76	94

Figure 2 Mean particle size distribution for the assessed thickness of sand and gravel in Resource Blocks A to C.

resource blocks A to C on this sheet. The volume (262 million m³) can be estimated to limits of ± 23 per cent at the 95 per cent confidence level by a calculation based on data from 55 sample points spread across the 3 resource blocks. However, it must be emphasised that the quoted volume of sand and gravel has no simple relationship with the amount which could be extracted in practice, as no allowance has been made in the calculations for any restraints (such as existing buildings and roads) on the use of the land for mineral working.

NOTES ON RESOURCE BLOCKS

Mineral in this district occurs mainly in deposits along the river valleys, and resource block boundaries have been drawn accordingly. Boreholes 86 NW 14 to 19, and 86 NE 21 and 22 were drilled in an attempt to prove a buried valley but mineral was not found; additionally boreholes 86 SW 34 to 37 failed to locate mineral south of the South Tyne Valley. Elsewhere all IMAU boreholes fall within resource block boundaries.

Block A

This block contains deposits laid down along the South Tyne Valley, and is divided into western and eastern portions by the small urban area of Haydon Bridge. Sand and gravel occurs in the Alluvium, 1st and 2nd terraces and the Glacial Sand and Gravel, but owing to the great lateral and vertical grading variations in, and lithological similarity of, the deposits, they are not differentiated at depth in the borehole records.

Generally the resource block boundaries follow geological boundaries, except for areas around boreholes 86 NE 27 and 86 NE 38, and near Wood Hall [863 646]. In these areas the Glacial Sand and Gravel has been proved, by remapping and additional borehole information, to occur in lenses beneath Boulder Clay, and the block boundaries represent the best attempt to delimit the mineral-bearing areas. Further upstream, west of Haydon Bridge, the Glacial Sand and Gravel deposits are not present, as proved by boreholes 86 SW 34–37, and the block boundaries follow the junction between Boulder Clay and river deposits.

The block has a mineral-bearing area of 6.2 km². Data from 12 IMAU boreholes have been used to calculate the resources of the block, and are summarised in Figure 3 and Table 4. Additionally, 9 confidential records have been used. The mineral consists of sands, 'clayey' sands, sandy gravels and gravels, and reaches maximum proved thicknesses of 10.0, 18.1 and 14.5 m in the Alluvium, 1st and 2nd terraces respectively, although the full thickness of mineral was not proved in many boreholes because of the difficulties encountered in drilling and sampling in the deposits. The Glacial Sand and Gravel reaches a maximum proved thickness of 16.8 m in a drumlin-like feature around borehole 86 NE 28, although the deposit is generally much thinner. For the whole block the mean mineral thickness is 6.9 m and the mean grading is fines 7 per cent, sand 44 per cent and gravel 49 per cent (including 11 per cent cobbles). The estimated total mineral volume is 43 million m³ ± 21 million m³.

Overburden, which has a mean thickness of 1.6 m, consists mainly of alluvial silt. Waste partings consisting mainly of laminated clay and silt occur generally in the deposits in the river valley, and reach a maximum thickness of 8.0 m in borehole 86 NE 28. Their mean thickness, however, is no more than 2 m.

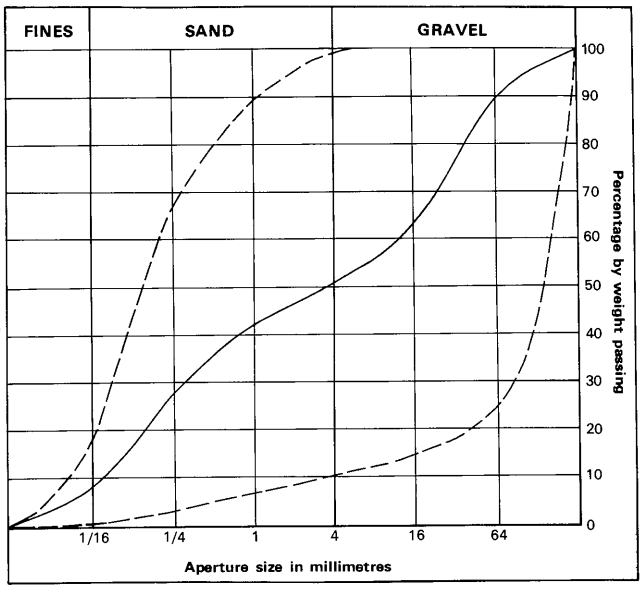


Figure 3 Grading characteristics of the mineral in Block A; the continuous line represents the weighted mean grading of the block; the broken lines denote the envelope within which the mean grading curves for individual boreholes fall.

Table 4 Block A: data used in the assessment of the resources

Borehole No.	Recorded thickness		Mean grading percentage						
	Mineral	Overburden	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}-1$ mm	Coarse sand $+1-4$ mm	Fine gravel $+4-16$ mm	Coarse gravel $+16-64$ mm	Cobbles $+64$ mm
	m	m							
NY 86 NE 27	1.0	1.2	8	4	6	8	6	36	32
NY 86 NE 28	16.8+*	0.2	19	48	12	3	4	11	3
NY 86 NE 38	3.6+	3.7	*no data available*						
NY 86 SW 26	10.0+	0.3	8	19	7	8	13	27	18
NY 86 SW 27	14.5+	2.5	3	7	10	14	19	36	11
NY 86 SW 28	18.1+	0.6	6	31	29	4	8	15	7
NY 86 SW 29	5.7	0.3	1	2	4	7	25	41	20
NY 86 SW 30	2.2	1.2	1	2	7	13	26	42	9
NY 86 SW 31	7.1+	3.5	6	11	15	10	20	30	8
NY 86 SW 32	2.8	1.0	2	5	8	9	19	34	23
NY 86 SW 33	5.4	0.5	2	11	6	8	19	32	23
NY 86 SE 12	2.6	0.8	4	10	26	8	14	30	8

* The + means that the full thickness of mineral was not proved in the borehole.

Block B

Although it is geologically similar to Block A, this block also includes the North Tyne valley, in which river terrace deposits have not been differentiated. Mineral-bearing deposits have an area of 9.6 km²; the mineral-free area of 0.3 km² consists of outcrops of bedrock and boulder clay. Data from 14 IMAU boreholes have been used to assess the resources of the block, and are summarised in Figure 4 and Table 5.

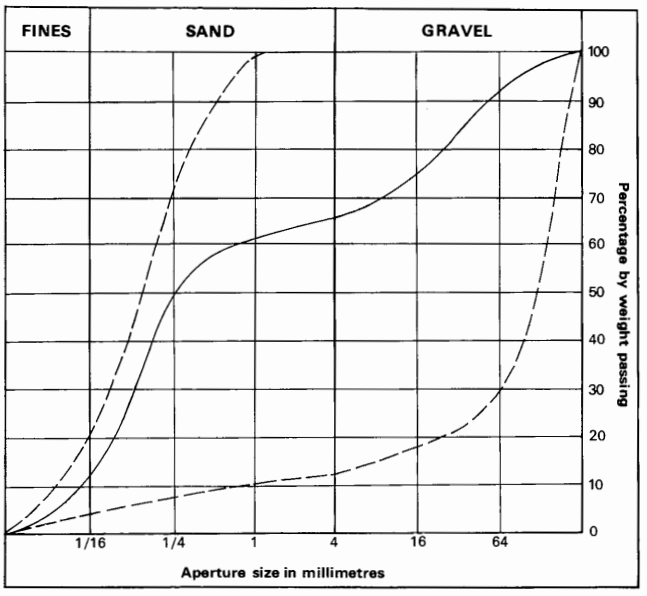


Figure 4 Grading characteristics of the mineral in Block B (for explanation see Figure 3).

Mineral in the Alluvium, 1st, 2nd and Undifferentiated terraces consists of sands, 'clayey' sands, sandy gravels and gravels, and ranges up to a maximum proved thickness of 17.2 m in borehole 96 NW 28. Mineral occurring in the North Tyne valley is generally much thinner and less coarse than that in the South Tyne valley. The Glacial Sand and Gravel varies greatly in thickness; borehole 96 NW 27 proved no mineral but confidential records suggest considerable thicknesses in the south of the block. For the whole block, the mean thickness of mineral is 5.4 m and the mean grading is fines 11 per cent, sand 54 per cent and gravel 35 per cent (including 9 per cent cobbles). Estimated mineral volume is 52 million m³ ± 31 million m³.

Overburden has a mean thickness of 1.7 m, and consists of silt and clay. Waste partings reach a maximum thickness of 9.9 m in borehole 96 NW 32, but are otherwise thin with a mean thickness of 1.1 m. They consist mainly of laminated clay.

Block C

This block has a mineral-bearing area of 14.3 km², and data from 19 IMAU boreholes and 8 confidential records have been used to assess the resources; details of IMAU boreholes are summarised in Figure 5 and Table 6. The mineral-bearing deposits are the Alluvium, 1st, 2nd and Undifferentiated terraces and the Glacial Sand and Gravel. The latter deposit occurs along the south-west and southern margin of the main resource block, and in two patches to the north and south with areas of 1 km² and 1.6 km² respectively. These patches consist mainly of sandy deposits, whereas the Glacial Sand and Gravel within the main area contains coarse gravels; together

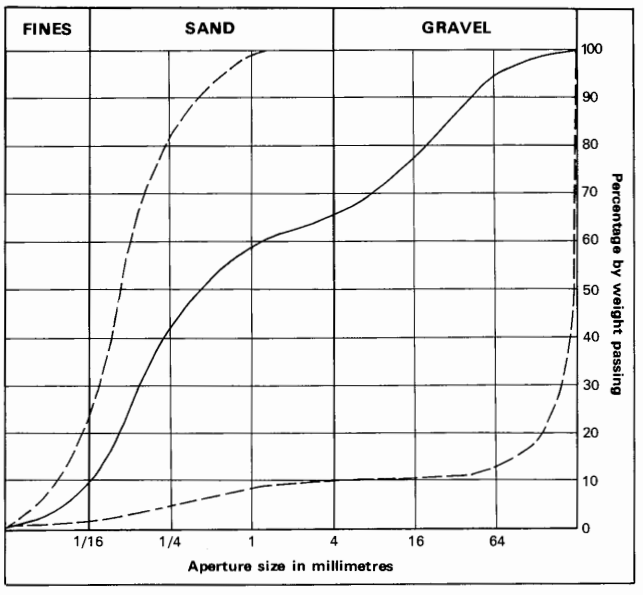


Figure 5 Grading characteristics of the mineral in Block C (for explanation see Figure 3).

Table 5 Block B: data used in the assessment of the resources

Borehole No.	Recorded thickness		Mean grading percentage						
	Mineral	Overburden	Fines $\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$–$\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}$–1 mm	Coarse sand +1–4 mm	Fine gravel +4–16 mm	Coarse gravel +16–64 mm	Cobbles +64 mm
	m	m							
NY 86 NE 23	1.5	1.5	4	4	3	7	31	29	22
NY 86 NE 24	15.4	0.3	20	50	7	3	6	10	4
NY 86 NE 25	6.0	0.2	2	13	11	8	21	30	15
NY 86 NE 26	3.1	0.2	2	11	17	4	10	36	20
NY 86 NE 29	2.7	0.2	18	39	23	2	6	12	0
NY 86 NE 30	1.2	4.5	3	13	13	6	21	22	22
NY 96 NW 24	0.0	3.2	–	–	–	–	–	–	–
NY 96 NW 25	1.0	1.5	6	3	12	11	32	30	6
NY 96 NW 26	3.0	1.3	8	16	10	8	25	30	3
NY 96 NW 27	0.0	10.0	–	–	–	–	–	–	–
NY 96 NW 28	17.2+*	0.7	7	44	14	3	6	15	11
NY 96 NW 29	2.1	0.2	10	33	30	10	7	10	0
NY 96 NW 31	2.0	1.1	9	13	10	9	22	30	7
NY 96 NW 32	11.5	0.2	17	51	7	2	6	12	5

* The + means that the full thickness of mineral was not proved in the borehole.

they have a mean thickness of 9.7 m. Mineral in the Alluvium reaches a maximum proved thickness of 21.8 m in borehole 96 SE 16, and the 1st and 2nd terraces reach maximum proved thicknesses of 19.9 m and 8.4 m in boreholes 96 NE 35 and 96 NE 36 respectively. For the whole block the mean mineral thickness is 11.7 m, and the estimated volume of mineral present is 167 million $m^3 \pm$ 43 million m^3. The mean grading is fines 9 per cent, sand 55 per cent and gravel 36 per cent (including 6 per cent cobbles).

Overburden is generally thin, except in borehole 96 SW 17, where 7.5 m of clay overlie mineral, with a mean thickness of 1.4 m. Waste partings consisting mainly of laminated clay occur in several boreholes and have a mean thickness of 2.0 m.

Table 6 Block C: data used in the assessment of the resources

Borehole No.	Recorded thickness		Mean grading percentage						
	Mineral	Overburden	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}-1$ mm	Coarse sand $+1-4$ mm	Fine gravel $+4-16$ mm	Coarse gravel $+16-64$ mm	Cobbles $+64$ mm
	m	m							
NY 96 NW 30	7.9	0.2	23	48	11	2	4	8	4
NY 96 NW 33	21.7+*	0.1	20	56	6	3	4	8	3
NY 96 NE 35	19.0+	0.9	12	55	11	5	6	9	2
NY 96 NE 36	8.4	0.5	13	34	5	4	14	27	3
NY 96 NE 37	1.8	1.2	10	25	27	6	17	15	0
NY 96 NE 40	6.0	1.4	14	27	32	1	4	18	4
NY 96 SW 14	15.4	0.3	5	6	5	9	17	37	21
NY 96 SW 15	12.5	2.0	3	10	15	10	21	32	9
NY 96 SW 16	6.0+	0.2	20	61	16	1	1	1	0
NY 96 SW 17	5.1	7.5	10	37	13	11	10	17	2
NY 96 SW 18	10.3	0.5	5	21	30	13	14	16	1
NY 96 SE 13	20.8	0.4	5	18	19	11	18	20	9
NY 96 SE 14	21.7+	0.1	9	54	24	3	3	6	1
NY 96 SE 15	17.0+	1.3	11	39	18	5	11	13	3
NY 96 SE 16	21.8+	3.2	2	13	21	9	21	25	9
NY 96 SE 17	12.3	0.5	8	36	15	3	8	24	6
NY 96 SE 18	4.5	1.1	3	21	37	12	11	11	5
NY 96 SE 19	7.3	2.8	5	7	10	9	19	38	12
NY 96 SE 20	2.0	1.5	1	3	4	4	8	37	43

* The + means that the full thickness of mineral was not proved in the borehole.

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, 10 km^2, is a compromise to meet the aims of the survey by providing sufficient sample points in each block. As far as possible the block boundaries are determined by geological boundaries so that, for example, glacial and river terrace gravels are separated. Otherwise division is by arbitrary lines, which may bear no relationship to the geology.

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 at a diameter of about 200 mm, 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 depth. The samples, each weighing between 25 and 45 kg, are despatched in heavy-duty polythene bags to a laboratory for grading. The grading procedure is based on British Standard 1377 (1967). Random checks on the accuracy of the grading are made in the Institute's laboratories.

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

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

APPENDIX B

STATISTICAL PROCEDURE

Statistical assessment

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

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

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

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

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 mean thickness, the standard deviation for volume approximates to that for mean thickness.

5 Given that the number of approximately evenly spaced sample points in the sampled area is n with mineral thickness measurements $l_{m_1}, l_{m_2}, \ldots l_{m_n}$, 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_{l_m}, expressed as a proportion of the mean thickness, is given by

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

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 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 $S_A / S_{\bar{l}_m} \leqslant \frac{1}{3}$ is assumed in all cases. It follows from equation [2] that

$$S_{\bar{l}_m} \leqslant S_V \leqslant 1.05\, S_{\bar{l}_m} \quad . \qquad [3]$$

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, 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: $L\bar{l}_m \leqslant L_v \leqslant 1.05\, L\bar{l}_m$

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

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

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 Figures 6 and 7.

Inferred assessment

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

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

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

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

APPENDIX C

CLASSIFICATION AND DESCRIPTION OF SAND AND GRAVEL

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

The terminology commonly used by geologists when describing sedimentary rocks (Wentworth, 1922) is not entirely satisfactory for this purpose. For example, Wentworth proposed that a deposit should be described as a 'gravelly sand' when it contains more sand than gravel and there is at least 10 per cent of gravel, provided that there is less than 10 per cent of material finer than sand (less than $\frac{1}{16}$ mm) and coarser than pebbles (more than 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 not considered to be potentially workable and falls outside the definition of mineral. Deposits which contain 40 per cent fines or less are classified primarily on the ratio of sand to gravel but qualified in the light of the fines content, as follows: less than 10 per cent fines—no qualification; 10 per cent or more but less than 20 per cent fines—'clayey'; 20 to 40 per cent fines—'very clayey'.

The term 'clay' (as written, with single quote marks) is used to describe all material passing $\frac{1}{16}$ 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 Figure 8). The procedure is as follows:

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

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

Many differing proposals exist for the classification of the grain size of sediments (Atterberg, 1905, Udden, 1914; Wentworth, 1922; Wentworth, 1935; Allen, 1936; Twenhofel, 1937; Lane and others, 1947). As Archer (1970a, b) has emphasised, there is a pressing need for a simple metric scale acceptable to both scientific and engineering interests, for which the class limit sizes correspond closely with certain marked changes in the natural properties of mineral particles. For example, there is an important change in the degree of cohesion between particles at about the $\frac{1}{16}$-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 (Table 7), which is used in this Report.

The fairly wide intervals in the scale are consistent with the general level of accuracy of the qualitative assessments of the resource blocks. Three sizes of sand are recognised, fine (+ $\frac{1}{16}$ − $\frac{1}{4}$ 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

Block calculation 1:25 000 Block } Fictitious

Area
Block: 11.08 km²
Mineral: 8.32 km²

Mean thickness
Overburden: 2.5 m
Mineral: 6.5 m

Volume
Overburden: 21 million m³
Mineral: 54 million m³

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

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

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

Calculation of confidence limits

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

$\Sigma(wl_m - \overline{wl_m})^2 = 15.82$
$n = 8$
t = 2.365

L_1 is calculated as

$$1.05\,(t/\overline{wl_m})\,\sqrt{[\Sigma\,(wl_m - \overline{wl_m})^2/n\,(n-1)]} \times 100$$
$$= 1.05 \times (2.365/6.5)\,\sqrt{[15.82/(8 \times 7)]} \times 100$$
$$= 20.3$$
$$\simeq 20 \text{ per cent}$$

Figure 6 Example of resource block assessment: calculation and results.

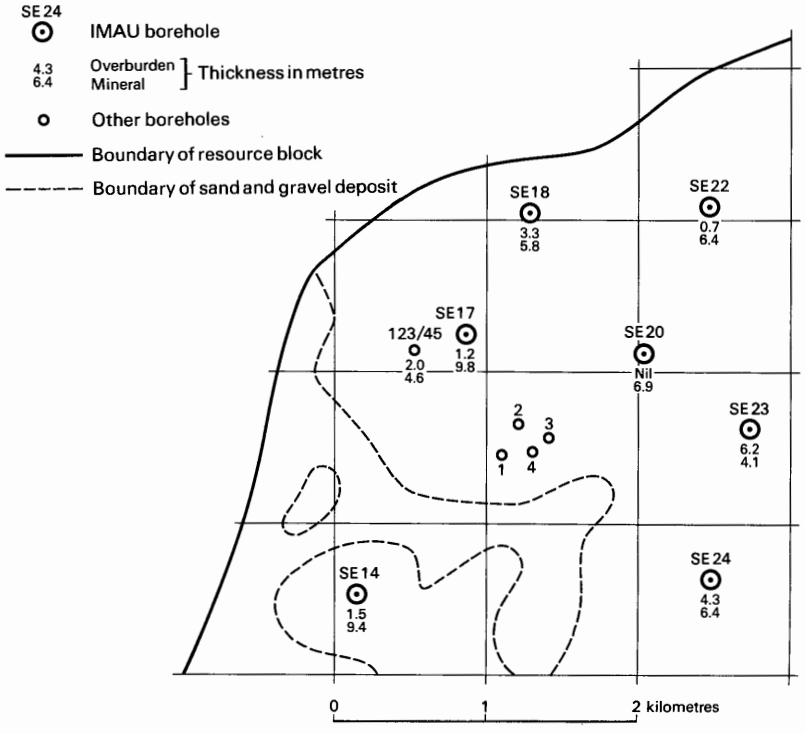


Figure 7 Example of resource block assessment: map of fictitious block.

Standard 1377: 1967). In this report the grading is tabulated on the borehole record sheets (Appendix F), the intercepts corresponding with the simple geometric scale $\frac{1}{16}$ 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 very approximate equal proportions with neither constituent accounting for less than about 25 per cent of the whole; 'flint with quartz' indicates that flint is dominant and quartz, the principal accessory rock type, comprises 5 to 25 per cent of the whole. Where the accessory material accounts for less than 5 per cent of the whole, but is still readily apparent, the phrase 'with some' has been used. Rare constituents are referred to as 'trace'.

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

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

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

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

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

Well-rounded: no original faces, edges or corners left. The entire surface consists of broad curves; flat areas are absent. The original shape is suggested by the present form of the grain.

Table 7 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

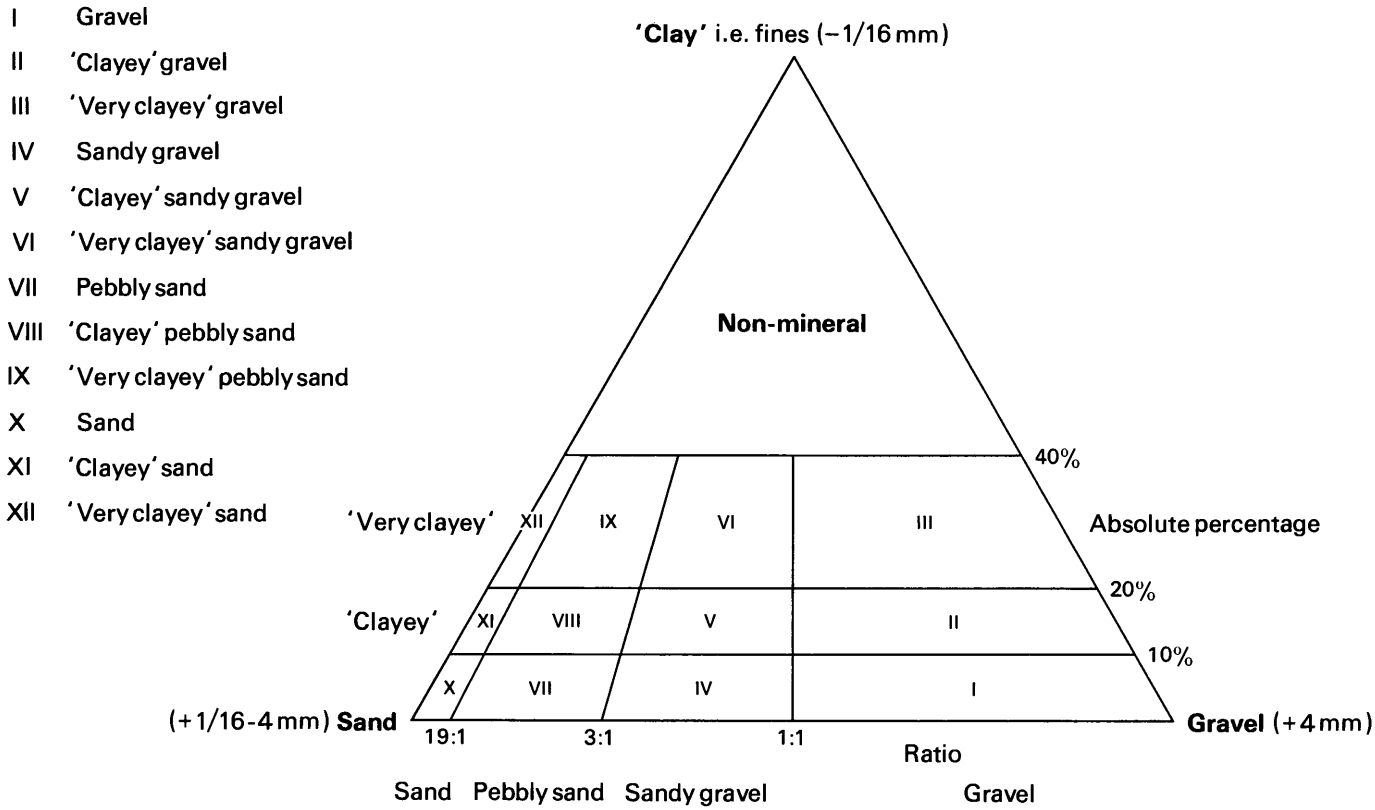


Figure 8 Diagram to show the descriptive categories used in the classification of sand and gravel.

APPENDIX D:
EXPLANATION OF THE BOREHOLE RECORDS

Annotated Example

NY 96 NW 29[1] **9079 6671**[2] **High Warden**[3] **Block B**

Surface level (+86.9 m) +285 ft[4]
Water not struck[5]
June 1975[6]

Overburden[7] 0.2 m
Mineral 2.1 m
Bedrock 1.4 m+[9]

LOG

Geological classification	Lithology	Thickness[8] m	Depth m
	Soil, brown, sandy	0.2	0.2
Glacial Sand and Gravel[10]	'Clayey' pebbly sand[11] Gravel: coarse and fine; well rounded quartzite, dark igneous rock and more angular yellow sandstone Sand: fine and medium; subrounded to rounded quartz and rock fragments Fines: yellow-brown silt	2.1	2.3
Stainmore Group	Mudstone, weathered at top, dark grey, silty, laminated, micaceous	1.4+	3.7

GRADING

Mean for deposit[14] *percentages*			Depth below surface (m)[12]	*percentages*[13]						
Fines	Sand	Gravel[14]		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
10	73	17	0.2–1.2	15	44	27	6	5	3	
			1.2–2.3	6	23	33	13	9	16	
			Mean	10	33	30	10	7	10	

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

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

1 The number of the 1:25 000 sheet on which the borehole lies, for example, NY 96.

2 The quarter of the 1:25 000 sheet on which the borehole lies and its number in a series for that quarter, for example, NW 29.

Thus the full Registration Number is NY 96 NW 29.

[In the text of this report usually the initial letters (NY) are not quoted.]

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

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

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

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

6 Type of Drill and Date of Drilling
A conventional shell and auger rig together with 12-, 10- and 8-inch diameter casing was used throughout the survey except for four boreholes which were drilled with a Minuteman 3 inch power auger. The month and year of completion of the borehole are stated.

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

8 Thickness and Depth
Measurements were made in metres. A conversion table from metres to feet is given in Appendix H.

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

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

11 Lithological description
When sand and gravel is recorded a general description based on the grading characteristics (for details see Appendix C) is followed by more detailed particulars. Where more than one mineral horizon is recognised, they are designated by the letters **a**, **b**, etc. The description of other rocks is based on visual examination in the field.

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

13 Grading results
The limits are as follows: gravel, +4 mm; sand, $-4+\frac{1}{16}$ mm; fines, $-\frac{1}{16}$ mm.

14 Mean Grading
The grading of the full thickness of the mineral horizons identified in the log is the mean of the grading of individual samples weighted by the thicknesses represented, if these vary. The classification used is shown in Table 7.

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

APPENDIX E

LIST OF BOREHOLES USED IN THE ASSESSMENT OF RESOURCES

Borehole number*	Grid references	Borehole number*	Grid references
IMAU BOREHOLES			
NY 66 NW 14	8484 6896	NY 96 NW 24	9047 6940
15	8416 6823	25	9157 6981
16	8122 6745	26	9136 6819
17	8315 6760	27	9230 6709
18	8069 6669	28	9028 6609
19	8193 6662	29	9079 6631
		30	9240 6624
NY 66 NE 21	8586 6934	31	9115 6558
22	8749 6980	32	9157 6572
23	8690 6762	33	9301 6526
24	8808 6763		
25	8866 6742	NY 96 NE 35	9522 6501
26	8989 6711	36	9715 6511
27	8542 6595	37	9803 6510
28	8692 6619	40	9986 6702
29	8876 6652		
30	8978 6611	NY 96 SW 14	9248 6498
38	8695 6545	15	9443 6469
		16	9380 6117
NY 66 SW 26	8022 6471	17	9445 6128
27	8046 6418	18	9340 6072
28	8099 6432		
29	8194 6396	NY 96 SE 13	9519 6436
30	8312 6413	14	9615 6483
31	8388 6442	15	9729 6417
32	8480 6447	16	9879 6411
33	8306 6384	17	9712 6326
34	8318 6323	18	9801 6367
35	8105 6380	19	9976 6375
36	8445 6370	20	9514 6107
37	8177 6300	OTHER BOREHOLES	
NY 66 SE 12	8574 6495	Twenty-one confidential borehole records	

* By sheet quadrant

APPENDIX F:

INDUSTRIAL MINERALS ASSESSMENT UNIT BOREHOLE RECORDS

NY 86 NW14 8484 6896 Settlingstones

Surface level (+146.3 m) +480 ft
Water not struck
September 1975

Waste 6.3 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, silty	0.7	0.7
Boulder Clay	Clay, brown, ochreous	1.5	2.2
	Clay, dark grey, hard, with pebbles of angular black mudstone, mineralised limestone and streaks of barytes	4.1	6.3
Upper Liddesdale Group	Sandstone, grey, argillaceous, carbonaceous	0.9+	7.2

NY 86 NW 15 8416 6823 Settlingstones

Surface level (+196.3 m) +644 ft
Water seepage at base of hole
June 1975

Waste 3.7 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pale, sandy	0.1	0.1
Boulder Clay	Clay, yellowish brown and grey, soft with rootlets and small sandstone pebbles	2.1	2.2
	Clay, dark grey, hard, with pebbles of sandstone, quartzite, dark limestone and shale	1.5	3.7
Upper Liddesdale Group	Limestone, dark grey	0.1+	3.8

NY 86 NW 16 8122 6745 Prior Park Plantation

Surface level (+215.5 m) +707 ft
Water not struck
June 1975

Waste 15.8 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark, sandy	0.1	0.1
Boulder Clay	Clay, soft, ochreous, contains roots	1.9	2.0
	Clay, hard, dark grey, contains boulders of white and yellow sandstone, dark limestone, shale and igneous rock	13.8	15.8
Stainmore Group	Limestone, dark grey	0.3+	16.1

NY 86 NW 17 8315 6760 Grindon Common

Surface level (+207.0 m) +679 ft
Water seepage at base of hole
June 1975

Waste 5.3 m
?Bedrock 1.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark, sandy, peaty	0.4	0.4
Boulder Clay	Clay, soft, yellow, sandy	1.0	1.4
	Clay, hard, dark grey, with boulders of limestone and sandstone	3.9	5.3
? Upper Liddesdale Group	Sandstone, white, with carbonaceous debris	1.7+	7.0

NY 86 NW 18 8096 6669 Muckle Moss

Surface level (+223.1 m) +732 ft
Water not struck
September 1975

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark, peaty	0.1	0.1
Boulder Clay	Clay, soft, grey and yellow, appears reworked; contains small pebbles of limestone and sandstone	1.4	1.5
	Clay, hard, dark grey and brown, with boulders of sandstone, limestone dolerite and some granite and mudstone	16.5+	18.0

NY 86 NW 19 8193 6662 Whinnetley Moss

Surface level (+203.9 m) +669 ft
Water not struck
September 1975

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark, peaty	0.3	0.3
Boulder Clay	Clay, soft, silty, yellow	1.7	2.0
	Clay, hard, dark grey, with boulders of sandstones, limestone and mudstone. Very uniform deposit	16.0+	18.0

NY 86 NE 21 8586 6934 Greyside

Surface level (+179.8 m) +590 ft
Water not struck
September 1975

Waste 1.4 m
? Bedrock 0.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Boulder Clay	Soil on clay, grey, ochreous with pebbles of sandstone and dolerite	1.4	1.4
? Whin Sill	Dolerite ? boulders	0.6+	2.0

NY 86 NE 22 8749 6980 Lane House

Surface level (+145.1 m) +476 ft
Water level +141.7 m (+465 ft)
September 1975

Waste 4.2 m
? Bedrock 0.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Topsoil, light brown, clayey	0.4	0.4
Boulder Clay	Clay, soft, yellowish-brown and grey, with rootlets and sand pockets	1.0	1.4
	Clay, hard, dark grey, with quartzite and dolerite pebbles	1.4	2.8
? Whin Sill	Dolerite, only fragments recovered	0.4+	4.6

NY 86 NE 23 8690 6762 Newbrough **Block B**

Surface level (+78.6 m) +258 ft
Water level +77.6 m (+255 ft)
September 1975

Overburden 1.5 m
Mineral 1.5 m
Waste 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Second Terrace	Soil on soft, grey and brown, micaceous silt with rootlets and sand pockets	1.5	1.5
	Gravel Gravel: fine, coarse and cobble; angular to subrounded quartzite, sandstone, limestones, dolerite and porphyry Sand: coarse, fine and medium; angular to subrounded quartz and rock fragments	1.5	3.0
Boulder Clay	Clay, dark grey with boulders of dolerite and limestone	1.0+	4.0
	Borehole abandoned on boulder obstruction		

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines $-\frac{1}{16}$	Sand $+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	Gravel $+4-16$	$+16-64$	$+64$
4	14	82	1.5–3.0	4	4	3	7	31	29	22

NY 86 NE 24 **8808 6763** **Fourstones** **Block B**

Surface level (+56.7 m) +186 ft
Water not encountered
September 1975

Overburden 0.3 m
Mineral 10.5 m
Waste 2.0 m
Mineral 4.9 m
Waste 3.3 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
First Terrace	**a** Gravel Gravel: coarse with fine and cobble; rounded to well rounded quartzite, green porphyry, dolerite and limestone with some granite, quartz and sandstone Sand: medium with coarse and fine; sub to well rounded quartz and rock fragments	3.7	4.0
	b 'Clayey' sand, 'very clayey' at base: fine; rounded quartz, with some rock fragments and brown silt	6.8	10.8
	Silt, sandy, greyish-brown	2.0	12.8
	c 'Very clayey' pebbly sand Gravel: fine; rounded sandstone Sand: fine; rounded quartz and rock fragments Fines: brownish-grey, micaceous.	4.9	17.7
Boulder Clay	Clay, hard, dark grey, with pebbles of sandstone and quartzite	3.3	21.0
Upper Liddesdale Group	Sandstone, grey, with plant remains	0.2+	21.2

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
a	1	24	75	0.3–1.3	2	1	10	12	26	37	12
				1.3–2.3	1	4	7	6	24	41	17
				2.3–4.0	1	2	19	8	14	40	16
				Mean	1	2	13	9	20	40	15
b	19	81	0	4.0–5.0	14	75	8	2	1		
				5.0–7.0	21	77	2				
				7.0–9.0	12	81	7				
				9.0–10.8	29	67	4				
				Mean	20	74	5	1			
c	34	60	6	12.8–14.8	40	55	5				
				14.8–17.7	30	47	9	5	7	2	
				Mean	34	51	7	3	4	1	

NY 86 NE 25 **8866 6724** **East Wharmley** **Block B**

Surface level (+50.0 m) +164 ft
Water level +48.0 m (+157.5 ft)
June 1975

Overburden 0.2 m
Mineral 6.0 m
Waste 4.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, silty	0.2	0.2
First Terrace	Gravel	6.0	6.2
	Gravel: coarse, fine and cobble; well rounded yellow and white quartzite and green acid volcanics with some quartz, granite, porphyry and conglomeratic sandstone		
	Sand: fine, medium and coarse; subrounded to subangular quartz and rock fragments		
Boulder Clay	Silt, olive-grey, soft, laminated, micaceous, pebbly towards base	1.8	8.0
	Clay, stiff, bluish-grey, sandy in parts, with boulders of limestone and sandstone	2.4+	10.4
	Borehole abandoned on boulders		

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
2	32	66	0.2–1.2	3	7	8	8	22	42	10
			1.2–2.2	3	13	20	10	16	24	14
			2.2–3.2	1	6	6	5	17	38	27
			3.2–4.2	1	9	16	12	26	21	15
			4.2–5.2	2	21	8	7	22	29	11
			5.2–6.2	2	21	8	7	23	28	11
			Mean	2	13	11	8	21	30	15

NY 86 NE 26 8989 6711 East Fourstones **Block B**

Surface level (+42.7 m) +140 ft
Water level +38.4 m (+126 ft)
September 1975

Overburden 0.2 m
Mineral 3.1 m
Waste 14.2 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown, silty	0.2	0.2
Alluvium	Gravel Gravel: coarse with cobble and fine; well rounded pale quartzite, dark grey, white and red sandstone with some dolerite, greenish volcanics, granite, quartz and porphyry Sand: medium with fine and coarse; subangular to rounded quartz and rock fragments	3.1	3.3
	Silt, dark grey, laminated, micaceous, pebbly towards base, very uniform	13.0	16.3
Boulder Clay	Clay, dark grey with pebbles of limestone and dolerite	1.2	17.5
Stainmore Group	Limestone, dark grey	0.3+	17.8

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
1	33	66	0.2–1.2	1	8	11	3	9	54	14
			1.2–2.2	1	5	15	4	8	37	30
			2.2–3.3	2	18	25	6	12	20	17
			Mean	1	11	17	5	10	36	20

NY 86 NE 27 **8542 6595** **East Brokenheugh** **Block A**

Surface level (+145.0 m) 476.5 ft
Water level +142.0 m (+467.5 ft)
September 1975

Overburden 1.2 m
Mineral 2.0 m
Bedrock 0.8 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.1	0.1
Boulder Clay	Clay, dark brown becoming yellow, sandy, silty and ochreous below 0.7 m	1.1	1.2
Glacial Sand and Gravel	Gravel Gravel: coarse and cobble with fine; subangular to well rounded sandy limestone Sand: coarse, medium and fine; subangular limestone chips and quartz	2.0	3.2
	Poor recovery between 2.2 and 3.2 m, boulder obstruction		
Upper Liddesdale Group	Mudstone, black, weathered, on soft grey sandstone	0.8+	4.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
8	18	74	1.2–2.2	8	4	7	8	6	35	32
			2.2–3.2	no recovery						

NY 86 NE 28 **8692 6619** **Bush Farm** **Block A**

Surface level (+94.5 m) +310.5 ft
Water level +80.5 m (+265 ft)
August 1975

Overburden 0.2 m
Mineral 12.0 m
Waste 8.0 m
Mineral 4.8 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, pebbly	0.2	0.2
Glacial Sand and Gravel	**a** 'Clayey' sandy gravel Gravel: fine and coarse; well rounded sandstones and quartzite, some greenish volcanics and granite Sand: medium and fine, some coarse; angular quartz and rock fragments Fines: brown silt	3.0	3.2
	b 'Very clayey' sand Sand: fine with medium; subrounded quartz and rock fragments with much coal debris Fines: brown, micaceous silt	9.0	12.2
	Silt, brown, with much fine sand	8.0	20.2
	c 'Very clayey' sand, components as above	2.0	22.2
	d Gravel Gravel: coarse with some cobble and fine; mainly angular fragments of locally derived yellow sandstone Sand: fine, subangular quartz fragments, yellowish-brown silt	2.8+	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
a	14	61	25	0.2–1.2	16	21	34	9	12	8	
				1.2–2.2	13	10	24	14	24	15	
				2.2–3.2	13	42	25	2	4	4	10
				Mean	14	24	28	9	13	9	3
b	22	77	1	3.2–5.2	20	70	8	1	0	1	
				5.2–7.2	16	48	30	4	2		
				7.2–9.2	18	68	11	1	1	1	
				9.2–12.2	30	67	3	0	0		
				Mean	22	64	12	1	1		
c	31	69		20.2–22.2	31	63	5	1			
d	8	17	75	22.2–25.0	8	10	3	4	8	56	11

NY 86 NE 29 8876 6652 East Wharmley **Block B**

Surface level (+85.0 m) +279 ft
Water level +83.0 m (+272.5 ft)
June 1975

Overburden 0.2 m
Mineral 2.7 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, light brown, sandy	0.2	0.2
Glacial Sand and Gravel	'Clayey' pebbly sand Gravel: coarse with fine; rounded friable yellow sandstone Sand: fine and medium; subangular to rounded quartz Fines: yellowish brown silt	2.7	2.9
Stainmore Group	Sandstone, yellow friable	0.1+	3.0

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
18	64	18	0.2–1.2	24	42	27	3	1	3	
			1.2–2.2	16	34	28	2	5	15	
			2.2–2.9	9	40	12	1	16	22	
			Mean	18	38	24	2	6	12	

NY 86 NE 30 8978 6611 Common House **Block B**

Surface level (+70.5 m) +232 ft
Water level +65.0 m (+213.5 ft)
August 1975

Overburden 4.5 m
Mineral 1.2 m
Waste 1.5 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pale brown, sandy	0.8	0.8
Glacial Sand and Gravel	Clay, brown, ochreous, with sand pockets and sandstone pebbles	3.7	4.5
	Gravel Gravel: fine, coarse and cobble; rounded quartzite, yellow sandstone and volcanics, some broken grey sandstone Sand: fine and medium with coarse; subrounded quartz and rock fragments	1.2	5.7
Boulder Clay	Clay, hard, grey with pebbles of sandstone	1.5	7.2
Stainmore Group	Sandstone, yellowish	0.1+	7.3

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
3	32	65	4.5–5.7	3	13	13	6	21	22	22

NY 86 NE 38 **8695 6545** **Bush Farm** **Block A**

Surface level (c +140 m) +469 ft
Water level not recorded
Minuteman power auger
January 1975

Overburden 3.7 m
Mineral 3.6 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Boulder Clay	Clay, hard, brown, stony	3.4	3.7
Glacial Sand and Gravel	Sand, silty, fine grained (not sampled)	3.6+	7.3

NY 86 SW 26 **8022 6471** **West Morralee** **Block A**

Surface level (+77.7 m) +255 ft
Water level +74.7 m (245.5 ft)
October 1975

Overburden 0.3 m
Mineral 4.5 m
Waste 1.2 m
Mineral 1.5 m
Waste 1.0 m
Mineral 2.4 m
Waste 2.1 m
Mineral 1.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	**a** Gravel Gravel: cobble, coarse and fine; well rounded quartzite and sandstone, dark and greenish igneous rock Sand: coarse, medium and fine; rounded quartz and rock fragments	4.5	4.8
	Clay, brown and grey, with small sandstone and mudstone pebbles	1.2	6.0
	b Gravel, components similar to above but with higher proportion of igneous rocks	1.5	7.5
	Clay, brown and grey, pebbly	1.0	8.5
	c 'Very clayey' sand Sand: fine; rounded quartz and rock fragments Fines: brown, micaceous	2.4	10.9
	Clay, dark grey, pebbly, silty	2.1	13.0
	d Gravel Gravel: mainly coarse; well rounded brownish-grey quartzite and sandstone, with some green and porphyritic igneous rocks and quartz Sand: coarse, medium and fine; rounded quartz and rock fragments	1.6+	14.6
	Borehole abandoned on boulders		

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
a	1	22	77	0.3–1.3	1	5	8	9	21	35	21
				1.3–2.3	1	4	9	10	18	31	27
				2.3–3.3	1	5	8	8	15	23	40
				3.3–4.8	1	6	6	11	17	22	37
				Mean	1	5	8	9	18	27	32
b	2	35	63	6.0–7.5	2	4	14	17	14	28	21
c	29	69	2	8.5–10.9	29	66	3	1	2		
d	2	12	86	13.0–14.6	2	3	4	5	16	68	2

NY 86 SW 27 **8046 6418** **West Morralee** **Block A**

Surface level (+86.9 m) +285.5 ft
Water level +73.9 m (+242.5 ft)
June 1975

Overburden 2.5 m
Mineral 14.5 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pale brown, silty	0.5	0.5
Second Terrace	Clay, stiff, brown and grey with sand pockets and sandstone pebbles	2.0	2.5
	Gravel Gravel: coarse with fine and cobble; angular to well rounded yellow and green sandstone and white quartzite with dark limestone and some greywacke, granite and dark igneous rocks Sand: coarse, medium and fine; rounded quartz and rock fragments	14.5+	17.0
	Borehole abandoned on boulders		

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
3	31	66	2.5–3.5	2	5	10	18	18	39	8
			3.5–4.5	6	7	8	14	20	39	6
			4.5–5.5	6	9	9	10	11	49	6
			5.5–7.0	2	10	13	18	20	34	3
			7.0–8.0	2	5	8	13	22	34	16
			8.0–9.0	2	6	15	12	19	32	14
			9.0–10.0	3	4	4	3	9	63	14
			10.0–11.0	4	8	7	3	11	38	29
			11.0–12.0	4	9	7	12	14	32	22
			12.0–13.0	2	7	6	12	23	36	14
			13.0–14.0	0	2	2	4	17	54	21
			14.0–15.0	3	9	18	25	27	18	
			15.0–17.0	3	9	18	25	27	18	
			Mean	3	7	10	14	19	36	11

NY 86 SW 28 **8099 6432** **East Morralee** **Block A**

Surface level (+78.3 m) +257 ft
Water level + 73.3 m (+240.5 ft)
October 1975

Overburden 0.6 m
Mineral 7.4 m
Waste 0.3 m
Mineral 10.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, silty	0.6	0.6
First Terrace	**a** Gravel Gravel: coarse, cobble and fine; well rounded quartzite and sandstone with green igneous rocks, red sandstone and some quartz Sand: coarse, medium and fine; rounded quartz and rock fragments	5.0	5.6
	b Sandy gravel, components as above, but with brown fines and coal specks	2.4	8.0
	Clay, greyish brown, laminated, micaceous, silty	0.3	8.3
	c Sand, 'clayey' at top Sand: fine and medium; well rounded quartz and rock fragments Fines: brown, micaceous, with coal specks	9.7	18.0
	d Gravel, composition as above	1.0+	19.0
	Borehole abandoned on boulders		

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
a	1	18	81	0.6–1.6	1	4	8	8	15	32	32
				1.6–2.6	1	3	5	7	17	38	29
				2.6–3.6	1	2	4	12	20	43	20
				3.6–4.6	1	2	3	6	29	37	22
				4.6–5.6	1	9	12	8	20	34	16
				Mean	1	4	6	8	20	37	24
b	7	66	27	5.6–6.6	5	26	21	6	15	27	
				6.6–8.0	8	42	31	3	8	8	
				Mean	7	35	27	4	11	16	
c	9	90	1	8.3–10.3	11	45	43	1			
				10.3–12.3	9	29	57	4	1		
				12.3–14.3	8	57	33	1	1		
				14.3–16.3	8	47	42	2	1		
				16.3–18.0	9	50	38	2	1		
				Mean	9	45	43	2	1		
d	3	43	54	18.0–19.0	3	18	17	8	18	29	7

NY 86 SW 29 **8194 6396** **Lipwood Well** **Block A**

Surface level (+71.3 m) +234 ft
Water level +67.7 m (+222.5 ft)
October 1975

Overburden 0.3 m
Mineral 5.7 m
Waste 1.0 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
First Terrace	Gravel Gravel: coarse with fine and cobble; well rounded brown and white quartzite and sandstone, dolerite, andesitic rocks, and some quartz Sand: coarse and medium; rounded quartz and rock fragments	5.7	6.0
Boulder Clay	Silt, bluish-grey, soft, laminated, with boulders of black limestone and sandstone	1.0+	7.0
	Borehole abandoned on boulders		

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
1	13	86	0.3–1.3	1	4	4	5	24	52	10
			1.3–2.3	1	3	9	9	15	29	34
			2.3–3.3	0	1	4	9	23	42	21
			3.3–4.3	1	1	3	8	26	27	34
			4.3–6.0	trace	1	1	6	33	50	9
			Mean	1	2	4	7	25	41	20

NY 86 SW 30 **8312 6413** **West Rattenraw** **Block A**

Surface level (+75.0 m) +246 ft
Water not struck
October 1975

Overburden 1.2 m
Mineral 2.2 m
Waste 1.4 m
? Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown	0.2	0.2
Second Terrace	Clay, yellowish-brown, soft, sandy	1.0	1.2
	Gravel: contains many boulders which have been smashed by the drilling equipment, therefore gradings given do not reflect the true grading of the deposit	2.2	3.4
Boulder Clay	Clay, hard, brown and grey, weathered, sandy, with red and grey sandstone pebbles	1.4	4.8
? Stainmore Group	Sandstone, possibly boulder	0.1+	4.9

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$+\frac{1}{16}$	$+\frac{1}{16}$–$\frac{1}{4}$	$+\frac{1}{4}$–1	+1–4	+4–16	+16–64	+64
1	22	77	1.2–2.2	1	2	8	14	22	46	7
			2.2–3.4	2	2	6	11	29	38	12
			Mean	1	2	7	13	26	41	10

NY 86 SW 31 **8388 6442** **Haydon Bridge** **Block A**

Surface level (+71.3 m) +234 ft
Water level +67.8 m (+222.5 ft)
October 1975

Overburden 3.5 m
Mineral 1.9 m
Waste 2.0 m
Mineral 1.4 m
Waste 0.5 m
Mineral 3.8 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	1.2	1.2
Second Terrace	Clay, yellow, ochreous, sandy and pebbly	0.8	2.0
	Clay, grey, laminated with peat and sand pockets	1.5	3.5
	a Gravel Gravel: coarse, fine and cobble; well rounded white quartzite, brown sandstone, dark igneous rock, some quartz, limestone and granite Sand: coarse, medium and fine; rounded quartz and rock fragments	1.9	5.4
	Clay, reddish-brown, hard, sandy with pebbles of sandstone and mudstone	2.0	7.4
	b 'Very clayey' sandy gravel Gravel: coarse and fine; rounded quartzite, sandstone and dark igneous rocks Sand: fine with medium and some coarse; well rounded quartz and rock fragments Fines: reddish-brown	1.4	8.8
	Clay, dark grey and brown, hard, with pebbles of sandstone, quartzite and dark igneous rock	0.5	9.3
	c Gravel Gravel: coarse and fine; components as above Sand: medium and coarse; components as above	3.8+	13.1
	Large conglomeratic sandstone boulders below 12.8 m, borehole abandoned		

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
a	3	29	68	3.5–4.5	2	6	7	13	32	28	12
				4.5–5.4	3	10	11	11	15	31	19
				Mean	3	8	9	12	24	29	15
b	25	55	20	7.4–8.8	25	37	13	5	9	11	
c	1	33	66	9.3–10.3	1	6	11	9	25	47	1
				10.3–11.3	1	3	13	10	17	43	13
				11.3–12.3	0	2	19	9	22	37	11
				12.3–13.1	1	4	29	16	24	23	3
				Mean	1	4	18	11	21	38	7

NY 86 SW 32 **8480 6447** **Haydon Bridge** **Block A**

Surface level (+61.6 m) +202.5 ft
Water level +60.3 m (+198 ft)
August 1975

Overburden 1.0 m
Mineral 2.8 m
Waste 3.0 m
Bedrock 0.9 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
First Terrace	Clay, sandy, brown	0.6	1.0
	Gravel Gravel: coarse, cobble and fine; well rounded quartzite, sandstone and porphyry with dark green volcanic rocks and limestone Sand: fine, medium and coarse; rounded quartz and rock fragments	2.8	3.8
	Silt, dark grey, clayey, laminated, with boulders of sandstone	3.0	6.8
Stainmore Group	Sandstone, yellow, hard	0.9+	7.7

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
2	22	76	1.0–2.0	1	10	16	10	16	39	8
			2.0–3.0	1	2	2	6	20	33	36
			3.0–3.8	3	4	6	10	22	29	26
			Mean	2	6	8	8	19	34	23

NY 86 SW 33 **8306 6384** **West Land Ends** **Block A**

Surface level (+69.8 m) +229 ft
Water level +67.0 m (+220 ft)
October 1975

Overburden 0.5 m
Mineral 4.0 m
Waste 7.3 m
Mineral 1.4 m
Waste 1.5 m
? Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, sandy, becomes silty, pebbly and clayey towards base	0.5	0.5
First Terrace	**a** Gravel Gravel: coarse with fine and cobble; well rounded sandstone, quartzite with green igneous rock, quartz and granite, and more angular brown and grey carbonaceous sandstone Sand: fine, medium and coarse; rounded quartz and rock fragments	4.0	4.5
	Clay, grey, laminated, micaceous, silty	0.3	4.8
	Sandy silt, brown, micaceous	7.0	11.8
	b Gravel Gravel: cobble, coarse with fine; well rounded quartzite, sandstone, green igneous rocks, some limestone and mudstone Sand: coarse, fine and medium; rounded quartz and rock fragments	1.4	13.2
Boulder Clay	Clay, dark grey, hard, with pebbles of grey sandstone, mudstone, limestone and igneous rocks	1.5	14.7
? Stainmore Group	Sandstone, pale brown	0.3+	15.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$+\frac{1}{16}$	$+\frac{1}{16}$–$\frac{1}{4}$	$+\frac{1}{4}$–1	+1–4	+4–16	+16–64	+64
a	2	27	71	0.5–1.5	1	3	10	9	22	41	14
				1.5–2.5	1	4	5	5	18	46	21
				2.5–4.5	3	22	5	9	17	24	20
				Mean	2	13	6	8	19	33	19
b	4	16	80	11.8–13.2	4	5	3	8	18	29	33

NY 86 SW 34 8318 6323 West Land Ends

Surface level (+114.0 m) +374 ft
Water level +111.8 m (+365 ft)
June 1975

Waste 5.0 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
? Boulder Clay	Silt, yellow, sandy, with small sandstone pebbles	0.7	1.2
	Clay, grey and yellow, soft, with sand pockets, roots and small sandstone pebbles	3.8	5.0
Stainmore Group	Mudstone, black, micaceous, shaly, unfossiliferous	0.5+	5.5

NY 86 SW 35 8105 6380 Tedcastle

Surface level (c +109.7 m) +360 ft
Water level not recorded
Minuteman power auger
February 1975

Waste 7.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.9	0.9
Boulder Clay	Clay, stiff, brown	6.4+	7.3

NY 86 SW 36 8445 6370 Crook Hill

Surface level (c+94.5 m) +310 ft
Water level not recorded
Minuteman power auger
January 1975

Waste 7.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Boulder Clay	Clay, sandy, pebbly	1.5	2.1
	Silt, sandy	4.3	6.4
	Gravel, sandy, clayey	0.9+	7.3
	Borehole abandoned on boulder obstruction		

NY 86 SW 37 8177 6300 Morralee Fell

Surface level (c + 179.8 m) +590 ft
Water level not recorded
Minuteman power auger
February 1975

Waste 1.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Boulder Clay	Clay, dark, sandy, pebbly	1.1+	1.4
	Borehole abandoned on boulder obstruction		

NY 86 SE 12 8574 6495 East Millhills **Block A**

Surface level (+57.9 m) +190 ft
Water not struck
September 1975

Overburden 0.8 m
Mineral 2.6 m
Waste 5.6 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
First Terrace	Silt, brown, micaceous, clayey	0.6	0.8
	a 'Clayey' sand Sand: medium with some fine; rounded quartz Fines: yellowish-brown, micaceous	0.6	1.4
	b Gravel Gravel: coarse with fine and cobble; well rounded dolerite, quartzite, grey limestone with some quartz, granite and porphyry Sand: mainly medium; rounded quartz and rock fragments	2.0	3.4
	Silt, grey, plastic, laminated, micaceous, with pellets of mudstone and some sandstone pebbles	5.6	9.0
Stainmore Group	Sandstone, yellow	1.0+	10.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
a	15	84	1	0.8–1.4	15	26	54	4	1		
b	1	32	67	1.4–2.4	1	3	17	10	20	39	10
				2.4–3.4	1	7	18	8	17	39	10
				Mean	1	5	18	9	18	39	10

NY 96 NW 24 9047 6940 Walwick Grange **Block B**

Surface level (+67.4 m) +221 ft
Water level +65.6 m (+215 ft)
July 1975

Waste 3.2 m
? Bedrock 0.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pale brown, silty to sandy	0.7	0.7
Undifferentiated Terrace	Sandy clay, stiff, brown with lenses of sand and, especially below 1.9 m, pebbles of quartzite and sandstone; 0.3 m band of sand and gravel at base	2.5	3.2
? Upper Liddesdale Group	Limestone, dark, ? solid	0.6+	3.8

NY 96 NW 25 9157 6981 Near Wall **Block B**

Surface level (+66.1 m) +217 ft
Water level +63.1 m (+207 ft)
July 1975

Overburden 1.5 m
Mineral 1.0 m
Waste 3.6 m
Bedrock 0.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Undifferentiated Terrace	Clay, stiff, brown, ochreous, sandy, with limestone pebbles	1.4	1.5
	Gravel Gravel: fine and coarse; subrounded sandstone, limestone and quartz Sand: medium and coarse; subrounded quartz grains and rock fragments	1.0	2.5
Boulder Clay	Clay, brown and grey, sandy, with limestone and sandstone pebbles and lenses of grey sand	3.6	6.1
Upper Liddesdale Group	Siltstone, weathered at top, pale and dark grey	0.7+	6.8

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
6	26	68	1.5–2.5	6	3	12	11	32	30	6

NY 96 NW 26 9136 6819 Warden **Block B**

Surface level (+52.7 m) +173 ft
Water level +48.8 m (+160 ft)
June 1975

Overburden 1.3 m
Mineral 3.0 m
Waste 9.0 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Undifferentiated Terrace	Clay, brown and grey, silty, with rootlets	1.1	1.3
	a 'Very clayey' pebbly sand Gravel: fine, coarse and cobble; rounded sandstone Sand: mainly fine; rounded quartz and rock fragments Fines: yellowish-grey	0.8	2.1
	b Gravel Gravel: coarse and fine; subrounded to well rounded yellow and grey quartzite, dark and light green igneous rocks, yellow sandstone with some granite, quartz and coral-rich dark limestone Sand: fine, medium and coarse; well rounded quartz and rock fragments	2.2	4.3
Boulder Clay	Clay, dark grey, stiff in parts, laminated, with micaceous and carbonaceous partings	7.4	11.7
	Clay, dark grey, hard, with pebbles of sandstone, quartzite and limestone	1.6+	13.3
	Borehole abandoned on limestone boulder		

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
a	25	58	17	1.3–2.1	25	45	11	2	4	6	7
b	2	26	72	2.1–3.1	2	5	6	9	34	43	1
				3.1–4.3	2	6	13	11	31	34	3
				Mean	2	6	10	10	32	38	2

NY 96 NW 27 9230 6709 Low Barns **Block B**

Surface level (+98.5 m) +323 ft
Water level +95.0 m (+311.5 ft)
September 1975

Waste 10.0 m
Bedrock 2.0 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, silty, pebbly	0.5	0.5
Glacial Sand and Gravel	Clay, sandy, yellow-brown, brown and red, high content of fine and coarse angular sand and some quartzite pebbles	3.0	3.5
	Clay, sandy in lower part, brown to 4.0 m, grey below, with pebbles of sandstone, limestone dolerite and mudstone	6.5	10.0
Stainmore Group	Sandstone, brown, weathered at top	2.0+	12.0

NY 96 NW 28 **9028 6609** **Baddox Farm** **Block B**

Surface level (+40.5 m) +133 ft
Water level +38.2 m (+125.5 ft)
August 1975

Overburden 0.7 m
Mineral 3.0 m
Waste 1.6 m
Mineral 14.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown	0.7	0.7
Alluvium	**a** Gravel Gravel: mainly coarse with fine; rounded sandstone, dolerite, granite and quartz Sand: medium with coarse and fine; rounded quartz and rock fragments	3.0	3.7
	Clay, grey, stiff, laminated, with pebbles of sandstone and quartz	1.6	5.3
	b Sand, fine; well rounded quartz and rock fragments with some brown fines and mica	8.5	13.8
	c 'Clayey' gravel, poor recovery of coarse and cobble sized limestone, sandstone and igneous rocks in matrix of grey silty sand	5.7+	19.5
	Borehole abandoned on boulder 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
a	1	32	67	0.7–1.7	2	9	16	6	23	41	3
				1.7–2.7	1	5	19	6	16	42	11
				2.7–3.7	0	3	18	14	22	31	12
				Mean	1	5	18	9	20	38	9
b	7	93	0	5.3–7.3	10	84	5	1			
				7.3–9.3	7	85	8				
				9.3–11.3	6	66	26	2			
				11.3–13.8	5	72	22	1			
				Mean	7	76	16	1			
c	12	27	61	13.8–19.5	12	15	9	3	6	25	30

NY 96 NW 29 **9079 6671** **High Warden** **Block B**

Surface level (+86.9 m) +285 ft
Water not struck
June 1975

Overburden 0.2 m
Mineral 2.1 m
Bedrock 1.4 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, sandy	0.2	0.2
Glacial Sand and Gravel	'Clayey' pebbly sand Gravel: coarse and fine; well rounded quartzite, dark igneous rock and more angular yellow sandstone Sand: fine and medium; subrounded to rounded quartz and rock fragments Fines: yellow-brown silt	2.1	2.3
Stainmore Group	Mudstone, weathered at top, dark grey, silty, laminated, micaceous	1.4+	3.7

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
10	73	17	0.2–1.2	15	44	27	6	5	3	
			1.2–2.3	6	23	33	13	9	16	
			Mean	10	33	30	10	7	10	

NY 96 NW 30 **9240 6624** **Broom Park** **Block C**

Surface level (+42.7 m) +140 ft
Water level +36.2 m (+119 ft)
July 1975

Overburden 0.2 m
Mineral 2.0 m
Waste 1.0 m
Mineral 0.7 m
Waste 0.3 m
Mineral 2.9 m
Waste 1.0 m
Mineral 3.3 m
Waste 7.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.2	0.2
First Terrace	**a** 'Very clayey' pebbly sand Gravel: coarse and cobble; rounded sandstone and quartzite with dolerite and limestone Sand: fine; rounded quartz and some rock fragments Fines: red-brown	2.0	2.2
	Silt, very sandy	1.0	3.2
	b 'Very clayey' sand: fine; subrounded to rounded quartz and rock fragments including coal	0.7	3.9
	Silt, sandy	0.3	4.2
	c 'Clayey' sandy gravel Gravel: fine, coarse and cobble; subrounded to rounded quartzite and sandstone with dolerite, acid volcanic rocks, granite and limestone Sand: fine and medium; subrounded to rounded quartz and rock fragments Fines: red-brown and grey	2.9	7.1
	Clay, dark grey, sandy, with pebbles of dolerite and sandstone	1.0	8.1
	d 'Very clayey' sand Sand: fine; subrounded quartz and rock fragments Fines: dark grey silt, interbedded with sand	3.3	11.4
Boulder Clay	Clay and silt, grey-brown, laminated sandy and pebbly, with boulders of limestone, sandstone, dolerite and extrusive igneous rocks in lower part	7.1+	18.5
	Borehole abandoned owing to boulder 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
a	24	60	16	0.2–1.2	26	43	4	2	2	15	8
				1.2–2.2	21	56	15	1	1	3	4
				Mean	24	49	10	1	1	9	6
b	39	61	0	3.2–3.9	39	50	11				
c	14	54	32	4.2–5.4	24	49	25	1	0	1	
				5.4–6.4	12	24	18	6	14	20	6
				6.4–7.1	1	5	10	10	20	39	15
				Mean	14	30	20	4	10	16	6
d	34	66	0	8.1–9.1	29	66	4	1			
				9.1–10.1	43	55	2				
				10.1–11.4	30	68	2				
				Mean	34	63	3				

NY 96 NW 31 **9115 6558** **Westwood** **Block B**

Surface level (+42.7 m) +140 ft
Water not struck
August 1975

Overburden 1.1 m
Mineral 2.0 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, light brown, sandy	1.1	1.1
Glacial Sand and Gravel	Gravel Gravel: fine and coarse with some cobble; subrounded to rounded quartzite, sandstone and igneous rock Sand: fine, medium and coarse; quartz and rock fragments including coal specks Fines: yellowish-brown micaceous silt and clay	2.0	3.1
Stainmore Group	Sandstone, yellow	0.3+	3.4

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
9	32	59	1.1–2.1	16	20	14	8	18	22	2
			2.1–3.1	3	6	7	9	27	36	12
			Mean	9	13	10	9	23	29	7

NY 96 NW 32 **9157 6572** **Kingshaw Green** **Block B**

Surface level (+38.4 m) +126 ft
Water not struck
August 1975

Overburden 0.2 m
Mineral 5.5 m
Waste 9.9 m
Mineral 6.0 m
Waste 2.0 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown	0.2	0.2
Alluvium	**a** 'Very clayey' sand Sand: fine with medium; rounded quartz and rock fragments Fines: brown micaceous silty clay	2.2	2.4
	b Gravel Gravel: coarse with fine and cobble; subrounded to rounded sandstone, quartzite, limestone, granite and acid volcanic rocks Sand: mainly medium and coarse; subangular to subrounded quartz, rock fragments with mica and coal fragments	3.3	5.7
	Clay, grey-brown, well laminated, silty with few rounded sandstone pebbles	9.9	15.6
	c 'Very clayey' sand Sand: fine; rounded quartz, rock fragments with mica and coal fragments Fines: grey-brown silty clay	6.0	21.6
	Silt, greyish-brown, micaceous, with some coal debris	2.0+	23.6

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
a	23	77	0	0.2–1.2	22	54	24				
				1.2–2.4	24	57	18	1			
				Mean	23	56	21				
b	0	18	82	2.4–3.4	0	2	16	11	20	38	13
				3.4–4.4	trace	2	11	9	20	42	16
				4.4–5.7	0	2	2	3	20	49	24
				Mean	0	2	9	7	20	43	19
c	24	76	0	15.6–16.6	27	72	1				
				16.6–17.6	28	71	1				
				17.6–19.6	24	75	1				
				19.6–21.6	19	79	1				
				Mean	24	75	1				

NY 96 NW 33 **9301 6526** **Old Bridge End** **Block C**

Surface level (+34.7 m) +114 ft
Water level +31.4 m (+103 ft)
July 1975

Overburden 0.1 m
Mineral 0.7 m
Waste 0.5 m
Mineral 21.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Alluvium	**a** 'Clayey' sandy gravel Gravel: coarse and fine, some cobble; subrounded to rounded sandstone, quartzite and some igneous rock Sand: fine with medium; subangular to rounded quartz and rock fragments Fines: grey-brown	0.7	0.8
	Silt, grey-brown, laminated, with lenses of fine sand and coal debris	0.5	1.3
	b Gravel Gravel: coarse with fine and cobble; rounded quartzite and sandstone with some limestone, siltstone and igneous rocks Sand: medium and coarse; rounded quartz and rock fragments	3.5	4.8
	c 'Very clayey' sand, gravel at base Gravel: coarse and fine; angular to rounded sandstone and quartzite with rare quartz and igneous rock Sand: fine; subangular to rounded quartz and rock fragments including coal Fines: grey silt, micaceous	17.5+	22.3
	Borehole abandoned on boulder 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
a	12	47	41	0.1–0.3	21	44	15	4	4	6	6
				0.3–0.8	9	19	14	8	21	22	7
				Mean	12	26	14	7	16	18	7
b	1	33	66	1.3–2.3	1	2	17	7	14	47	12
				2.3–3.3	1	3	20	8	15	27	26
				3.3–4.8	1	6	17	16	21	24	15
				Mean	1	4	18	11	17	32	17
c	24	73	3	4.8–5.8	26	48	19	6	1		
				5.8–6.8	31	68	1				
				6.8–7.8	38	61	1				
				7.8–8.8	18	82					
				8.8–9.8	22	76	1	1			
				9.8–10.8	21	75	3	1			
				10.8–12.4	24	62	5	2	1	6	
				12.4–13.4	21	76	3				
				13.4–15.0	16	79	4				
				15.0–16.5	21	74	5				
				16.5–18.0	20	75	5				
				18.0–19.5	21	76	3				
				19.5–21.7	37	60	3				
				21.7–22.3	5	6	4	17	18	50	
				Mean	24	68	4	1	trace	3	

NY 96 NE 35 **9522 6501** **Anick** **Block C**

Surface level (+32.3 m) +106 ft
Water level +28.0 m (+92 ft)
July 1975

Overburden 1.6 m
Mineral 0.9 m
Waste 1.0 m
Mineral 19.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	1.4	1.4
	Silt, brown, sandy	0.2	1.6
First Terrace	**a** 'Very clayey' sand Sand: fine; subangular to well rounded quartz Fines: brown, with mica flakes	0.9	2.5
	Clay, silty, grey to brown, with sand and peat lenses	1.0	3.5
	b Gravel Gravel: coarse and fine with cobble; well rounded white and brown quartzite with some sandstone, green porphyritic volcanic rocks and limestones, quartz and granite Sand: fine to coarse; subrounded to well rounded quartz and rock fragments with coal and wood debris	3.0	6.5
	c 'Clayey' sand Sand: mainly fine; subrounded to well rounded quartz and rock fragments Fines: brownish-grey, micaceous silt	11.5	18.0
	d Sandy gravel Gravel: coarse and fine; well rounded sandstone, quartzite and igneous rock Sand: mainly fine; rounded quartz and rock fragments	4.5+	22.5
	Borehole abandoned on boulder 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
a	27	73		1.6–2.5	27	61	12				
b	2	35	63	3.5–4.5	1	11	16	11	18	26	17
				4.5–5.5	1	3	4	9	29	40	14
				5.5–6.5	3	25	16	11	18	24	3
				Mean	2	13	12	10	22	30	11
c	15	84	1	6.5–7.5	16	73	4	4	2	1	
				7.5–8.5	13	85	2				
				8.5–9.5	12	85	3				
				9.5–10.5	5	83	12				
				10.5–11.5	6	76	18				
				11.5–12.5	6	22	45	20	1	6	
				12.5–13.5	29	60	9	2			
				13.5–14.5	27	66	4			3	
				14.5–15.5	17	80	3				
				15.5–16.5	20	76	4				
				16.5–18.0	17	76	7				
				Mean	15	71	10	3		1	
d	9	61	30	18.0–19.0	11	28	7	13	12	21	8
				19.0–20.0	10	53	15	14	7	1	
				20.0–21.0	10	57	24	6	3		
				21.0–22.5	6	22	10	6	17	39	
				Mean	9	38	13	9	11	18	2

NY 96 NE 36 9715 6511 Sandhoe **Block C**

Surface level (+40.8 m) +134 ft
Water not struck
October 1975

Overburden 0.5 m
Mineral 4.9 m
Waste 1.6 m
Mineral 3.5 m
Waste 7.3 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pale brown, sandy	0.5	0.5
Second Terrace	**a** Gravel Gravel: coarse and fine; well rounded quartzite, brown, red and white sandstone, greywacke, porphyry and quartz Sand: fine to coarse; rounded quartz, rock fragments and coal specks	4.9	5.4
	Silt, brownish-grey, laminated, micaceous	1.6	7.0
	b 'Very clayey' sand Sand: fine; subrounded quartz and rock fragments Fines: brown	3.5	10.5
Boulder Clay	Silt, grey, laminated, micaceous	2.0	12.5
	Clay, brown and grey, silty, with lenses of sand and sandstone pebbles	5.3	17.8
Stainmore Group	Sandstone, white	0.2+	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
a	3	21	76	0.5–1.5	11	17	10	5	16	36	5
				1.5–2.5	1	4	6	7	23	50	9
				2.5–3.5	1	2	8	7	25	47	10
				3.5–4.5	1	2	9	3	21	64	
				4.5–5.4	3	4	11	9	37	30	6
				Mean	3	6	9	6	24	46	6
b	26	74		7.0–10.5	26	74					

NY 96 NE 37 9803 6510 Corbridge **Block C**

Surface level (+43.0 m) +141 ft
Water level +37.9 m (+124.5 ft)
August 1975

Overburden 1.2 m
Mineral 1.8 m
Waste 3.0 m
? Bedrock 0.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, light brown, sandy	1.2	1.2
Second Terrace	'Clayey' sandy gravel Gravel: fine and coarse; well rounded quartz and volcanic rocks Sand: fine and medium; well rounded quartz and rock fragments Fines: brown	1.8	3.0
Boulder Clay	Clay, bluish-grey with sand pockets and sandstone pebbles	3.0	6.0
? Stainmore Group	Sandstone, cream	0.6+	6.6

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
10	58	32	1.2–2.2	11	30	23	7	16	13	
			2.2–3.0	10	19	33	4	18	16	
			Mean	10	25	27	6	17	15	

NY 96 NE 40 **9986 6702** **Aydon** **Block C**

Surface level (+128 m) +421 ft
Water level +121 m (+397 ft)
December 1977

Overburden 1.4 m
Mineral 6.0 m
Waste 1.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Sand and Gravel	Clay, brown to dark brown, sandy, with sandstone pebbles	1.1	1.4
	a Gravel Gravel: coarse; pale micaceous sandstone Sand: fine and medium; subangular to well rounded quartz, rock fragments and coal	2.0	3.4
	b Sand, fine; rounded quartz and rock fragments	2.0	5.4
	c 'Very clayey' sand Sand: fine; rounded quartz and rock fragments Fines: bands of greyish-brown micaceous silt	2.0	7.4
	Silt, dark grey, laminated, micaceous	1.6+	9.0
	Borehole abandoned owing to lack of progress		

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}$–$\frac{1}{4}$	$+\frac{1}{4}$–1	+1–4	+4–16	+16–64	+64
a	4	25	71	1.4–3.4	4	14	9	2	13	54	4
b	2	98		3.4–5.4	2	85	11	2			
c	37	63		5.4–7.4	37	60	3				

NY 96 SW 14 **9248 6498** **Hexham Golf Course** **Block C**

Surface level (+62.5 m) +205 ft
Water not struck
November 1975

Overburden 0.3 m
Mineral 13.4 m
Waste 1.9 m
Mineral 2.0 m
Waste 1.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Sand and Gravel	**a** Gravel Gravel: coarse and cobble with fine; well rounded brown and grey sandstone, quartzite and dolerite with black limestone, some granite and greywacke Sand: fine to coarse; angular to rounded quartz and rock fragments	13.4	13.7
	Clay, soft, yellow, pebbly, sandy	1.9	15.6
	b 'Clayey' gravel Gravel: coarse with fine; components as above Sand: fine to coarse; components as above Fines: grey and yellow	2.0	17.6
? Boulder Clay	Boulders of limestone and sandstone in clay matrix	1.7+	19.3
	Borehole abandoned on boulder 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
a	4	17	79	0.3–1.3	8	20	18	12	21	21	
				1.3–2.3	4	4	5	10	28	40	9
				2.3–3.3	3	3	4	8	19	45	18
				3.3–4.3	3	3	5	8	19	32	30
				4.3–5.3	2	3	4	9	11	26	45
				5.3–6.3	4	3	4	6	16	41	26
				6.3–7.3	4	3	4	8	15	32	34
				7.3–8.3	5	3	4	8	20	36	24
				8.3–9.3	5	3	3	7	14	42	25
				9.3–10.3	4	3	3	7	16	43	25
				10.3–13.7	4	3	3	6	16	43	25
				Mean	4	4	5	8	17	37	25
b	14	36	50	15.6–17.6	14	15	10	11	13	37	

NY 96 SW 15 **9443 6469** **Bridge End** **Block C**

Surface level (+32.6 m) +107 ft
Water level +28.9 m (+95 ft)
July 1975

Overburden 2.0 m
Mineral 11.5 m
Waste 7.4 m
Mineral 1.0 m
Waste 3.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Fill and soil	0.3	0.3
Alluvium	Silt, sandy, brown	1.7	2.0
	a Gravel Gravel: coarse and fine with some cobble; well rounded sandstone and quartzite with green porphyritic volcanic rocks, granite and limestone Sand: mainly medium and coarse; well rounded quartz and rock fragments	11.5	13.5
	Silt, greyish-brown, laminated, clayey in parts, with micaceous, sandy partings	7.4	20.9
	b 'Very clayey' sand Sand: fine; subrounded to well rounded quartz and rock fragments Fines: brown	1.0	21.9
	Silt, brown, micaceous, very sandy	3.1+	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
a	1	33	66	2.0–3.0	1	6	15	8	22	44	4
				3.0–4.0	1	6	12	10	21	32	18
				4.0–5.0	1	3	16	11	21	31	17
				5.0–6.0	1	3	12	12	24	33	15
				6.0–7.0	1	4	22	9	21	31	12
				7.0–8.0	1	3	12	9	26	46	5
				8.0–9.0	1	7	14	6	20	50	2
				9.0–10.0	2	16	27	6	20	28	1
				10.0–11.0	1	3	11	11	33	41	
				11.0–12.0	1	2	14	15	21	32	15
				12.0–13.5	1	2	24	21	22	19	11
				Mean	1	5	17	11	23	34	9
b	32	68	0	20.9–21.9	32	67	1				

NY 96 SW 16 **9380 6117** **Houtley Farm** **Block C**

Surface level (+135.6 m) +445 ft
Water not struck
August 1975

Overburden 0.2 m
Mineral 6.0 m
Waste 6.0 m
Mineral 12.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	**a** 'Clayey' pebbly sand Gravel: fine and coarse; subangular to well rounded sandstone and quartzite Sand: mainly fine; subrounded to well rounded quartz and rock fragments	6.0	6.2
	Silt, red-brown, laminated, sandy	6.0	12.2
	b 'Very clayey' sand Sand: fine with some medium; subrounded to well rounded quartz and rock fragments Fines: bands of stiff, reddish-brown and grey micaceous silt interbedded with soft, grey clay	12.8+	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
a	17	77	6	0.2–1.2	11	17	30	10	14	15	3
				1.2–2.2	13	56	25	3	2	1	
				2.2–3.2	18	58	19	3	2		
				3.2–4.2	16	69	14	1			
				4.2–6.2	22	64	14	0			
				Mean	17	54	20	3	3	3	
b	21	79		12.2–14.2	12	66	22				
				14.2–16.2	40	40	19	1			
				16.2–18.2	37	53	10				
				18.2–20.2	16	61	22	trace			
				20.2–22.2	16	72	12				
				22.2–25.0	9	86	5				
				Mean	21	64	15				

NY 96 SW 17 **9443 6128** **Houtley** **Block C**

Surface level (+112.2 m) +368.5 ft
Water not struck
August 1975

Overburden 7.5 m
Mineral 1.9 m
Waste 1.0 m
Mineral 3.2 m
Waste 4.4 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Boulder Clay	Clay, grey-blue and dark brown, silty, sandy at base	7.2	7.5
Glacial Sand and Gravel	**a** Gravel Gravel: mainly coarse; subangular to subrounded, limestone, sandstone and igneous rock Sand: mainly coarse and medium; subangular to subrounded quartz and rock fragments	1.9	9.4
	Clay, grey-brown, silty, laminated	1.0	10.4
	b 'Clayey' pebbly sand Gravel: fine and coarse; subrounded sandstone and igneous rocks Sand: fine; rounded quartz and rock fragments Fines: grey-brown	3.2	13.6
	Clay, grey-brown, stiff, laminated	4.4+	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
a	3	39	58	7.5–8.5	2	3	13	21	19	36	6
				8.5–9.4	5	4	16	22	17	32	4
				Mean	3	3	14	22	18	35	5
b	15	73	12	10.4–11.4	12	20	19	13	17	19	
				11.4–12.4	15	75	8	1	1		
				12.4–13.6	17	72	9	1	1		
				Mean	15	56	12	5	6	6	

NY 96 SW 18 **9340 6072** **Newbiggin Hill** **Block C**

Surface level (+139.9 m) +459.5 ft
Water level +129.9 m (+426.5 ft)
August 1975

Overburden 0.5 m
Mineral 10.3 m
Waste 6.1 m
? Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, sandy	0.5	0.5
Glacial Sand and Gravel	Sandy gravel Gravel: fine and coarse; subangular to well rounded sandstone, conglomerate, quartzite, with volcanic rocks and some mudstone Sand: medium and fine and some coarse, subrounded to well rounded quartz and rock fragments	10.3	10.8
Boulder Clay	Clay, bluish-grey, hard, with sand lenses and quartzite pebbles	6.1	16.9
? Stainmore Group	Quartzite, white	0.2+	17.1

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
5	64	31	0.1–1.5	7	7	21	16	25	24	
			1.5–2.5	2	13	21	12	21	31	
			2.5–3.4	7	42	26	9	10	6	
			3.4–4.4	3	25	17	12	24	19	
			4.4–5.4	3	18	43	15	11	10	
			5.4–6.4	3	23	22	10	17	25	
			6.4–7.4	2	12	15	15	20	30	6
			7.4–8.4	4	20	35	15	11	15	
			8.4–9.4	6	26	52	12	4		
			9.4–10.8	8	22	44	16	4	6	
			Mean	5	21	30	13	14	16	1

NY 96 SE 13 9519 6436 Anick Grange Haugh **Block C**

Surface level (+30.0 m) +98.5 ft
Water level +26.5 m (+87 ft)
July 1975

Overburden 0.4 m
Mineral 20.8 m
Waste 1.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Alluvium	**a** 'Very clayey' sand Sand: mainly fine; rounded quartz Fines: light brown silt bands	3.1	3.5
	b Gravel Gravel: coarse with fine and cobble; subrounded to rounded sandstone, greywacke, quartzite with limestone and dark igneous rocks Sand: medium and coarse; subangular to well rounded quartz and rock fragments	7.0	10.5
	c Sandy gravel Gravel: fine and coarse; composition as above except for increased percentage of limestone and dark igneous rocks Sand: medium with fine and coarse; components as above	10.7	21.2
Boulder Clay	Clay, sandy, with large boulders	1.3+	22.5
	Borehole abandoned on boulder 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
a	21	78	1	0.4–1.4	27	48	24	1			
				1.4–2.4	23	60	16	1			
				2.4–3.5	15	57	27	1			
				Mean	21	55	23	1			
b	2	27	71	3.5–4.5	0	2	8	9	18	33	30
				4.5–5.5	1	6	11	11	24	33	14
				5.5–6.5	1	6	13	13	27	30	10
				6.5–7.5	2	7	13	10	26	28	14
				7.5–8.5	1	5	9	10	25	29	21
				8.5–9.5	2	7	10	9	20	29	23
				9.5–10.5	1	5	14	14	28	30	8
				Mean	2	5	11	11	24	30	17
c	2	52	46	10.5–11.5	2	9	44	10	13	18	4
				11.5–12.5	1	2	9	19	33	28	8
				12.5–13.5	1	4	14	15	29	36	1
				13.5–14.5	1	7	20	15	30	25	2
				14.5–15.5	2	13	21	20	22	15	7
				15.5–16.5	4	27	36	18	12	3	
				16.5–17.5	4	21	28	11	19	17	
				17.5–18.5	2	14	18	11	20	26	9
				18.5–20.0	1	9	20	15	18	21	16
				20.0–21.2	5	44	26	6	3	9	7
				Mean	2	15	23	14	20	20	6

NY 96 SE 14 **9615 6483** **Anick Grange** **Block C**

Surface level (+30.8 m) +101 ft
Water level +27.7 m (+91 ft)
July 1975

Overburden 0.1 m
Mineral 5.2 m
Waste 2.4 m
Mineral 0.8 m
Waste 0.8 m
Mineral 15.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Alluvium	**a** 'Clayey' pebbly sand Gravel: coarse; well rounded sandstone Sand: mainly fine; subrounded quartz Fines: greyish-brown, micaceous	2.4	2.5
	b Gravel Gravel: coarse with fine and some cobble; well rounded sandstone, quartzite, green and black igneous rock, some porphyry, granite and quartz Sand: medium with coarse and fine; subrounded to well rounded quartz and rock fragments	2.8	5.3
	Silt, grey, laminated, sandy	2.4	7.7
	c Sand, fine with some medium; subrounded to well rounded quartz and rock fragments	0.8	8.5
	Silt, grey, laminated	0.8	9.3
	d 'Clayey' sand Sand: fine with some medium; well rounded quartz and rock fragments Fines: brown and grey, micaceous silt	15.7+	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
a	11	74	15	0.1–1.1	11	53	19	2	2	12	
				1.1–2.5	11	53	19	2	2	12	
				Mean	11	53	19	2	2	12	
b	1	28	71	2.5–3.5	1	8	6	5	22	48	10
				3.5–4.5	1	9	16	11	25	38	
				4.5–5.3	1	6	19	6	16	41	11
				Mean	1	8	13	7	21	43	7
c	3	97		7.7–8.5	3	81	16				
d	10	90		9.3–12.3	24	61	14	1			
				12.3–15.3	3	58	38	1			
				15.3–18.3	13	45	33	9			
				18.3–21.7	4	71	25				
				21.7–25.0	9	67	24				
				Mean	10	61	27	2			

NY 96 SE 15 **9729 6417** **Wide Haugh** **Block C**

Surface level (+27.4 m) +90 ft
Water level +24.6 m (+81 ft)
June 1975

Overburden 1.3 m
Mineral 7.9 m
Waste 0.2 m
Mineral 9.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Silt, pale brown, sandy, micaceous	1.3	1.3
	a Gravel Gravel: coarse and fine with some cobble; rounded to well rounded sandstone, quartzite and green acid igneous rock, with some pink granite, porphyry and quartz Sand: mainly medium; subangular to rounded quartz and rock fragments	7.9	9.2
	Silt, olive-green, laminated, clayey	0.2	9.4
	b 'Clayey' sand with unrecovered boulders Sand: mainly fine; subrounded to rounded quartz and rock fragments Fines: grey, micaceous	9.1+	18.5
	Borehole abandoned on boulder 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
a	2	40	58	1.3–2.3	4	6	10	6	12	36	26
				2.3–3.3	2	4	18	16	24	27	9
				3.3–4.3	1	2	9	9	24	52	3
				4.3–5.3	1	5	22	8	30	32	2
				5.3–6.3	1	3	25	12	38	21	
				6.3–7.7	1	4	16	10	35	29	5
				7.7–9.2	3	10	63	3	7	11	3
				Mean	2	5	26	9	23	29	6
b	18	80	2	9.4–16.8	20	72	8				
				16.8–18.0	12	61	15	5	5	2	
				18.0–18.5	5	26	36	16	8	9	
				Mean	18	68	10	2	1	1	

NY 96 SE 16 9879 6411 Corbridge **Block C**

Surface level (+25.3 m) +83 ft
Water level +22.3 m (+73 ft)
September 1975

Overburden 3.2 m
Mineral 21.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Silt, brown, sandy, micaceous, clayey	3.0	3.2
	a Gravel Gravel: coarse and fine with cobble; well rounded white and grey sandstone, quartzite, greywacke and green igneous rocks with some limestone, quartz and granite Sand: medium, fine and coarse; subrounded to well rounded quartz and rock fragments	13.0	16.2
	b Pebbly sand Gravel: coarse and some fine; components as above Sand: medium with fine; components as above	3.2	19.4
	c Gravel Gravel: fine and coarse with some cobble; components as above Sand: medium and coarse with some fine; components as above	5.6+	25.0
	Boulders smashed by drilling operation, grading may be unrepresentative		

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
a	2	35	63	3.2–4.2	1	2	4	7	27	39	20
				4.2–5.2	3	21	14	5	16	27	14
				5.2–6.2	4	28	16	4	18	30	
				6.2–7.2	1	5	11	14	31	35	3
				7.2–8.2	2	13	21	15	28	18	3
				8.2–9.2	2	3	16	11	20	31	17
				9.2–10.2	2	6	11	16	30	33	2
				10.2–11.2	2	8	13	11	29	26	11
				11.2–12.2	1	5	7	9	32	43	3
				12.2–13.2	2	14	15	6	15	18	30
				13.2–14.2	1	10	10	6	24	37	12
				14.2–15.2	2	14	23	6	18	32	5
				15.2–16.2	2	17	24	10	15	24	8
				Mean	2	11	15	9	23	30	10
b	4	91	5	16.2–17.2	3	23	64	4	1	5	
				17.2–19.4	4	36	53	2	1	4	
				Mean	4	32	56	3	1	4	
c	2	36	62	19.4–20.4	2	14	42	15	15	12	
				20.4–21.4	1	8	19	8	20	29	15
				21.4–22.4	5	8	21	16	21	22	7
				22.4–23.4	1	3	7	17	35	25	12
				23.4–25.0		2	4	11	36	34	13
				Mean	2	6	17	13	27	25	10

NY 96 SE 17 **9712 6326** **Dilston Park** **Block C**

Surface level (+56.4 m) +185 ft
Water level +51.4 m (+168.5 ft)
August 1975

Overburden 0.5 m
Mineral 4.3 m
Waste 0.5 m
Mineral 8.0 m
Waste 7.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Glacial Sand and Gravel	**a** Gravel Gravel: coarse with some fine and cobble; subangular to well rounded sandstone, quartzite with some volcanic rocks and limestone Sand: mainly medium; well rounded quartz and rock fragments	4.3	4.8
	Silt, brownish-grey, laminated, sandy, micaceous	0.5	5.3
	b Gravel Gravel: coarse with some fine and cobble; components as above Sand: mainly medium; components as above	2.0	7.3
	c 'Clayey' sand Sand: fine, with some medium; subrounded to well rounded quartz and rock fragments Fines: greyish-brown, micaceous	6.0	13.3
Boulder Clay	Silt, greyish-green, laminated, micaceous, sandy	5.7	19.0
	Clay, dark grey, sandy, pebbly	2.0+	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
a	5	24	71	0.5–1.5	3	4	6	5	14	55	13
				1.5–2.5	6	9	11	5	18	48	3
				2.5–3.5	5	7	11	6	20	49	2
				3.5–4.8	4	7	16	5	14	42	12
				Mean	5	7	12	5	16	47	8
b	4	20	76	5.3–6.3	6	5	6	3	5	53	22
				6.3–7.3	3	6	12	7	19	39	14
				Mean	4	5	10	5	12	46	18
c	12	88		7.3–9.3	12	71	16	1			
				9.3–11.3	6	60	33	1			
				11.3–13.3	18	71	11				
				Mean	12	67	20	1			

NY 96 SE 18 9801 6367 Dilston Crossing **Block C**

Surface level (+34.1 m) +112 ft
Water level +28.1 m (+92.5 ft)
September 1975

Overburden 1.1 m
Mineral 4.5 m
Waste 0.4 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
	Silt, brown, sandy	0.6	1.1
Second Terrace	Sandy gravel Gravel: fine, coarse with some cobble; well rounded sandstone, quartzite with limestone, porphyry, granite and quartz Sand: medium with fine and coarse; rounded quartz and rock fragments	4.5	5.6
? Boulder Clay	Silt, dark grey-green, laminated, sandy	0.4	6.0
Stainmore Group	Sandstone, brown and yellow	1.0+	7.0

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
3	70	27	1.1–2.1	2	4	10	8	20	35	21
			2.1–3.1	4	23	57	6	5	5	
			3.1–4.1	3	11	45	19	15	7	
			4.1–5.6	4	38	37	12	7	2	
			Mean	3	21	38	11	11	11	5

NY 96 SE 19 9976 6375 Howden Dene **Block C**

Surface level (+26.2 m) +86 ft
Water level +25.0 m (+82 ft)
October 1975

Overburden 2.8 m
Mineral 1.7 m
Waste 9.5 m
Mineral 2.6 m
Waste 0.2 m
Mineral 3.0 m
Waste 3.0 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Silt, clayey, brown at top becoming paler and shelly at base	2.5	2.8
	a Gravel Gravel: coarse with fine and cobble; well rounded sandstone, quartzite, acid volcanic rock with porphyry, granite, quartz and limestone Sand: mainly medium; rounded quartz and rock fragments	1.7	4.5
	Clay and silt, stiff, grey, sandy, shelly	9.5	14.0
	b Gravel Gravel: coarse with fine; components as above Sand: fine, medium and coarse; components as above	2.6	16.6
	Silt, dark grey	0.2	16.8
	c Gravel Gravel: coarse with fine and cobble; components as above Sand: fine, medium and coarse; components as above	3.0	19.8
? Boulder Clay	Silt, dark grey	3.0	22.8
Stainmore Group	Sandstone, grey	0.2+	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
a	1	24	75	2.8–3.8	1	2	8	7	25	46	11
				3.8–4.5	2	8	18	7	12	25	28
				Mean	1	5	12	7	20	37	18
b	4	37	59	14.0–16.6	4	10	14	13	19	40	
c	7	19	74	16.8–17.8	5	7	9	7	20	40	12
				17.8–18.8	4	5	5	8	23	38	17
				18.8–19.8	11	8	3	4	12	35	27
				Mean	7	7	6	6	18	38	18

NY 96 SE 20 **9514 6107** **Hexham Levels** **Block C**

Surface level (+72.8 m) +239 ft
Water level +62.8 m (+206 ft)
September 1975

Overburden 1.5 m
Mineral 2.0 m
Waste 7.5 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and silt, brown, sandy, pebbly	1.5	1.5
Alluvium	Gravel Gravel: cobble and coarse; well rounded quartzite and sandstone with some limestone, porphyry and quartz Sand: fine, medium and coarse; subrounded to rounded quartz and rock fragments	2.0	3.5
Boulder Clay	Clay, dark grey, hard, sandy, pebbles of mudstone and sandstone	7.5	11.0
Stainmore Group	Mudstone, black	1.0+	12.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
1	11	88	1.5–2.5	2	3	3	3	7	36	46
			2.5–3.5	1	3	4	5	9	38	40
			Mean	1	3	4	4	8	37	43

APPENDIX G

CONVERSION TABLE, METRES TO FEET (to nearest 0.5 ft)

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

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INSTITUTE OF GEOLOGICAL SCIENCES

INDUSTRIAL MINERALS ASSESSMENT UNIT

THE SAND AND GRAVEL RESOURCES OF SHEET NY86 & 96 (HEXHAM, NORTHUMBERLAND)

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

ORDNANCE SURVEY
SHEET NY 86 & NY 96
PROVISIONAL EDITION

THE SAND AND GRAVEL RESOURCES OF SHEET NY 86 & 96 (HEXHAM, NORTHUMBERLAND)

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

EXPLANATION OF SYMBOLS AND ABBREVIATIONS

DRIFT

	Peat P-1	
	Alluvium -silt, clay, sand and gravel. A-43	
	1st Terrace 1T-25	River Terrace deposits -sands, sandy gravels and gravels, partly clayey.
	2nd Terrace 2T-18	
	Undifferentiated Terraces UT-7	
	Glacial Sand and Gravel -clayey sand, sands and gravels. GS-45	
	Boulder Clay -grey and brown stony clay. BC-22	

RECENT AND PLEISTOCENE

SOLID

LCM	Coal Measures -cyclic sequences of shales, sandstones and coals.	PERMO-CARBONIFEROUS CARBONIFEROUS
MG	Stainsmore Group, undivided -limestones, sandstones, shales and thin coals.	
GL	Great Limestone, in Stainmore Group -well-bedded grey limestone, locally shelly.	
ULd	Upper Liddesdale Group -limestones, sandstones, shales and thin coals.	

IGNEOUS

qD	Quartz Dolerite

Made Ground MG-2

BOUNDARY LINES

- Geological boundary, Drift.
- Geological boundary, Solid.
- Fault, crossmark indicates downthrow side.
- Glacial drainage channel.
- Resource Block boundary.

Broken line denotes uncertainty.

BOREHOLE DATA

SITE LOCATION

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

I.M.A.U. BOREHOLES

Borehole Registration Number → NE 36 / 45.6 134 — Surface level in metres and feet above O.D. (Newlyn)

Borehole Site →

Geological Classification:
- 0.5 (1.5) — Overburden
- 4.3 — Mineral (sand and gravel)
- Waste
- 7.6 — 3.5+ — Mineral (sand and gravel)
- 7.2 + (MG) 0.2 + — Waste / Bedrock

Grading Diagram

Thicknesses in metres

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

Borehole Registration Number

Each I.M.A.U. borehole is identified by a Registration Number, eg. NE 36. 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 36 is NY 96 NE 36.

Grading Diagrams

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

Sand (+ 1/16 -6mm) — Fines (-1/16mm) — Gravel (+ 6mm)

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.

CATEGORIES OF DEPOSITS

- Exposed mineral. CAT-E6
- 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

Where appropriate on other sheets a category 'Discontinuous spreads of mineral beneath overburden' is recognised.

RESOURCE BLOCKS

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

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

Made and printed for the Institute of Geological Sciences, by the Director General of the Ordnance Survey, Southampton.

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

Original geological survey by D. Burns, H. Miller and H. H. Howell.
Partial resurvey of parts of sheets 19 and 20 by W. Anderson, G. A. Burnett, R. G. Curruthers and T. Robertson in 1929-49, R. G. Carruthers and T. Robertson, District Geologists; and by D. W. Holliday, J. R. Davies, D. H. Land and P. A. Rathbone in 1969-70, B. J. Taylor and J. G. O. Smart, District Geologists.
Resurvey of parts of sheets 13, 14 and 20 by D. W. Holliday and D. V. Frost in 1968-71, B. J. Taylor, District Geologist.

Sand and Gravel Survey by J. H. Lovell, L. M. Cooper and I. Jackson in 1975.
R. G. Thorrett, Head, Industrial Minerals Assessment Unit.

1:25 000 Sand and Gravel Resource Sheet published 1980.
G. M. Brown, D.Sc; F.R.S; Director, Institute of Geological Sciences.
1980.

The GRID lines on this sheet are at 1 Kilometre interval.
Heights are in feet above Mean Sea Level at Newlyn.
Contour values are in feet.
A figure in italics on this map represents WASH as seen 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.

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Compiled from 6" sheets last fully revised 1970. Other partial (systematic) revisions 1938-52 have been incorporated.

NY87	NY97 13	NZ07 14
NY86	NY96 19	NZ06 20
NY85	NY95	NZ05

Diagram showing the relation of the National Grid 1:25,000 sheets with the One-Inch Geological Sheets 13, 14, 19 and 20.

Scale 1:25000

Yards 1000 0 1 2 Miles

Metres 1000 0 1 2 3 Kilometres

L.E.Denaike 1980