

The sand and gravel resources of the country around Whitchurch and Malpas, Clwyd, Cheshire and Shropshire

Description of 1:25 000 sheet SJ 44, 54

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

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

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PREFACE

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

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

This report describes the resources of sand and gravel of 200 km² of country around Whitechurch and Malpas, in the counties of Clwyd, Cheshire and Shropshire, shown on the accompanying resource map. The survey was supervised by I. Jackson, and carried out by him, S. J. Mathers, D. J. Lowe and A. N. Morigi. The work is based on a six-inch geological survey by E. G. Poole, A. J. Whiteman and D. Magraw in 1955-57. A. A. Wilson has substantially amended the solid geological lines and contributed the account of the solid geology.

J. D. Burnell, ISO, and G. I. Coleman (Land Agents) were responsible for negotiating access to land for drilling. The ready co-operation of landowners and tenants in this work is gratefully acknowledged.

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24 January 1983

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SUMMARY

The geological maps of the Institute of Geological Sciences, pre-existing borehole information and 99 boreholes drilled for the Industrial Minerals Assessment Unit form the basis of the assessment of the sand and gravel resources of the country around Whitchurch and Malpas.

The glacial sediments of the district proved to be more complex than is shown on the published geological map. Glacial Sand and Gravel, present over much of the area in the south and east, shows rapid lateral and vertical variation in composition although sand-grade deposits predominate. Recorded thicknesses of overburden and waste also have a wide range.

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

The 1:25 000 map is divided into 7 resource blocks, containing between 2.9 and 37.2 km² of sand and gravel. For each block the geology of the deposits is described, and the mineral-bearing area, the mean thicknesses of overburden and mineral and the mean gradings are stated. Detailed borehole data are also given. The geology, the position of the boreholes and the outlines of the resource blocks are shown on the accompanying map.

Notes

Each borehole registered with the Institute is identified by a four-element code (e.g. SJ 44 SE 8). The first two elements define the 10-km square (of the National Grid) in which the borehole is situated; the third element defines a quadrant of that square, and the fourth is the accession number of the borehole. In the text of the report the borehole is normally referred to by the last three elements alone (e.g. 44 SE 8).

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

Bibliographical reference

JACKSON, I., LOWE, D. J., MORIGI, A. N. and MATHERS, S. J. 1983. The sand and gravel resources of the country around Whitchurch and Malpas, Clwyd, Cheshire and Shropshire: description of 1:25 000 sheet SJ 44 and SJ 54. *Miner. Assess. Rep. Inst. Geol. Sci.*, No. 136.

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INTRODUCTION

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

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

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

- a The deposit should average at least 1 m in thickness.
- b The ratio of overburden to sand and gravel should be no more than 3:1.
- c The proportion of fines (particles passing a 0.063 mm B.S. sieve) should not exceed 40 per cent.
- d The deposit should lie within 25 m of the surface, this being taken as the likely maximum working depth under most circumstances. It follows from the second criterion that boreholes are drilled no deeper than 18 m if no sand and gravel has been proved.

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

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

For the particular needs of assessing sand and gravel resources, a grain-size classification based on the geometric scale $\frac{1}{8}$ mm, $\frac{1}{4}$ mm, 1 mm, 4 mm, 16 mm, 64 mm has been adopted. The boundaries between fines (that is, the clay and silt fractions) and sand, and between sand and gravel grade material, are placed at $\frac{1}{8}$ mm and 4 mm respectively (see Appendix C).

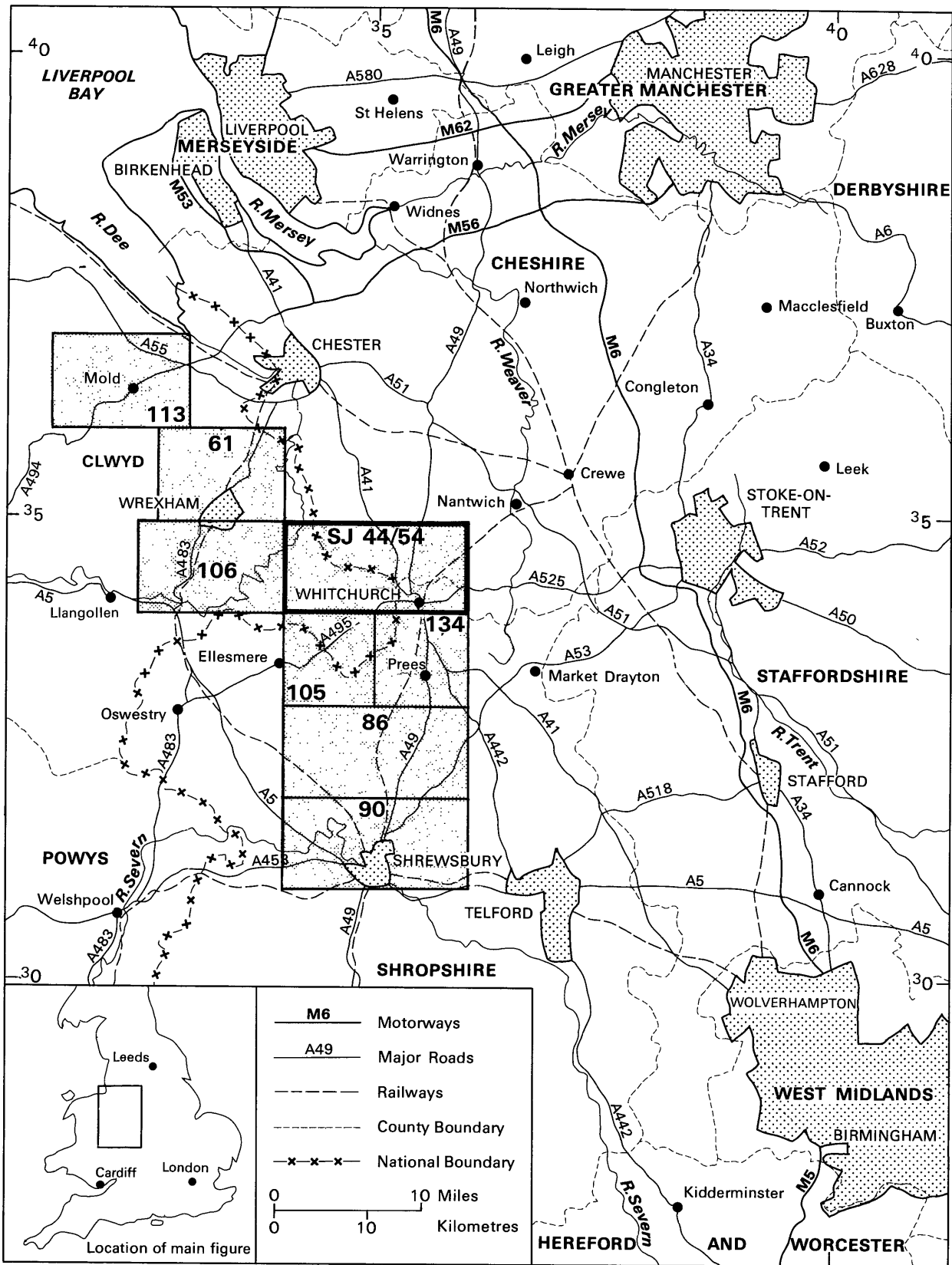


Figure 1 Sketch-map showing the location of the district. (Sand and gravel resources have been assessed by IMAU in the 1:25 000 sheet areas which have been shaded: the relevant Mineral Assessment Report number is quoted.)

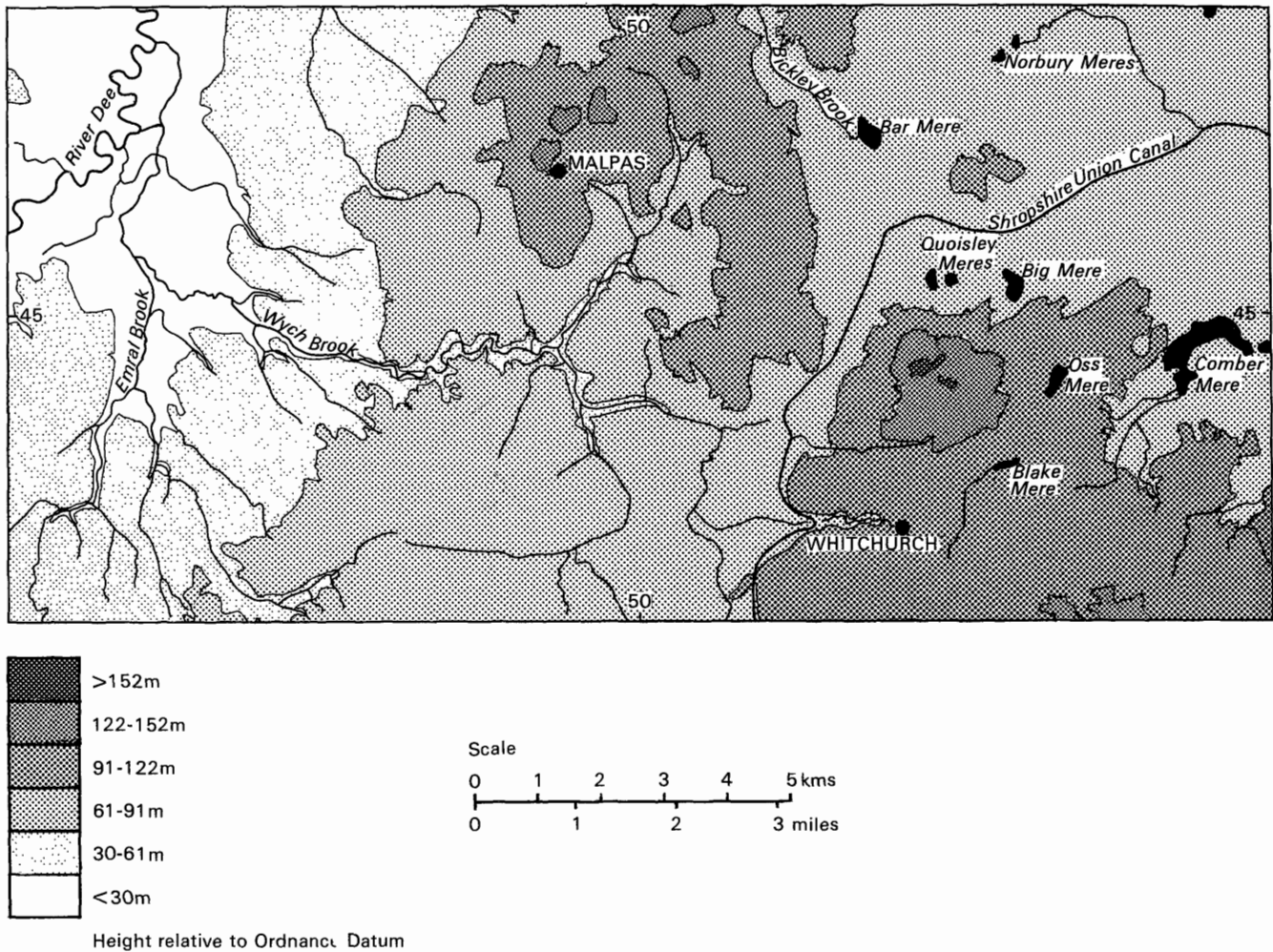


Figure 2 Topography of the district.

The volume and other characteristics are assessed within resource blocks, each of which, ideally, contains approximately 10 km² of sand and gravel. No account is taken of any factors, for example roads, villages or land of high agricultural or landscape value, which might stand in the way of sand and gravel being exploited, although towns are excluded. The estimated total volume therefore bears no simple relationship to the amount that could be extracted in practice.

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

DESCRIPTION OF THE DISTRICT

The district occupies 200 km² of country to the south-east of Wrexham and lies within the counties of Cheshire, Clwyd and Shropshire (Figure 1). The largest settlement is the market town of Whitchurch [544 415] near the southern border of the district; Malpas, close to the centre of the area [485 473], is the largest village.

Except for minor light industry in and around Whitchurch the district is mainly agricultural. Dairy farming predominates and supports a small food-processing industry, whilst arable farming, especially of potatoes and other root crops, is carried out on some areas of lighter, better-drained soil.

Topography

The River Dee, which meanders across the north-west of the district, has a flood-plain up to 2 km wide with an

average elevation of 10 m AOD. To the south-east of the Dee the land rises gently and fairly evenly to form an undulating plateau approximately 80 to 100 m AOD (Figure 2). Around Whitchurch, several prominent ridges of glacial origin reach a maximum elevation of 156 m AOD near Wirswall [545 441]. West of Whitchurch, the land is locally deeply dissected by streams which flow ultimately to the Dee, whilst to the north and east the country presents a flatter, gently rolling aspect with wide shallow valleys and numerous meres and small mosses. Around and north-west of Malpas, the topography reflects the presence of the underlying solid rocks, with a number of parallel sandstone ridges and fault scarps, rising to about 110 m AOD at Kidnal Hill [477 487]. These features mark the south-westerly culmination of the mid-Cheshire Ridge.

Geology

The geology of the Whitchurch district has been described by Poole and Whiteman (1966) and is published on New Series One-inch Geological Sheet 122 (Nantwich). Although the accompanying resource map is based on this work, drilling during the assessment programme proved the published geological map to be in need of substantial amendment, particularly with respect to the drift stratigraphy.

Thus, whereas drift boundaries limiting outcrops of Glacial Sand and Gravel have been included on the resource map for assessment purposes, it should be emphasised that these lines are locally considered to be unreliable as a guide to the actual drift sequence proved by drilling. It was also considered more meaningful to

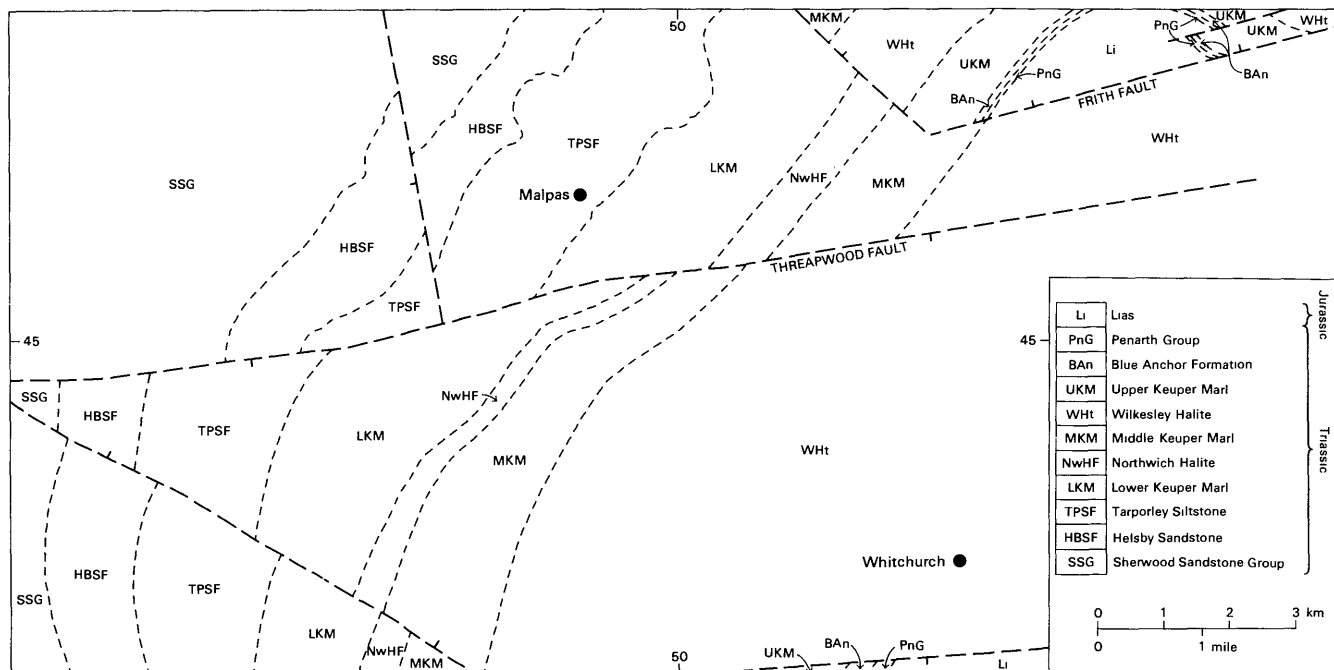


Figure 3 Sketch map showing the solid geology of the district.

Table 1 Geological Sequence

DRIFT	
Quaternary	
Recent and Pleistocene	'Head' Peat Alluvium Alluvial Fan River Terrace Deposits, undifferentiated Fluvio-glacial Gravel Glacial Sand and Gravel Glacial Silt and Clay Till
SOLID	
Jurassic	Lias
Triassic	Penarth Group ('Rhaetic') Blue Anchor Formation ('Tea Green Marl') 'Upper Keuper Marl' Wilkesley Halite ('Upper Keuper Saliferous Beds') 'Middle Keuper Marl' Northwich Halite ('Lower Keuper Saliferous Beds') 'Lower Keuper Marl' Tarpорley Siltstone ('Keuper Waterstones') Helsby Sandstone ('Keuper Sandstone' and 'Keuper Sandstone Conglomerate') Sherwood Sandstone Group ('Upper Mottled Sandstone', 'Bunter Pebble Beds', 'Lower Mottled Sandstone')

abandon the category 'boulder clay' on the resource map in favour of undifferentiated glacial drift deposits (which include till as well as other glacial silts and clays). Generalised drift lines from Sheet 122 are illustrated in Figure 4. Because most of the area is covered by drift deposits, which locally exceed 100 m in thickness (Figure 5), solid rocks are exposed only in small areas around Malpas and in the bottom of the deeper valleys such as the Wych Brook. The solid lines have been amended by A. A. Wilson and now take account of IMAU and other recent borehole information (see Figure 3). The geological sequence is summarised in Table 1 where deposits are listed, as far as possible, in order of increasing age.

SOLID

Triassic These sediments crop out on the north-western limb of the Wem-Audlem Syncline. The earliest group, the Sherwood Sandstone, is mainly drift-covered and consists of 800 m of fine-grained reddish brown sandstone with a median pebbly unit. Two IMAU boreholes proved the uppermost formation, the Wilmslow Sandstone ('Upper Mottled Sandstone'), and one recorded the overlying Helsby Sandstone ('Keuper Sandstone Conglomerate' and 'Keuper Sandstone'), which consists of approximately 70 m of brown sandstone with pebbles towards the base; this formation forms the conspicuous feature of Overton Scar [471 490].

Beds above the Helsby Sandstone are largely overlain by glacial drift, except in the valley of Wych Brook where there is intermittent exposure upwards through the succession to the topmost 'Middle Keuper Marl'. The Tarpорley Siltstone ('Keuper Waterstones') is some 250 m thick and contains two contrasting facies, namely alternating sandstones and laminated mudstone and an aeolian sandstone (the Malpas Sandstone). Three boreholes reached the first facies and one the second facies. The Lower Keuper Marl, approximately 550 m in thickness, consists of poorly laminated beds of dominantly reddish

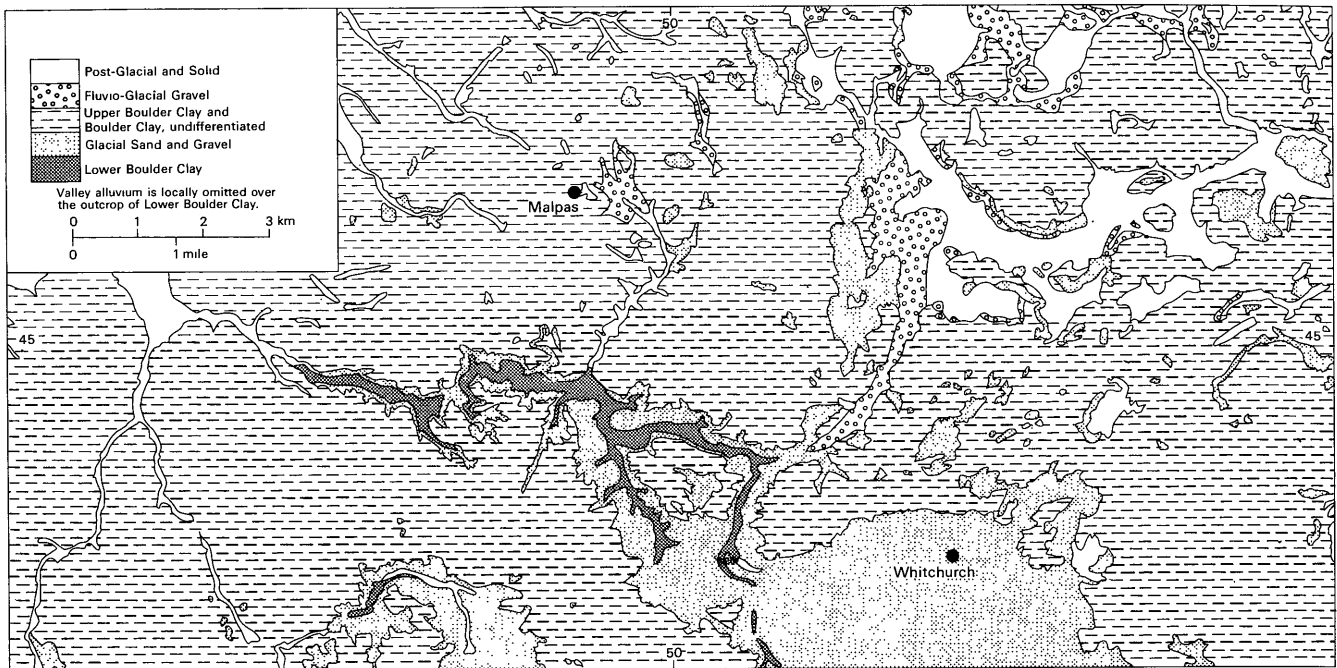


Figure 4 Sketch map showing the drift geology of the district (after Poole and Whiteman).

brown colour overlain by laminated reddish brown and greenish grey mudstone (with many very thin intercalated siltstone beds). Six boreholes sunk during the present programme reached this formation. The overlying Northwich Halite ('Lower Keuper Saliferous Beds') is 330 m thick in the east but only about 80 m thick in the west. It consists of halite with interbedded mudstones, overlain at outcrop by collapse breccias. The 'Middle Keuper Marl' comprises 300 m of structureless beds alternating with laminated ones (some being of greenish grey colour) overlain by structureless reddish brown mudstone with gypsum nodules. The Wilkesley Halite ('Upper Keuper Saliferous Beds') forms an extensive outcrop which is larger than had been realised hitherto. It consists of 400 m of halite with several mudstone partings. Four IMAU boreholes probably penetrated collapsed beds that normally overlie the salt. The 'Upper Keuper Marl', 160 m in thickness, comprises chocolate and reddish brown structureless mudstone with a few thin greenish grey bands. Nodules and bands of anhydrite occur at many levels. One IMAU borehole is thought to have reached this formation.

The Blue Anchor Formation ('Tea Green Marl') consists of about 16 m of greyish green partly calcareous mudstones and siltstones. The Penarth Group ('Rhaetic'), comprises 13 m of silty mudstones with thin beds of sandstone and limestone.

Jurassic The Lias crops out on the fringe of the Prees outlier in the south-east of the district, and in two smaller outliers near Frith Farm [577 493] and Combermere Park [590 440]. Borehole 54 NE 8, drilled 1 km west of the Frith Farm Lias outcrop as originally mapped by IGS, penetrated dark grey Lower Lias mudstones, indicating a considerable extension of the outlier.

DRIFT

The glacial deposits encountered in IMAU boreholes comprise a complex and laterally variable sequence which cannot be accommodated in the framework of Upper Sands, Upper Boulder Clay, Middle Sands and Lower Boulder Clay advocated by Poole and Whiteman (1961, 1966) and depicted on New Series One-inch Geological Sheet 122 (Nantwich). Correlation between

deposits encountered in boreholes and exposures is difficult, but it is apparent that spreads of till previously assigned to the Upper Boulder Clay on field mapping evidence are interbedded with deposits of clay, silt, sand and gravel previously assigned to the Middle Sands, and that in this district no continuous till sheet referable to the Upper Boulder Clay exists. Thus, whereas Poole and Whiteman regarded the glacial sequence as the product of two distinct ice advances and retreats, it now seems likely that most of the deposits seen at outcrop and in boreholes could have been deposited during a single (probably Late Devensian) glacial episode.

Throughout most of the district a basal lodgement till partly equivalent to the Lower Boulder Clay is overlain by a series of ice-decay or stagnation deposits, including sands and gravels, silts and clays, melt-out and flow-tills, which may be partly or wholly subaqueous in origin.

Crescentic or arcuate ridges of mixed morainic material, considered by Poole and Whiteman to be the products of their first glacial retreat phase, have a fresh morphological expression which is unlikely to have survived either remoulding by a subsequence advance or burial by retreat deposits of a second glaciation. Thus, these moraines may represent the deposits of relatively brief standstills during the retreat of the last glaciation.

The possibility of ponded glacial meltwater covering a large part of the region (cf Lake Lapworth; Poole and Whiteman, 1961; Worsley, 1975) cannot be ignored. Much of the relatively coarse-grained outwash material probably represents proximal deltaic deposits which locally prograde over finer grained distal deposits. Certainly, a continuous grain-size spectrum exists and the lateral equivalence of coarse- and fine-grained sediments is in places demonstrable. Elsewhere, it is suspected that tills generated by subaqueous mass flow may pass into or be overlain by fine-grained lag sediments.

Several boreholes in the district penetrated the lodgement till/'Lower Boulder Clay' to prove underlying sands, gravels, clays, tills and, in one instance (borehole 54 NE 12), organic deposits. Elsewhere, the lodgement till lay directly on a bedrock surface or on a 'Keuper'-derived deformation till. The earlier deposits, assumed to occupy hollows or channels in the rockhead surface,

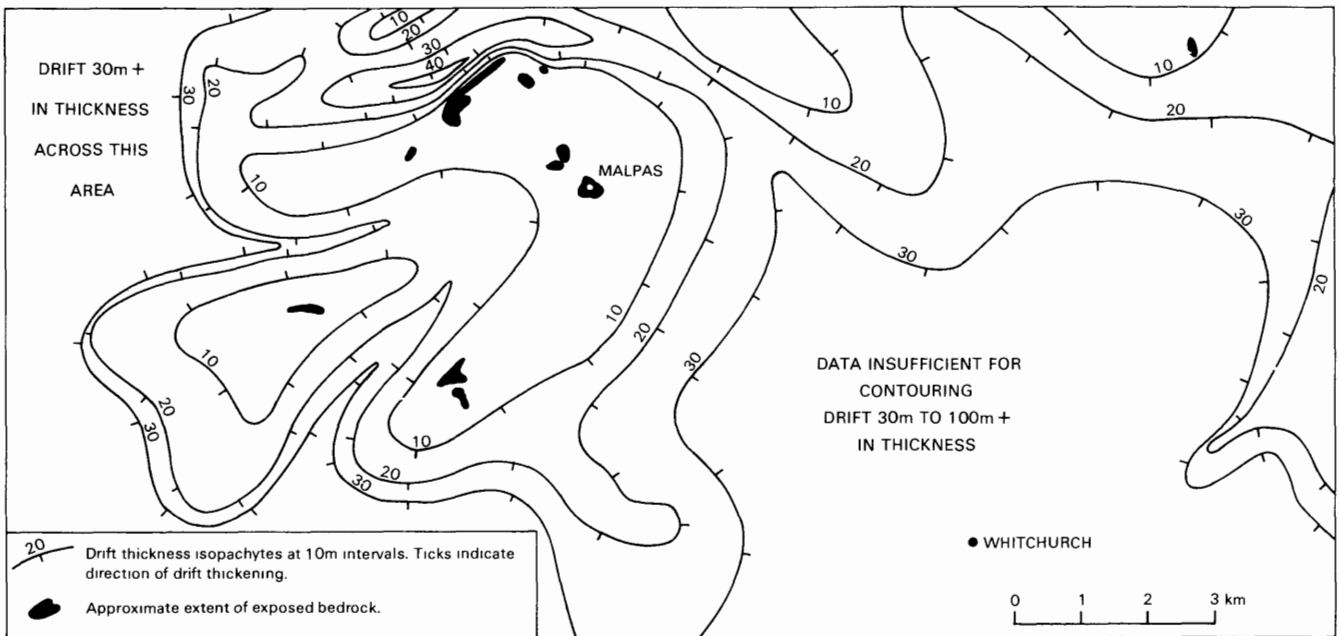


Figure 5 Generalized thickness of drift.

may in part represent remnants of sediments laid down in advance of the last ice sheet, whereas others may be the products of older (? early or pre-Devensian) glaciations and interstadial or interglacial environments.

Post-glacial deposits in the area consist of river terraces, alluvial fans, alluvium and peat, the last two generally infilling hollows in the irregular surface of the glacial deposits. In many places, glacial or post-glacial deposits have been subjected to intense leaching and weathering or have been moved by hillwash, landslip or solifluxion - so that they may no longer resemble the parent material. For convenience such deposits have been classified as 'Head'.

Till Although deposits of till cover extensive tracts of the district, they are probably less widespread than shown on the published geological map. A range of sediments exists but several distinct lithologies are recognised. Sandy, pebbly clays, present throughout the district, are broadly of two types. A very hard deposit is found at a low level in many boreholes, usually underlying later outwash deposits. This till, which may be reddish brown or greyish brown in colour, probably represents the lodgment till laid down beneath the ice sheet. Elsewhere, particularly in the east of the district, sandy pebbly clays of variable thickness occur at higher levels, often interbedded with outwash deposits. These clays are generally softer than the supposed lodgment till, are usually reddish brown in colour and may be melt-out and flow-tills deposited during ice decay. At some localities, notably south-west of Whitechurch (for example, in boreholes 54 SW 24 and 54 SW 28), these tills are extremely sandy and their weathered surface layers have previously been mapped as Glacial Sand and Gravel.

Another type of till, immediately overlying bedrock (as in boreholes 44 SE 8 and 44 SE 18), was encountered less commonly. It consists mainly of haphazard fragments of country rock in a matrix of degraded country rock and clay with very few far-travelled pebbles. Little transport of material appears to have been involved and it seems probable that the deposit represents a deformation till.

Stone-free or virtually stone-free clays found mainly in the west, and believed by Poole and Whiteman to

represent a true till sheet, may be of lacustrine origin in many places and are discussed in the section on Glacial Silts and Clays.

Erratics in all the tills are commonly of mixed size up to cobble grade, the drilling technique precluding recovery of any material of larger dimensions. Palaeozoic sediments, particularly Carboniferous rocks, are ubiquitous, as are volcanic and intrusive igneous types typical of both the Lake District and southern Scotland. Permo-Triassic sediments are locally common, particularly in the east of the district. Some tills contain abundant quartz pebbles with subordinate amounts of flint/chert and well rounded Carboniferous limestone. Erratics of softer Penarth Group or Liassic sediments are extremely localized and found only close to the subcrops of the parent rock, being too weak to endure long transport. The erratics range from angular to well rounded and are commonly polished or striated. The locally derived Permo-Triassic erratics tend to be angular whereas the more far-travelled material is generally at least sub-rounded. The suite of erratics supports the suggestion of most previous workers in the area that the ice sheet responsible for most of the till deposits originated in the north, with an important north-westerly (Irish Sea) component. This suggestion is reinforced by the presence of comminuted marine shells. In the extreme west of the area, some till may have been derived from ice originating in the Welsh hills as evidenced by erratics of Welsh-type pyroclastic rocks and unusual grits of the Cefn-y-Fedw Sandstone type which are found locally.

Glacial Sand and Gravel Because the Whitechurch area has no working or disused sand and gravel pits and few significant natural exposures, the detailed sedimentology, including the vertical and lateral relationships of these deposits, is not known. Outwash deposits, predominantly sand of highly variable thickness, were proved across most of the area, but drilling showed that a single continuous, lithostratigraphical unit such as the Middle Sands of Poole and Whiteman (1961) does not occur. Furthermore, in certain areas, especially south-west of Whitechurch, it is now clear that deposits previously mapped as Glacial Sand and Gravel are the leached tops of extremely sandy till sheets, the original clay content

commonly being preserved as a 'pan' 1.5 to 2 m beneath the surface.

Thick sequences of gravel or sandy gravel were proved in only a small number of boreholes (for example 44 SE 13 and 54 NE 11) and because these deposits were not found in adjacent boreholes it is assumed that these coarser sediments occupy isolated channels. Pebbly sands and the various sand-grade deposits were encountered more commonly and were usually thicker than the gravels. In many instances the deposits seemed to show a rhythmic or cyclic grading with, sporadically, an overall upward coarsening of cycles. It is assumed that these finer sediments represent the more distal products of ice decay outwash and that most of the proximal gravels lie outside the area of assessment.

In some areas, particularly along the southern margin of the area west of Whitchurch, thick deposits (in excess of 18.5 m) of fine and medium sand occur as flat-topped benches or terraces. The concordant summit levels of these features and the similarity of their levels to those of the upper surfaces of such features as the Wrexham Delta Terrace (Wedd and others, 1928) to the west of the Dee is significant, and may indicate a water surface level in a depositional basin such as a melt-water lake.

Glacial Silt and Clay The presence of beds of fine-grained sediment within the glacial sequence has long been recognised, though such deposits have not been considered to be mappable units. Drilling has shown that beds referable to Glacial Silt and Clay are far more common than previously assumed and the likelihood is that parts of the district formerly mapped as Boulder Clay consist of these deposits. Broadly, they are of two types.

Massive, virtually stone-free silts and clays, which seem to be the distal equivalents of coarser deposits elsewhere, are widespread but are particularly common in the west and in the area of Willey Moor. A thickness of more than 20 m of massive silt, relieved only by thin bands of 'very clayey' sand, was proved in borehole 54 NW 36. Elsewhere thicknesses ranging between 5 and 10 m are common. In boreholes where smaller thicknesses were recorded, the silt or clay usually represents the upper part of a graded unit.

Finely laminated clays form a distinctive lithology of widespread occurrence and are assumed to represent varved or rhythmic clays laid down in very quiet conditions in the centre of a lacustrine basin. Thicknesses proved vary from 100 mm to more than 6 m (as in borehole 54 SE 52). Generally, these clays are very hard and often highly contorted and sheared, possibly due to penecontemporaneous loading.

Both types of silt and clay are found within sequences which include till and Glacial Sand and Gravel, and it seems reasonable to assume that, because they were laid down subaqueously, much of the sand and gravel and many of the higher tills may be of subaqueous origin also.

Fluvio-glacial Gravel This deposit is shown on the published geological map occurring as terraces in the north-east of the district and as larger spreads in the Willey Moor valley and east of Malpas. Borehole 44 NE 30, east of Malpas, proved 4.2 m of 'very clayey' pebbly sand and gravel on bedrock, but drilling in the major spread at Willey Moor revealed fine-grained sediments probably better referred to Glacial Silt and Clay. Borehole 54 NE 8, drilled in mapped Fluvio-glacial Gravel, proved 4.6 m of sand with some gravel on presumed lodgement till. It is uncertain whether these 'terrace' deposits are fluvio-glacial in origin or represent early post-glacial river terraces or alluvial infill, but their dissected nature suggests an appreciable age.

River Terrace Deposits In the west of the area, the River Dee has two discontinuous terraces, the first about

1 to 1.5 m above the floodplain and the second 5 to 6 m higher. Boreholes 44 NW 26 and 30, sunk into mapped Second Terrace, proved Glacial Silt and Clay at surface, suggesting that the Dee terraces are at least in part remnants of erosional benches rather than depositional features. Farther east, boreholes drilled into discontinuous terraces mapped in the Bickley Moss area and in the broad valley between Marbury and Wrenbury proved mixed deposits of 'clayey' sand and 'clayey' pebbly sand although borehole 54 NE 21 encountered till at the surface.

Alluvium and Alluvial Fan The Dee floodplain and most of the smaller valleys in the area carry spreads of alluvium. Borehole 44 NW 23 in the Dee valley proved soft, partly organic, silts and clays overlying sandy gravel to a depth of 8.7 m. In the smaller valleys the alluvium is up to 3 m thick and generally consists of soft clay and sandy silt, although locally (for example, in borehole 54 SW 23) it may comprise sand and gravel.

Limited amounts of lacustrine alluvium occur locally, filling old lake beds and depressions, but these have not been delineated on the geological map. Borehole 54 NE 10 between Big Mere and Little Mere at Marbury proved 0.8 m of soft laminated clay on sandy till. Much of the near-surface clay proved by drilling in the valleys of Willey Moor and west of Wrenbury probably represents lacustrine alluvium, both areas reportedly having supported large lakes in historical times. A thick deposit of silt and clay containing organic debris was encountered in borehole 54 SW 30; the sediments are tentatively included within this group, but until further research is carried out, their origin remains problematical.

Peat Found in numerous infilled hollows across the area, peat is often associated with 'gytta' (organic mud)

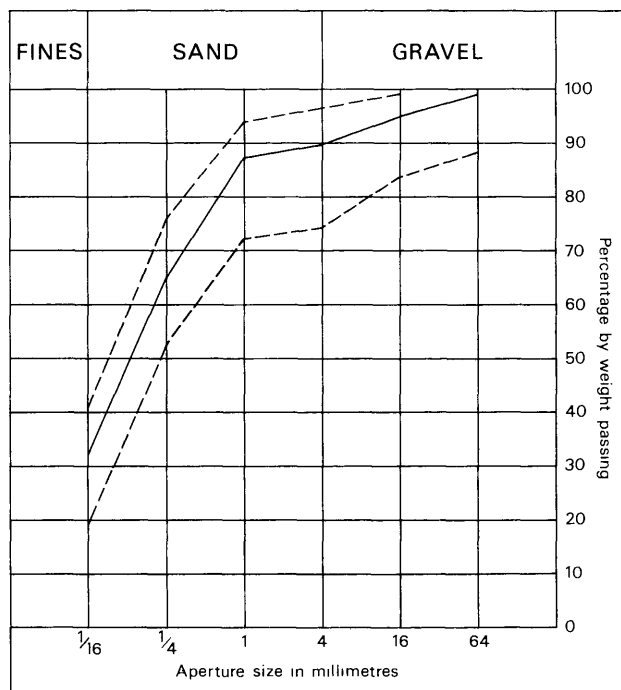


Figure 6 Particle-size distribution of a sandy till (samples from 54 SW 28). (The continuous line is the cumulative frequency curve of the mean grading of the deposit as a whole; the broken lines denote the envelope within which the grading curves for individual samples fall.)

Table 2 Lithological analyses of the +8 -32 mm gravel from selected boreholes (expressed in percentage weight).

Borehole number	Size fraction (mm)	Igneous		Palaeozoic		Permo-Triassic		Quartz	Flint and chert	Limestone	Others
		fine-grained	coarse-grained	arenites	argillites	arenites	argillites				
Alluvium											
44 NW 22	+16	10	7	16	62	0	0	4	0	0	1
	+8-16	13	2	10	72	0	0	2	0	0	1
	mean	11	5	13	67	0	0	3	0	0	1
44 NW 24	+16	22	9	37	21	0	0	8	0	0	0
	+8-16	20	4	46	22	0	0	4	2	trace	1
	mean	21	7	41	21	0	0	6	1	trace	1
River Terrace Deposits											
44 NE 30	+16	5	5	40	7	37	trace	4	trace	0	2
	+8-16	8	4	23	17	41	2	4	trace	1	trace
	mean	6	4	32	10	11	14	9	trace	6	1
Glacial Sand and Gravel											
44 NE 31	+16	17	7	33	8	9	6	11	0	8	1
	+8-16	20	2	20	12	13	20	8	trace	5	trace
	mean	19	4	26	10	11	14	9	trace	6	1
44 SW 14	+16	5	0	65	0	13	0	13	0	0	0
	+8-16	24	2	46	3	12	1	10	2	trace	trace
	mean	19	1	51	3	13	1	11	1	trace	trace
44 SE 8	+16	14	17	28	13	3	1	5	0	19	0
	+8-16	19	5	26	24	8	3	8	trace	7	trace
	mean	17	13	28	19	6	2	7	trace	8	trace
44 SE 13	+16	20	15	26	8	12	4	5	1	5	4
	+8-16	15	10	21	20	9	4	6	2	9	4
	mean	18	13	24	12	11	4	6	1	7	4
54 NW 27	+16	5	9	37	22	16	0	3	8	0	0
	+8-16	26	2	23	22	21	0	4	1	0	1
	mean	12	7	32	22	18	0	4	5	0	trace
54 NW 32	+16	3	7	23	7	43	6	3	0	6	2
	+8-16	8	3	14	22	36	10	3	trace	3	1
	mean	5	4	19	13	38	8	3	trace	3	5
54 NW 17	+16	5	7	39	25	20	0	2	0	0	2
	+8-16	13	6	33	18	15	3	5	2	5	trace
	mean	10	15	36	16	13	2	4	trace	3	1
54 SW 24	+16	8	9	32	8	24	0	3	16	0	0
	+8-16	18	16	25	17	12	1	8	2	1	0
	mean	14	13	27	14	17	1	6	7	1	0
54 SW 27	+16	13	11	38	17	6	2	11	0	2	0
	+8-16	12	11	31	24	6	3	5	1	6	1
	mean	13	11	34	22	6	2	7	trace	5	0
54 SE 44	+16	16	8	21	27	17	1	3	0	4	3
	+8-16	17	6	23	26	12	2	5	1	8	trace
	mean	17	7	22	27	15	1	4	trace	6	1
54 SE 48	+16	19	17	35	9	3	0	9	2	5	1
	+8-16	13	7	44	12	8	0	8	1	6	1
	mean	16	13	39	10	5	0	8	2	6	1
54 SE 53	+16	3	37	31	3	4	14	7	trace	1	0
	+8-16	14	5	34	15	15	7	3	trace	5	2
	mean	10	17	32	11	11	10	4	trace	4	1

deposits. In borehole 54 NW 32 at Willey Moor Lock (close to the centre of a drained lake reported in this area), 1.5 m of peat and 0.3 m of organic clay were found.

Head Throughout the district numerous boreholes revealed that, close to the surface, deposits of all types had been strongly weathered, leached, or cryoturbated, making them strikingly different in appearance to the parent deposit. Elsewhere it was possible to recognise material transported by hillwash, 'soil creep', landslip or solifluxion. In cases where the original nature of the material was predictable, the name of the unaltered deposit has been applied; elsewhere and in the absence of a more suitable term, these mixed and highly altered deposits have been referred to as 'Head'.

Composition of the Sand and Gravel Deposits

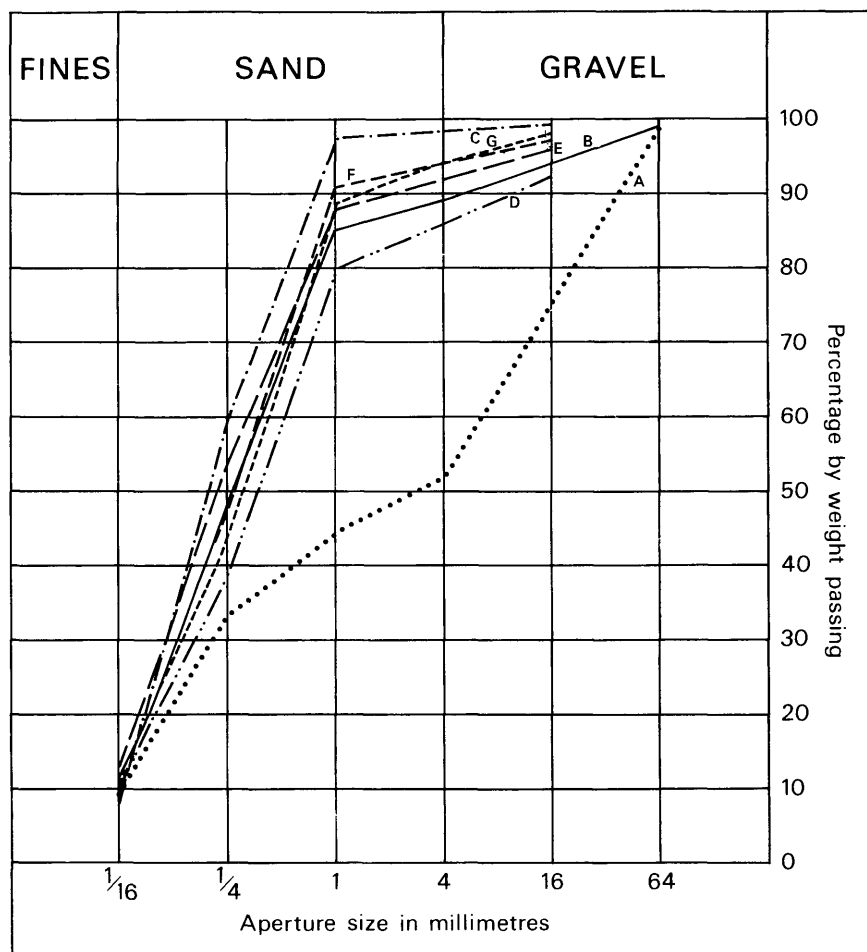
The chief potentially workable deposits are found within the Glacial Sand and Gravel; mineral within Fluvio-glacial Gravel, River Terrace Deposits and Alluvium is subordinate both in extent and thickness. Locally (for example in borehole 54 SW 24, south-east of

Whitchurch), till may grade as mineral but, while the detailed distribution of the deposit is not known, it is assumed to be limited in extent and has been excluded from the assessment. The grading results of till samples are shown in Figure 6.

Detailed grading data and a description of the gravel lithology based on visual inspection are included in the borehole logs in Appendix E. The results of a selected number of detailed pebble analyses are given in Table 2.

Glacial Sand and Gravel While these sediments show rapid lateral and vertical variations of grade, sand deposits, which are 'clayey' and pebbly in many places, predominate. Significant deposits of gravel and sandy gravel are uncommon and were encountered only in boreholes 44 SE 8 and 13, 54 NW 30 and 32, 54 NE 11 and 54 SE 45 and 53. The mean grading of all the samples is fines 10 per cent, sand 82 per cent and gravel 8 per cent.

The gravel fraction is usually composed of almost equal proportions of fine and coarse pebbles. Palaeozoic arenites predominate but Permo-Triassic and younger arenites, Palaeozoic argillites and fine and coarse-grained igneous rocks are also common. Permo-Triassic and younger argillites, quartz, flint, chert and limestone occur in only small amounts. The sand fraction is fine



Block	Percentage by weight passing					
	1/16 mm	1/4 mm	1 mm	4 mm	16 mm	64 mm
A	9	33	44	52	75	98
B	9	48	85	89	94	99
C	7	59	97	98	99	100
D	10	38	80	86	93	100
E	12	53	88	92	96	100
F	9	47	91	94	97	100
G	11	44	89	94	98	100

Figure 7 Mean particle-size distribution for the assessed thickness of sand and gravel in resource blocks A to G.

and medium-grained and comprises quartz, with lithic grains more prevalent in the coarser grades.

Fluvio-glacial Gravel Mineral within this deposit occurs only sporadically and is of varied composition. Borehole 44 NE 30 encountered 'very clayey' pebbly sand overlying gravel whereas 54 NE 8 proved sand with some fine gravel. The fine and coarse-grained gravel recorded in 44 NE 30 consists of Permo-Triassic arenites with Palaeozoic arenites and argillites, fine and coarse-grained igneous rocks and quartz. Sand within the deposit is chiefly fine and medium-grained quartz.

River Terrace Deposits Mineral within River Terrace Deposits proved to be discontinuous and generally thin. 'Clayey' and pebbly sands were encountered in boreholes 54 NW 29 and 30 and 54 NE 17. Lithologically, the fine and coarse gravel is comparable to the glacial material from which it is derived. The sand is predominantly medium-grained quartz.

Alluvium Only alluvium beneath the southern part of the Dee floodplain is considered to be potentially workable. Two boreholes proved gravel with a mean grading of fines 2 per cent, sand 27 per cent, gravel 71 per cent. The +4 mm fraction, composed of equal amounts of fine and coarse pebbles, comprised Palaeozoic arenites and argillites with fine and coarse-grained igneous rocks. The sand is medium to coarse-grained and consists of quartz with lithic grains.

The Map

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

Geological data The geological boundary lines and symbols are based broadly on the most recent geological maps of the area, which was surveyed in 1955-57 at the

Table 3 Sand and gravel resources of the district

Block	Area		Mean thickness			Volume of sand and gravel			Mean grading percentage		
	Block	Mineral	Overburden	Mineral	Waste	Limits at the 95% probability level			Fines	Sand	Gravel
	km ²	km ²	m	m	m	m ³ x 10 ⁶	± %	± m ³ x 10 ⁶	- $\frac{1}{16}$ mm	+ $\frac{1}{16}$ -4 mm	+4 mm
B	35.8	30.8	7.6	12.7	0.9	391	31	121	9	80	11
D	14.8	9.8	0.7	10.3	4.5	101	50	51	10	76	14
E	40.1	37.2	2.3	7.4	0.8	275	26	72	12	80	8
F	22.9	21.9	3.9	10.5	2.9	230	40	92	9	85	6
G	11.0	10.5	4.8	8.2	2.9	86	62	53	11	83	6
Inferred assessments											
A	9.6	4.2	4.5	4.7	1.2	20)		9	43	48
C	2.9	2.9	0.7	18.4	2.6	53)	speculative	7	91	2

scale of 1:10 560. Both the solid geological lines and the limits of drift deposits (to a lesser degree) have been amended to take account of more recent sub-surface information. As stated elsewhere (p 4) it has been considered preferable to abandon the terms 'Upper Boulder Clay' and 'Lower Boulder Clay' for the purposes of the map and all areas previously mapped as such are now described as Glacial Drift, undifferentiated, thus acknowledging the presence of massive and laminated silts and clays in addition to discontinuous till deposits. Figure 4 shows the supposed extent of these deposits as originally mapped. (A short aerial reconnaissance was flown in an attempt to relate, at a basic level, topography to the genesis, distribution and thickness of the drift deposits. Due partly to less-than-ideal weather conditions, the results were inconclusive).

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

Mineral resource information The mineral-bearing ground is divided into resource blocks (see Appendix A). Within a resource block the mineral is subdivided into areas where it is exposed, that is where the overburden averages less than 1 m in thickness, and areas where it is present in continuous, or almost continuous, spreads beneath overburden. The discontinuous mineral category had not been recognised in this area.

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

For the most part the depicted distribution of the various categories of deposits is based on the mapped geological boundaries. Where there is a transition from one category to another which cannot be related to the geological map and which cannot be delineated accurately, inferred boundaries have been inserted. Such boundaries (for which a distinctive zigzag symbol is used) are drawn primarily for the purpose of volume estimation. The symbol is intended to indicate an approximate location within a likely zone of occurrence rather than to represent the breadth of the zone, its size being determined only by cartographic considerations.

For the purpose of measuring areas the centre line of the symbol is used.

RESULTS

The statistical results are summarised in Table 3. Fuller grading particulars are shown in Figure 7 and the mean gradings and 'grading envelopes' for each resource block are given in Figures 8 to 14.

Accuracy of results For five resource blocks, the accuracy of the results at the 95 per cent probability level (that is, on average nineteen out of every twenty sets of limits constructed in this way contain the true value for the volume of mineral) varies between 26 per cent and 62 per cent (Appendix B). However, the true volumes are more likely to be nearer the figure estimated than either of the limits. Moreover, it is probable that roughly the same percentage limits would apply for the statistical estimate of mineral volume within a very much smaller parcel of ground (say 100 hectares) containing similar sand and gravel deposits, if the results from the same number of sample points (as provided by, say, ten boreholes) were used in the calculation. Thus, if closer limits are needed for quotation of reserves, data from more sample points would be required, even if the area were quite small. It must be emphasised that the quoted volume of mineral has no simple relationship with the amount that could be extracted in practice, as no allowance has been made in the calculations for any restraints (such as existing buildings and roads) on the use of the land for mineral working.

Notes on the Resource Blocks

The potentially workable sand and gravel deposits of the district have been divided into seven resource blocks. Five have been assessed at the indicated level; inferred assessments are offered for blocks A and C (see Introduction). Block A encompasses the fluvial deposits of the River Dee, whereas the remainder of the blocks mainly include mineral of glacial origin. IMAU and other boreholes (including several confidential records) in the northern part of sheet SJ 44 and in a relatively smaller strip of ground in the east of SJ 54 proved these areas to be generally barren; inferred boundaries have been inserted accordingly.

Block A (Table 4, Figure 8)

Block A contains the alluvium of the Dee floodplain, marginal terrace deposits and subjacent glacial sediments. Only 4.2 km² are inferred to be mineral-bearing; two boreholes within alluvium (44 NW 23 and 24) proved excessive overburden thicknesses (in terms of the arbit-

Table 4 Block A: data from IMAU boreholes

Borehole	Recorded thickness			Mean grading percentage						
	Overburden	Mineral	Waste*	Fines	Sand			Gravel		
				- $\frac{1}{16}$ mm	Fine + $\frac{1}{16}$ - $\frac{1}{4}$ mm	Medium + $\frac{1}{4}$ -1 mm	Coarse +1-4 mm	Fine +4-16 mm	Coarse +16-64 mm	Cobble +64 mm
m	m	m								
Alluvium										
44 NW 22	2.7	5.0		3	6	17	8	30	34	2
44 NW 25	3.6	4.0		1	2	9	14	37	33	4
Mean				2	4	12	11	34	34	3
Glacial Sand and Gravel										
44 NW 22	3.0	5.0	2.3	23	68	8	0	1	0	0
All deposits										
44 NW 22	5.7	5.0	2.3	13	40	12	4	14	16	1
44 NW 23	absent									
44 NW 24	absent									
44 NW 25	3.6	4.0		1	2	9	14	37	33	4
Mean				9	24	11	8	23	23	2

* Within mineral

rary limiting criteria, p.1) and boreholes 44 NW 26 and 30, sited on terrace deposits, encountered no sand and gravel. Borehole 44 NW 22 recorded 2.7 m of alluvial gravel overlying glacial material including 2.3 m of silt and at least 3.0 m of 'clayey' sand. Borehole 44 NW 25 encountered only 3.6 m of alluvial gravel. These thicknesses produce a minimum speculative estimate of volume of 20 million m³. Overburden, consisting of alluvial silt, clay and peat, has an average thickness of 4.5 m. A waste parting 2.3 m thick between the fluvial and glacial mineral was noted in borehole 44 NW 22.

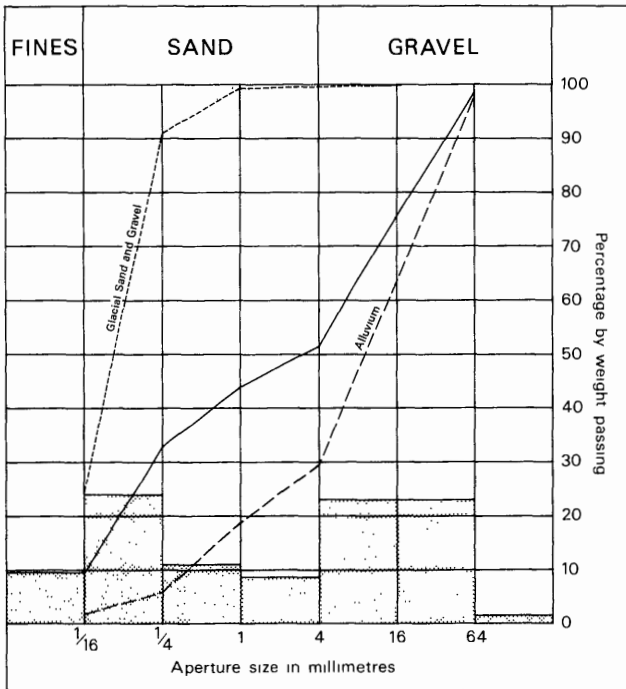


Figure 8 Grading characteristics of the mineral in block A. The mean grading of the block as a whole is shown as a cumulative curve (continuous line) and as a histogram. The mean grading curves for Alluvium and Glacial Sand and Gravel are also shown.

Block B (Table 5, Figure 9)

This block, situated in the south-west of the district, is 35.8 km² in area. Mineral (30.8 km²) comprising deposits of Glacial Sand and Gravel, is concealed beneath glacial clays except for small sinuous outcrops in the valley of Wych Brook and in the south. However, borehole 44 SW 14, sited in an area mapped as till, proved sand from the surface. Four boreholes in the east of the block failed to prove mineral and a conjectural 'barren' area is therefore enclosed by inferred boundaries.

Nine IMAU boreholes proved mineral ranging between 3.9 m (44 SE 8) and 21.0 m (44 SE 11) thick; at three

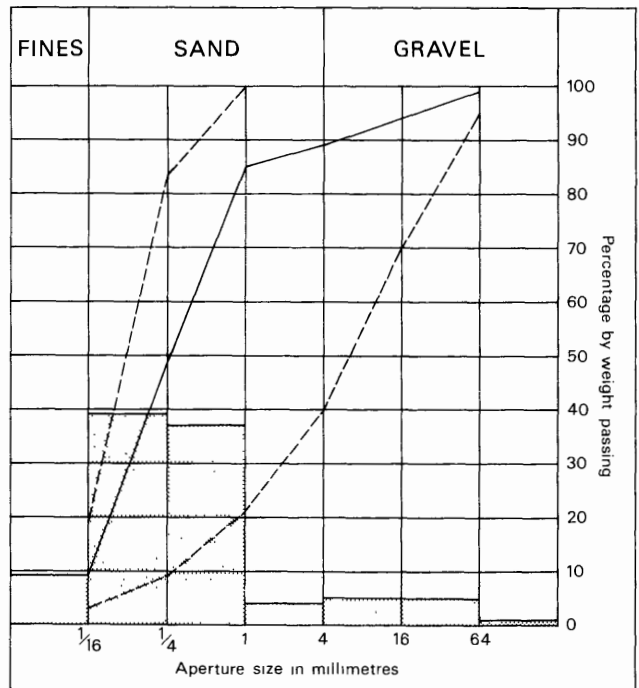


Figure 9 Grading characteristics of the mineral in block B. The continuous line is the cumulative frequency curve for the mean grading of the block as a whole; the broken lines denote the envelope within which the mean grading curves for individual boreholes fall. The mean grading of the block is also shown as a histogram.

Table 5 Block B: data from IMAU boreholes

Borehole	Recorded thickness			Mean grading percentage						
	Mineral	Overburden	Waste	Fines	Sand			Gravel		
	m	m	m	- $\frac{1}{8}$ mm	Fine + $\frac{1}{8}$ - $\frac{1}{4}$ mm	Medium + $\frac{1}{4}$ -1 mm	Coarse +1-4 mm	Fine +4-16 mm	Coarse +16-64 mm	Cobble +64 mm
44 NE 27	8.0	9.0		19	55	19	2	3	2	0
44 SW 9	6.3+	18.7		18	65	17	0	0	0	0
44 SW 10	9.2	6.8		5	42	48	1	2	2	0
44 SW 14	11.9	0.3		8	37	49	4	2	0	0
44 SE 8	3.9	5.3	0.3	3	6	12	19	30	25	5
44 SE 10	9.7	9.5		4	36	56	3	1	0	0
44 SE 11	21.0+	2.5	1.5	11	55	32	1	0	0	1
44 SE 13	16.5+	2.5	6.0	3	18	27	11	19	20	2
44 SE 14	absent									
44 SE 17	absent									
44 SE 19	absent									
44 SE 20	absent									
44 SE 21	10.1	10.3	2.8	10	32	54	3	1	0	0
Mean				9	39	37	4	5	5	1

* Within mineral

sites, the base of the deposit was not reached and in one of the three non-IMAU boreholes used in the assessment at least 23.2 m of sand and gravel were recorded. The mean proved thickness of 12.7 m produces an estimate of volume of 391 million m³ ± 31 per cent. Sands and 'clayey' sands predominate, but the deposit of gravel at borehole 44 SE 8 and the thick (14.0 m+) sandy gravel at borehole 44 SE 13 are notable. The mean grading for the block is fines 9 per cent, sand 80 per cent and gravel 11 per cent. Overburden ranges up to 18.7 m in thickness (44 SW 9) but has a mean of only 7.6 m. Waste partings between 0.3 and 4.0 m thick were encountered at four sites (44 SE 8, 11 13 and 21).

Block C (Table 6, Figure 10)

A small area (2.9 km²) of exposed Glacial Sand and Gravel on the southern margin of the district comprises

this block. Up to 21.3 m of sand were recorded in three boreholes, but the base of the deposit was not reached. The mean grading of the block is fines 7 per cent, sand 91 per cent, gravel 2 per cent; the mean proved thickness is 18.4 m giving a conservative estimate of volume of 53 million m³. Overburden consists only of soil and thin (1.3 m) till. Waste partings 5.5 and 2.4 m thick were proved in boreholes 44 SE 12 and 15, respectively.

Block D (Table 7, Figure 11)

Block D encompasses 9.8 km² of mainly exposed glacial mineral surrounding the unassessed urban area of Whitchurch. Boreholes 54 SW 28, 29 and 31 failed to prove mineral and an inferred boundary has been inserted delineating the area assumed to be barren. Five IMAU and four pre-existing boreholes recorded between 2.5 and 18.5 m of mineral which ranged in composition

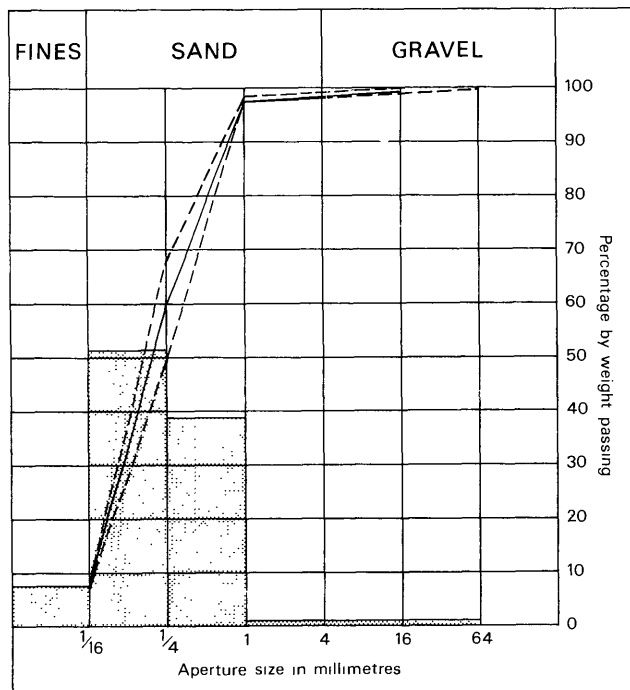


Figure 10 Grading characteristics of the mineral in block C (for explanation, see Figure 9).

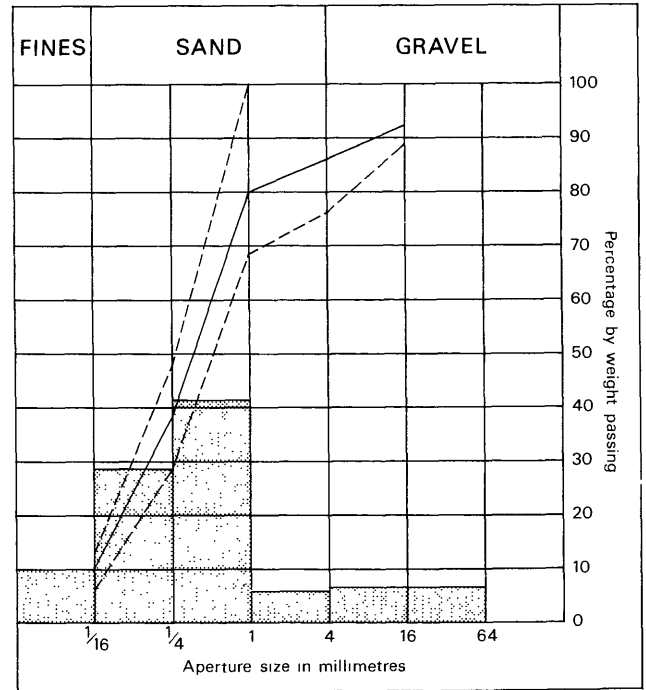


Figure 11 Grading characteristics of the mineral in block D (for explanation, see Figure 9).

Table 6 Block C: data from IMAU boreholes

Borehole	Recorded thickness			Mean grading percentage						
	Mineral	Over-burden	Waste*	Fines	Sand			Gravel		
					- $\frac{1}{16}$ mm	Fine + $\frac{1}{16}$ - $\frac{1}{4}$ mm	Medium + $\frac{1}{4}$ -1 mm	Coarse +1-4 mm	Fine +4-16 mm	Coarse +16-64 mm
m	m	m								
44 SE 9	20.3+	0.2		7	43	48	1	1	0	0
44 SE 12	13.6+	0.4	5.5	7	53	37	1	1	1	0
44 SE 15	21.3+	1.3	2.4	6	61	30	1	1	1	0
Mean				7	52	38	1	1	1	0

* Within mineral

Table 7 Block D: data from IMAU boreholes

Borehole	Recorded thickness			Mean grading percentage						
	Mineral	Over-burden	Waste*	Fines	Sand			Gravel		
					- $\frac{1}{16}$ mm	Fine + $\frac{1}{16}$ - $\frac{1}{4}$ mm	Medium + $\frac{1}{4}$ -1 mm	Coarse +1-4 mm	Fine +4-16 mm	Coarse +16-64 mm
m	m	m								
54 SW 25	13.0	0.5		13	43	32	5	4	3	0
54 SW 32	4.1	0.9		9	21	62	4	3	1	0
54 SW 44	10.0	1.0	8.0	6	23	49	7	7	8	0
54 SE 45	13.1	0.6	9.6	9	19	40	8	12	12	0
54 SE 46	2.5	0.5		9	38	53	0	0	0	0
Mean				10	28	42	6	7	7	0

* Within mineral

from 'clayey' sand to sandy gravel with a mean grading of fines 10 per cent, sand 76 per cent and gravel 14 per cent. The mean thickness is 10.3 m and the estimate of volume is 101 million m³ ± 50 per cent. Overburden, up to 1.4 m in thickness, is usually only soil. Waste partings (between 8.0 and 9.6 m thick) were encountered in four of the boreholes.

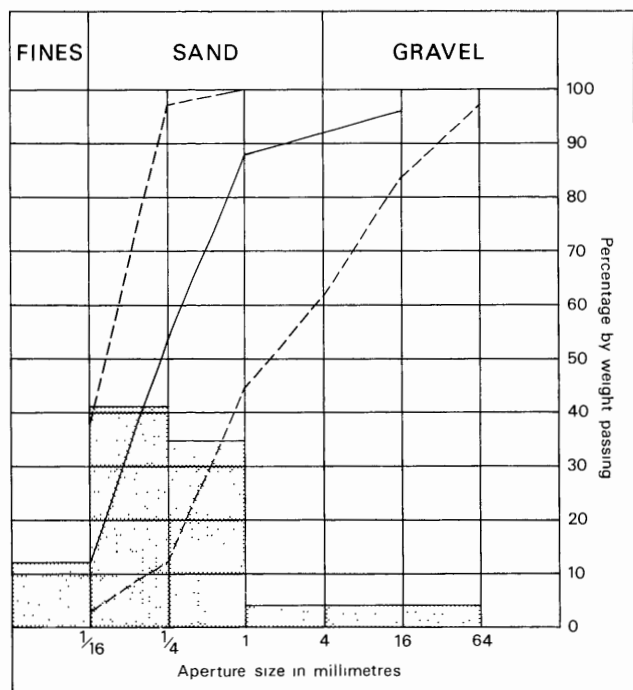


Figure 12 Grading characteristics of the mineral in block E (for explanation, see Figure 9).

Block E (Table 8, Figure 12)

This block includes approximately 37 km² of mainly glacial mineral in the north part of the district. Deposits of Fluvio-glacial Gravel and river terraces in the Malpas, Willey Moor and Bickley Moss areas are locally potentially workable. Boreholes 54 NW 20, 21, 23 and 35 failed to prove sand and gravel and sites 54 NW 21 and 23 have

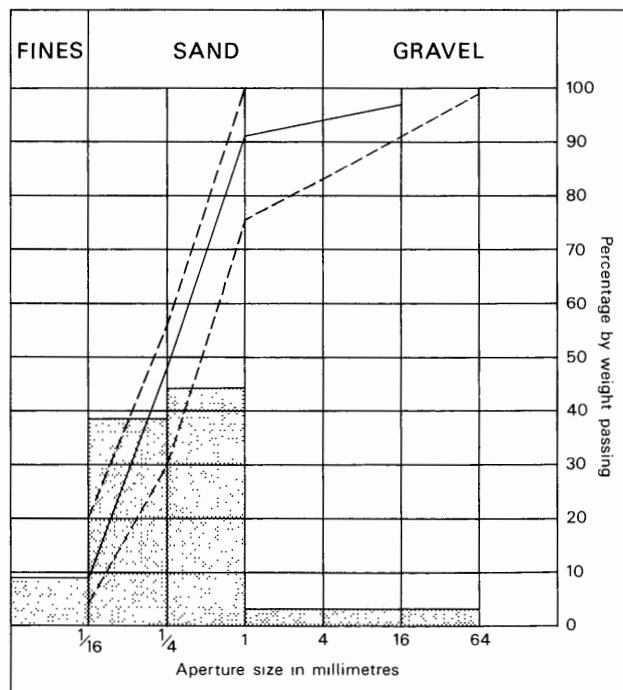


Figure 13 Grading characteristics of the mineral in block F (for explanation see Figure 9).

Table 8 Block E: data from IMAU boreholes

Borehole	Recorded thickness			Mean grading percentage						
	Mineral m	Over- burden m	Waste* m	Fines	Sand			Gravel		
				- $\frac{1}{16}$ mm	Fine $+\frac{1}{16}$ - $\frac{1}{4}$ mm	Medium $+\frac{1}{4}$ -1 mm	Coarse $+1$ -4 mm	Fine $+4$ -16 mm	Coarse $+16$ -64 mm	Cobble $+64$ mm
Fluvio-glacial Gravel										
44 NE 30	4.2	0.3		19	29	18	5	14	13	2
54 NE 8	4.6	0.6		6	44	47	2	1	0	0
Mean				12	37	33	4	7	6	1
River Terrace Deposits										
54 NW 25	0.6	0.4		11	33	35	9	9	3	0
54 NW 29	1.0	0.3		11	32	47	2	1	7	0
54 NW 30	0.7	0.4		13	45	39	1	1	1	0
Mean				12	36	41	4	3	4	0
Glacial Sand and Gravel										
44 NE 29	4.2	11.3		7	48	43	1	1	0	0
54 NW 20	absent									
54 NW 21	absent									
54 NW 22	7.1	0.4		7	33	48	2	4	5	1
54 NW 23	absent									
54 NW 24	8.0	1.5		3	25	68	2	1	1	0
54 NW 25	4.3	0.4		8	25	47	6	6	8	0
54 NW 26	10.0	4.0		8	51	41	0	0	0	0
54 NW 27	14.2	1.0	1.8	12	44	32	2	4	5	1
54 NW 28	15.8	1.0	4.2	28	57	15	0	0	0	0
54 NW 29	5.5	0.3		2	31	53	7	5	2	0
54 NW 30	16.4	0.4	2.8	11	41	35	5	5	3	0
54 NW 31	8.6+	4.0	7.4	16	81	3	0	0	0	0
54 NW 32	14.2+	2.0	3.8	6	32	36	8	8	10	0
54 NW 33	6.4	4.0		7	22	59	6	4	2	0
54 NW 34	13.8	5.4		18	58	22	1	0	1	0
54 NW 35	absent									
54 NW 36	1.9	0.6		10	54	35	1	0	0	0
54 NE 6	8.1	8.9		9	26	56	2	3	4	0
54 NE 7	6.5	1.0		9	56	34	0	0	1	0
54 NE 11	11.5	3.5		5	7	33	17	22	13	3
54 NE 15	2.9	0.3		38	36	22	2	2	0	0
Mean				12	41	35	4	4	4	0
All deposits										
44 NE 29	4.2	11.3		7	48	43	1	1	0	0
44 NE 30	4.2	0.3		19	29	18	5	14	13	2
54 NW 20	absent									
54 NW 21	absent									
54 NW 22	7.1	0.4		7	33	48	2	4	5	1
54 NW 23	absent									
54 NW 24	8.0	1.5		3	25	68	2	1	1	0
54 NW 25	4.9	0.4		8	26	47	6	6	7	0
54 NW 26	10.0	4.0		8	51	41	0	0	0	0
54 NW 27	14.2	1.0	1.8	12	44	32	2	4	5	1
54 NW 28	15.8	1.0	4.2	28	57	15	0	0	0	0
54 NW 29	6.5	0.3	0.5	3	32	53	6	4	2	0
54 NW 30	17.1	0.4	2.8	12	40	36	4	5	3	0
54 NW 31	8.6+	4.0	7.4	16	81	3	0	0	0	0
54 NW 32	14.2+	2.0	3.8	6	32	36	8	8	10	0
54 NW 33	6.4	4.0		7	22	59	6	4	2	0
54 NW 34	13.8	5.4		18	58	22	1	0	1	0
54 NW 35	absent									
54 NW 36	1.9	0.6		10	54	35	1	0	0	0
54 NE 6	8.1	8.9		9	26	56	2	3	4	0
54 NE 7	6.5	1.0		9	56	34	0	0	1	0
54 NE 8	4.6	0.6		6	44	47	2	1	0	0
54 NE 11	11.5	3.5		5	7	33	17	22	13	3
54 NE 15	2.9	0.3		38	36	22	2	2	0	0
Mean				12	41	35	4	4	4	0

* Within mineral

Table 9 Block F: data from IMAU boreholes

Borehole	Recorded thickness			Mean grading percentage						
	Mineral	Over-burden	Waste*	Fines	Sand			Gravel		
	m	m	m	- $\frac{1}{16}$ mm	Fine + $\frac{1}{16}$ - $\frac{1}{4}$ mm	Medium + $\frac{1}{4}$ -1 mm	Coarse +1-4 mm	Fine +4-16 mm	Coarse +16-64 mm	Cobble +64 mm
44 SE 16	1.6	0.4		20	32	35	5	5	3	0
44 SE 18	7.1	0.3		11	43	38	2	3	2	1
54 SE 22	16.7	0.5		8	47	40	2	2	1	0
54 SE 23	absent									
54 SW 24	7.9	3.2	6.9	13	39	39	4	3	1	1
54 SW 26	3.2	3.8		12	44	29	3	4	7	1
54 SW 27	20.5+	1.0	2.0	4	25	58	3	4	6	0
54 SW 30	13.7+	0.4	11.4	8	33	46	4	5	3	1
54 SE 43	8.6	13.2		14	38	48	0	0	0	0
54 SE 47	11.2+	5.8	8.0	8	55	36	1	0	0	0
54 SE 48	7.0	3.5	9.0	9	36	31	7	8	8	1
Mean				9	38	44	3	3	3	0

* Within mineral

Table 10 Block G: data from IMAU boreholes

Borehole	Recorded thickness			Mean grading percentage						
	Mineral	Over-burden	Waste*	Fines	Sand			Gravel		
	m	m	m	- $\frac{1}{16}$ mm	Fine + $\frac{1}{16}$ - $\frac{1}{4}$ mm	Medium + $\frac{1}{4}$ -1 mm	Coarse +1-4 mm	Fine +4-16 mm	Coarse +16-64 mm	Cobble +64 mm
River Terrace Deposits										
54 NE 17	4.3	0.6		20	16	55	4	4	1	0
Glacial Sand and Gravel										
54 NE 16	2.5	0.2		12	26	52	5	5	0	0
54 NE 17	6.0+	0.6		6	32	55	5	2	0	0
54 SE 53	17.8+	4.3	2.9	11	36	43	5	4	2	0
Mean				10	36	43	5	4	2	0
All deposits										
54 NE 16	2.5	0.2		12	26	52	5	5	0	0
54 NE 17	10.3+	0.6	7.6	12	25	54	5	3	1	0
54 NE 20	6.9	1.0	9.9	8	42	38	4	4	4	0
54 SE 52	absent									
54 SE 53	17.8+	4.3	2.9	11	36	41	5	5	2	0
Mean				11	33	45	5	4	2	0

* Within mineral

been separated by an inferred boundary, but in the vicinity of the other boreholes the extent of the barren ground is uncertain and cannot be delineated; the absence of mineral has been taken into account by entering a nil thickness in the volume calculations. However, 17 IMAU and four other boreholes proved mineral within the glacial deposits. This ranges up to 16.4 m in thickness but the mean is only 7.4 m and produces a volume estimate of 275 million m³ \pm 26 per cent. Except for borehole 54 NE 11, which proved 11.5 m of sandy gravel, sands and pebbly sands (commonly 'clayey') predominate and the mean grading for the deposit is fines 12 per cent, sand 80 per cent, gravel 8 per cent.

Significant mineral deposits within the Fluvio-glacial Gravel were encountered only in boreholes 44 NE 30 and 54 NE 8 and consisted of 4.2 m of 'clayey' sandy gravel and 4.6 m of sand, respectively. River terrace deposits at boreholes 54 NW 25, 29 and 30 possessed only thin (0.6 to 1.0 m) deposits of 'clayey' sand and 'clayey' pebbly sand. These two deposits are classified as potentially workable only because they overlie thicker glacial mineral.

Overburden, with a mean thickness of 2.3 m, may locally (e.g. 44 NE 29) reach as much as 11.3 m in areas of undifferentiated Glacial Drift. Waste partings between 0.5 and 6.4 m comprise Glacial Silt and Clay, till and fluvial clays.

Block F (Table 9, Figure 13)

The higher ground to the north and east of Whitchurch and the country flanking Wych Brook and Grindley Brook are included in this block, which has an area of 22.9 km². Glacial Sand and Gravel is the only mineral-bearing deposit. The strip of alluvium in the floor of Red Brook is too small to be assessed (see Appendix B) even though borehole 54 SW 23 proved 1.0 m of 'very clayey' sand overlying 1.6 m of pebbly sand. Fluvio-glacial Gravel deposits mapped in the valley of Grindley Brook may be better referred to Glacial Silt and Clay. In an area considered overall to be mineral-bearing, a pre-existing borehole (54 SE 15) encountered no mineral within glacial deposits and a nil thickness for this borehole has been entered in the calculations.

The remaining 14 boreholes, ten IMAU and four other boreholes (including one confidential record), prove that the potentially workable sand and gravel varies greatly in thickness (from 1.6 to 20.5 m). The mean of 10.5 m produces an estimate of volume of 230 million m³ ± 40 per cent. Sands, 'clayey' and pebbly, again predominate, although 3.7 m of sandy gravel were recorded in borehole 54 SW 30. The mean grading is fines 9 per cent, sand 85 per cent, gravel 6 per cent.

Overburden reaches a maximum proved thickness of 13.2 m in borehole 54 SE 43, but in the west of the block it is significantly less than this and the mean thickness is 3.9 m. Waste partings, comprising Glacial Silt and Clay and till, have thicknesses of 8.0 and 9.0 m in boreholes 54 SE 47 and 48 and combined thicknesses of 6.9 and 11.4 m in boreholes 54 SW 24 and 30; in the remaining ten boreholes they were much thinner or absent.

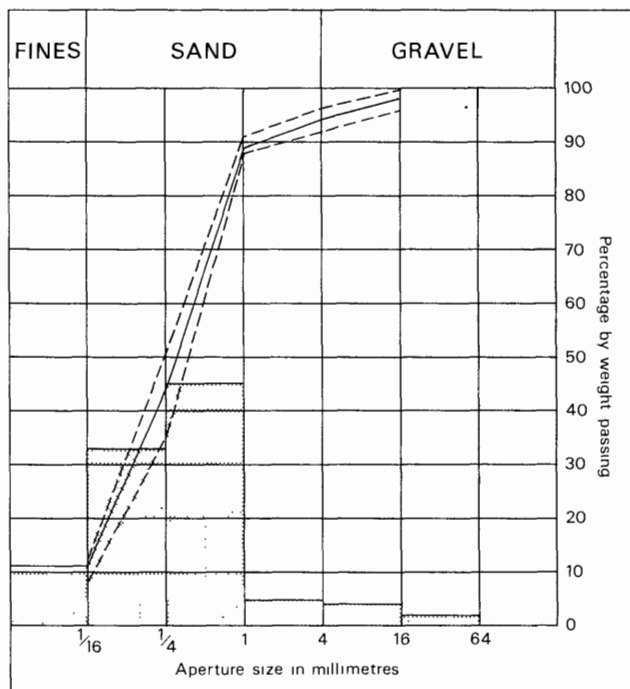


Figure 14 Grading characteristics of the mineral in block G (for explanation, see Figure 9).

Block G (Table 10, Figure 14)

This block is situated on the eastern margin of the district and contains 10.5 km² of mineral. Twelve boreholes (four IMAU and eight others, including five confidential records) proved sand and gravel of variable thickness ranging up to 19.8 m. Although borehole 54 SE 52 did not encounter mineral, the extent of the barren ground is uncertain and a nil thickness has been entered in the calculations. The block mean thickness is

8.2 m and the estimate of volume is 86 million m³ ± 62 per cent.

Except for borehole 54 NE 17, which encountered 4.3 m of 'very clayey' pebbly sand and pebbly sand of possible fluvial origin, the mineral of the block is Glacial Sand and Gravel. 'Clayey' sands with pebbly bands predominate and the mean grading for the block is fines 11 per cent, sand 83 per cent, gravel 6 per cent. Variable overburden thicknesses of up to 17.1 m (54 SE 21) were recorded in the south where till and Glacial Silt and Clay overlie mineral. Boreholes sited on outcrops of River Terrace Deposits and Glacial Sand and Gravel usually encountered only soil less than 1.0 m thick. Thick waste partings (7.6 and 7.7 m) were noted in boreholes 54 NE 17 and 20, respectively; elsewhere waste is much thinner or absent.

Conclusions

Glacial Sand and Gravel, the dominant drift deposit of the district, is also the chief source of potentially workable sand and gravel. However, in most instances, mineral comprises sand-grade deposits, and gravel occurs only sporadically. In the west (blocks B and C), the distribution of the mineral deposits generally conforms to the mapped geological boundaries, but in the east (blocks D, E, F and G) the sequence is more complex and mineral, overburden and waste thickness show wide and irregular variations.

Except for the alluvial deposits beneath the southern part of the Dee flood-plain, younger drift deposits have demonstrated only limited potential as a source of aggregates.

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APPENDIX A

FIELD AND LABORATORY PROCEDURES

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

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

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

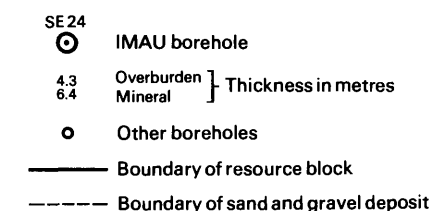
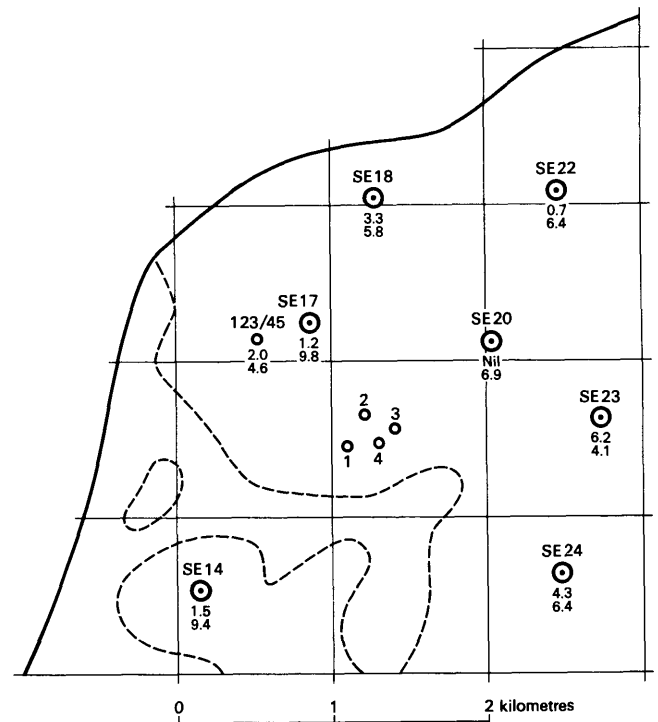
The drilling machine employed should be capable of providing a continuous sample representative of all unconsolidated deposits, so that the in-situ grading can be determined, if necessary, to a depth of 30 m (100 ft) at a diameter of about 200 mm (8 in), beneath different types of overburden. It should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

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

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

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

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



Example of resource block assessment: map of a fictitious block

APPENDIX B

STATISTICAL PROCEDURE

Statistical assessment

1 A statistical assessment is made of an area of mineral greater than 2 km², if there are at least five evenly spaced boreholes in the resource block (for smaller areas, see Paragraph 12 below).

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

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

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

4 The above relationship may be transposed such that

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

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

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

5 Given that the number of approximately evenly spaced sample points in the sampled area is n with mineral thickness measurements $l_{m1}, l_{m2}, \dots, l_{mn}$, then the best estimate of mean thickness, \bar{l}_m , is given by

$$\bar{l}_m = \frac{\sum (l_{m1} + l_{m2} \dots l_{mn})}{n}$$

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

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

where l_m is any value in the series l_{m1} to l_{mn} .

6 The sampled area in each resource block is coloured pink on the map. Wherever possible, calculations relate to the mineral within mapped geological boundaries (which may not necessarily correspond to the limits of a deposit). Where the area is not defined by a mapped boundary, that is, where the boundary is inferred, a distinctive symbol is used. Experience suggests that the errors in determining area are small relative to those in thickness. The relationship $S_A / S_{\bar{l}_m} \leq 0.3$ is assumed in all cases. It follows from Equation [2] that

$$S_{\bar{l}_m} \leq S_V \leq 1.05 S_{\bar{l}_m} \quad [3]$$

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

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

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

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

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

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

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

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

per cent,

and when n is greater than 20, as

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

per cent.

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

Inferred assessment

12 If the sampled area of mineral in a resource block is between 0.25 km² and 2 km², an assessment is inferred on the basis of geological and topographical information, usually supported by the data from one or two boreholes. The volume of mineral is calculated as the product of the area, measured from field data, and the estimated thickness. Confidence limits are not calculated.

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

14 No assessment is attempted for an isolated area of mineral less than 0.25 km².

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

Block calculation

Scale: 1:25 000
Block: Fictitious

Area
Block: 11.08 km²
Mineral: 8.32 km²

Mean thickness
Overburden: 2.5 m
Mineral: 6.5 m

Volume
Overburden: 21 million m³
Mineral: 54 million m³

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

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

Sample point	Weighting w	Overburden		Mineral		Remarks
		l_o	wl_o	l_m	wl_m	
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	$\frac{1}{2}$	1.2	1.6	9.8	7.2	Hydrogeology Unit record
123/45	$\frac{1}{2}$	2.0		4.6		
1	$\frac{1}{4}$	2.7	2.6	7.3	5.8	Close group of four boreholes (commercial)
2	$\frac{1}{4}$	4.5		3.2		
3	$\frac{1}{4}$	0.4		6.8		
4	$\frac{1}{4}$	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	$ (wl_m - \overline{wl_m}) $	$(wl_m - \overline{wl_m})^2$
9.4	2.9	8.41
5.8	0.7	0.49
6.9	0.4	0.16
6.4	0.1	0.01
4.1	2.4	5.76
6.4	0.1	0.01
7.2	0.7	0.49
5.8	0.7	0.49

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

$n = 8$

$t = 2.365$

L_V is calculated as

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

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

$= 20.3$

≈ 20 per cent.

APPENDIX C

CLASSIFICATION AND DESCRIPTION OF SAND AND GRAVEL

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

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

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

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

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

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

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

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

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

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

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

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

The relative proportions of the rock types present in the gravel fraction are indicated by the use of the words 'and' or 'with'. For example, 'flint and quartz' indicates roughly equal proportions with neither constituent accounting for less than about 25 per cent of the whole; 'flint with quartz' indicates that flint is dominant and quartz, the principal accessory rock type, comprises 5 to 25 per cent of the whole. Where the accessory material accounts for less than 5 per cent of the whole, but is still readily apparent, the phrase 'with some' has been used. Rare 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, 1975), are as follows.

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

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

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

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

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

Classification of gravel, sand and fines

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

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

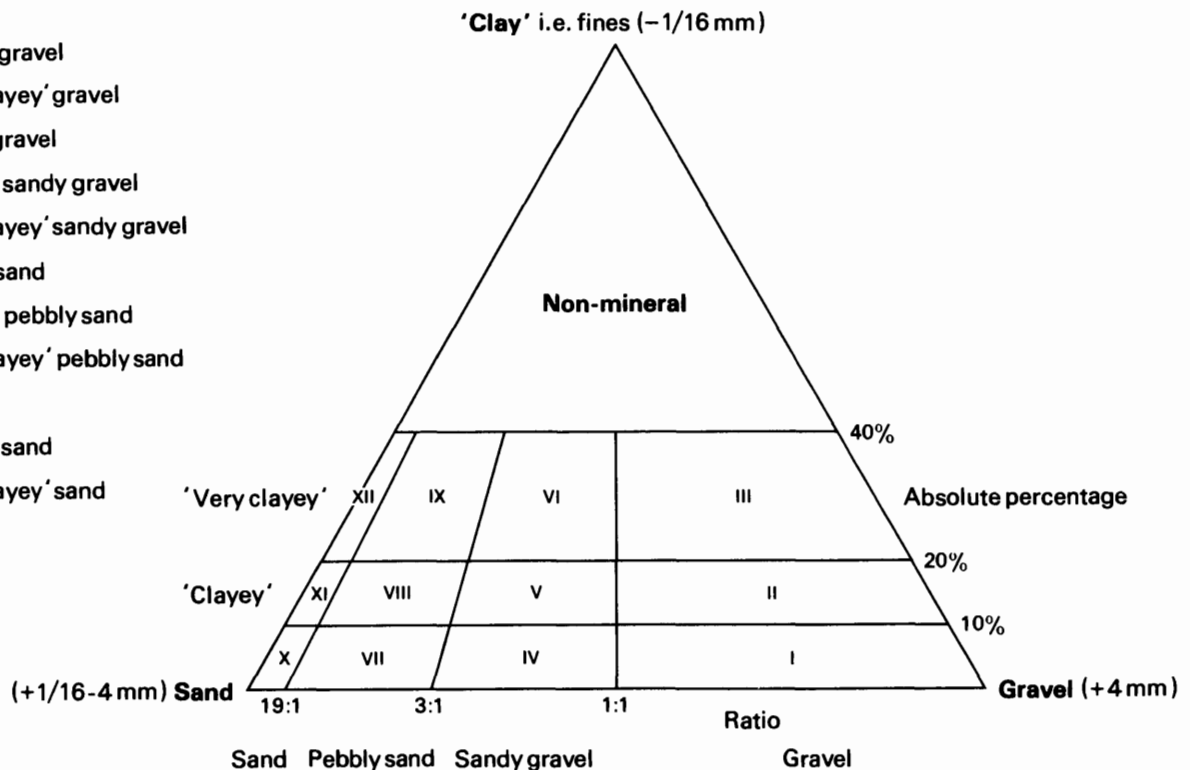


Diagram showing the descriptive categories used in the classification of sand and gravel

APPENDIX D

EXPLANATION OF THE BOREHOLE RECORDS

Annotated fictitious example

CK 66 NW 5¹	6191 6962²	Northfields³	Block B
Surface level +49.7 m (+163 ft) ⁴			Overburden ⁷ 2.8 m
Water struck at +45.9 m			Mineral 5.4 m
October 1972			Waste 1.1 m
			Mineral 1.4 m
			Bedrock 0.7 m ⁸

LOG

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

GRADING¹⁰

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

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

1 Borehole Registration Number

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

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

Thus the full Registration Number is CK 66 NW 5.

2 National Grid Reference

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

3 Location

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

4 Surface level

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

5 Groundwater conditions

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

6 Type of drill and date of drilling

Unless otherwise stated, the borehole was drilled by a shell and auger rig using 200 and 150 mm casing. The month and year of completion of drilling are stated.

7 Overburden, mineral, waste and bedrock

Mineral is sand and gravel which, as part of a deposit,

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

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

9 Lithological description

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

10 Grading data

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

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

The mean grading of groups of samples making up an identified bed of mineral are also given in detail and in summary. Where more than one bed is recognised the mean grading for the whole of the mineral in the borehole may be given. Where necessary, in calculating mean gradings, data for individual samples are weighted by the thickness represented.

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

APPENDIX E

INDUSTRIAL MINERALS ASSESSMENT UNIT BOREHOLE RECORDS

SJ 44 NW 21 4072 4883 Roden's Hall

Surface level +24.9 m (+82 ft)
Water not struck
November 1981

Waste 19.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Silt and Clay	Clay, silty, pebbly, moderate brown, hard, weathered to 1.5 m depth, medium bluish grey film on vertical joint faces	8.7	9.0
	Clay, laminated, stoneless, moderate brown, hard at 12 m, otherwise firm	10.0+	19.0

SJ 44 NW 22 4042 4655 Dungrey Hall

Surface level +12.3 m (+40 ft)
Water struck at +9.0 m
September 1981

Block A

Overburden 5.0 m
Mineral 2.7 m
Waste 2.3 m
Mineral 3.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Silt, clayey, friable, moderate brown, some rootlets, soft	3.1	3.3
	Clay, very sandy, greyish brown	1.7	5.0
	a Gravel Gravel: coarse and fine with some cobbles, rounded to subrounded, Palaeozoic argillites with fine- grained igneous rocks, Palaeozoic arenites, and some coarse-grained igneous rocks and quartz Sand: medium and coarse quartz Fines: silt and clay	2.7	7.7
Glacial Silt and Clay	Silt, with sandy and clayey layers, moderate reddish brown	2.3	10.0
Glacial Sand and Gravel	b 'Very Clayey' sand Sand: fine with medium, quartz Fines: moderate reddish brown silt and clay	3.0+	13.0
	Borehole abandoned due to slow progress		

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages									
	Fines	Sand	Gravel		Fines			Sand				Gravel		
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm			
a	3	31	66	5.0-6.5	3	8	26	6	22	35	0			
				6.5-7.7	2	4	7	10	40	33	4			
				Mean	3	6	17	8	30	34	2			
b	23	76	1	10.0-13.0	23	68	8	trace	1	0	0			
a+b	13	56	31	Mean	13	40	12	4	14	16	1			

SJ 44 NW 23 4163 4744 Wern Block A

Surface level +12.1 m (+40 ft) Waste 22.0 m+

Water struck at +5.3 m

September 1981

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Clay, silty, moderate brown, soft, wood fragments between 3 m and 5 m	5.7	6.0
	Clay, silty, sandy, pebbly, greenish black, some wood fragments, soft	0.6	6.6
	Silt, clayey, dark grey, some wood fragments, soft	0.2	6.8
	Sandy gravel Gravel: fine, rounded to subrounded, Palaeozoic arenites and argillites Sand: medium and coarse, quartz	1.9	8.7
Glacial Silt and Clay	Clay, silty, moderate with brown, hard	4.3	13.0
	Clay, silty with sporadic pebbles, moderate brown, firm to 15 m, becoming soft below	9.0+	22.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages									
	Fines	Sand	Gravel		Fines			Sand				Gravel		
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm			
	6	68	26	6.8-7.8	6	5	35	28	22	4	0			
				7.8-8.7	No grading data available									

Surface level +10.0 m (+33 ft)
 Water struck at +4.5 m
 September 1981

Waste 20.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Alluvium	Clay, silty, stoneless, moderate brown, soft	1.9	2.0
	Clay, becoming sandy with depth, brownish grey to 3.2 m, greenish black below, soft	1.7	3.7
	Clay, brownish grey, soft	1.8	5.5
	Gravel Gravel: fine and coarse, rounded, Palaeozoic arenites with Palaeozoic argillites, fine- and coarse-grained igneous rocks, quartz and some Permo-Triassic arenites with traces of flint, chert and limestone Sand: medium and coarse, quartz with lithic grains Fines: silt and clay	1.8	7.3
Glacial Silt and Clay	Clay, silty, some pebbles and rare shell fragments, moderate brown, laminated between 19.0 m and 20.0 m, hard to 8.0 m becoming soft to 20.0 m	12.7+	20.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
2	30	68	5.5-6.5	3	3	13	11	40	30	0
			6.5-7.3	1	2	15	18	39	25	0
			Mean	2	2	14	14	41	27	0

SJ 44 NW 25 4284 4788

Dogkennel Farm

Block A

Surface level +10.7 m (+35 ft)
Water struck at +6.7 m
September 1981

Overburden 4.0 m
Mineral 3.6 m
Waste 14.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, silty, dark yellowish brown	1.3	1.3
Peat	Peat, fibrous black wood fragments and thin silty clay layers	1.7	3.0
Alluvium	Clay, silty, sandy, brownish grey, soft	1.0	4.0
	Gravel Gravel: fine and coarse, rounded, Palaeozoic arenites and argillites and fine- and coarse-grained igneous rocks Sand: coarse and medium, quartz with lithic grains Fines: silt and clay	3.6	7.6
Glacial Silt and Clay	Clay, stoneless, moderate reddish brown	14.7+	22.3

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
1	25	74	4.0-5.0	1	2	14	22	32	22	7
			5.0-6.0	1	2	8	11	36	40	2
			6.0-7.6	1	2	8	10	39	37	3
			Mean	1	2	9	14	37	33	4

SJ 44 NW 26 4216 4606

Worthenbury

Block A

Surface level +15.2 m (+50 ft)
Water not struck
November 1981

Waste 19.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.8	0.8
Glacial Silt and Clay	Clay, very sandy and pebbly, pale brown, some sand lenses and pods, hard	1.2	2.0
Glacial Sand and Gravel	Gravel, coarse and fine, rounded to subrounded, Palaeozoic arenites and argillites with Permo-Triassic arenites	0.5	2.5
Glacial Silt and Clay	Clay, silty, rare pebbles, moderate brown with a medium bluish grey film on joints, hard to 5.0 m becoming firm below	3.5	6.0
	Clay, laminated, stoneless, moderate brown, soft with sandy pods and laminae	3.0	9.0
	Clay, stoneless, massive, moderate brown, firm with shell fragments in sandy parts	10.1+	19.1

SJ 44 NW 27 4376 4833 The Purser

Surface level +35.6 m (+117 ft)
 Water not struck
 September 1981

Waste 21.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Silt and Clay	Clay, stoneless, moderate brown, very hard to 0.5 m becoming firm with depth	20.8+	21.0

SJ 44 NW 28 4432 4770 Soughan's Farm

Surface level +35.8 m (+117 ft)
 Water not struck
 September 1981

Waste 7.8 m
 Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Silt and Clay	Clay, silty and sandy, moderate brown with a medium bluish grey film on joint faces, soft and weathered to 0.8 m, very hard to 2 m becoming firm below		
Sherwood Sandstone Group	Sandstone, red, very hard	0.3+	8.1

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
51	49	0	7.8-8.1	51	44	5	trace	0	0	0

SJ 44 NW 29 4441 4612 The Bank

Surface level +41.7 m (+137 ft)
 Water not struck
 October 1981

Waste 19.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Silt and Clay	Clay, sandy and silty, moderate yellowish brown to 0.75 m, becoming moderate brown with depth, poorly laminated with fine sand partings, some shell fragments, hard	3.7	4.0
	Clay, silty, laminated and stoneless, moderate brown with moderate orange pink silt partings, hard	5.0	9.0
	Clay, silty, sandy, pebbly, moderate brown, poorly laminated in part with lenses and pods of sand, some shell fragments, hard, becoming harder with depth	7.0	16.0
	Clay, silty, sandy, pebbly, moderate brown, laminated, sheared, hard	1.5	17.5
	Clay, silty, sandy, pebbly, moderate brown, hard	2.0+	19.5

SJ 44 NW 30 4118 4976 Is-y-Coed Farm

Block A

Surface level +51 m (+15 ft)
 Water not struck
 November 1981

Waste 19.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Silt and Clay	Clay, silty, slightly sandy, pebbly, moderate brown with medium bluish grey film on joints to 9.0 m; subrounded Permo-Triassic sandstone clasts prominent; hard to 9.0 m, becoming firm with depth	11.9	12.1
	Clay, silty, laminated, stoneless, moderate brown, firm	7.6+	19.7

SJ 44 NE 25 4614 4937 Horton Hall

Surface level +41.9 m (+137 ft)
 Water not struck
 November 1981

Waste 19.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial Silt and Clay	Clay, slightly pebbly, weathered, moderate brown with light olive grey mottling, firm	0.3	0.7
	Clay, silty, moderate brown with greenish grey streaks, firm	1.3	2.0
	Clay, sandy, silty, pebbly, some shell fragments, moderate brown, firm	7.4	9.4
Glacial Sand and Gravel	'Clayey sand' Sand: medium, subrounded quartz Fines: moderate reddish brown silt and clay	0.3	9.7
Till	Clay, silty, pebbly with sandy laminae, greyish red, very hard	9.4+	19.1

SJ 44 NE 26 4751 4915 Kidnall

Surface level +81.1 m (+266 ft)
 Water not struck
 October 1981

Waste 3.8 m
 Bedrock 6.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, sandy, pebbly, moderate reddish brown	1.5	1.8
	Clay, sandy, silty, pebbly	1.4	3.2
	Clay, sandy, pebbly, moderate brown, very hard	0.6	3.8
Helsby Sandstone	Sandstone, medium-grained, moderate reddish brown, very hard	6.2+	10.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16} - \frac{1}{4}$	$+\frac{1}{4} - 1$	+1 -4	+4 -16	+16 -64	+64 mm
7	93	0	3.8-5.8	4	42	54	0	0	0	0
			5.8-8.3	7	22	71	0	0	0	0
			8.3-10.0	11	40	49	0	0	0	0
			Mean	7	33	60	trace	0	0	0

Surface level +78.4 m (+257 ft)
 Water struck at +71.4 m
 September 1981

Overburden 9.0 m
 Mineral 8.0 m
 Bedrock 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Silt, sandy, pebbly, moderate brown	0.5	0.7
	Clay, sandy, pebbly with shell fragments and coal, moderate reddish brown with light bluish grey streaks to 4.0 m depth, hard, pebbles polished and striated	6.3	7.0
Glacial Silt and Clay	Silt, with sandy laminae 1-2 mm thick	0.9	7.9
Till	Clay, sandy, very pebbly, very hard, friable, sheared in places	1.1	9.0
Glacial Sand and Gravel	a 'Very clayey' sandy gravel Gravel: fine and coarse, rounded to subrounded Palaeozoic arenites and argillites, coarse- and fine-grained igneous rocks and Permo-Triassic arenites Sand: fine and medium quartz Fines: moderate reddish brown silt and clay	2.0	11.0
	b 'Clayey' sand Sand: fine with medium quartz Fines: moderate reddish brown silt and clay	6.0	17.0
Tarporley Siltstone	Siltstone, dark reddish brown, very hard	1.5+	18.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines		Sand			Gravel	
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
a	29	50	21	9.0-11.0	29	18	24	8	13	8	0
b	15	85	0	11.0-13.0	12	69	19	0	0	0	0
				13.0-15.0	8	66	25	0	1	0	0
				15.0-17.0	26	66	8	0	0	0	0
				Mean	15	68	17	trace	trace	0	0
	10	82	8	17.0-17.5	10	62	19	1	3	5	0
a+b	19	76	5	9.0-17.0	19	55	19	2	3	2	0

SJ 44 NE 28 4866 4627 The Fields

Surface level +100.4 m (+329 ft)
 Water not struck
 October 1981

Waste 7.2 m
 Bedrock 1.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Silt, sandy, moderate brown, weathered	1.3	1.6
	Clay, sandy, silty, pebbly, moderate brown mottled with greenish grey, hard	3.4	5.0
Glacial Sand and Gravel	Sand: medium quartz	0.3	5.3
Till	Clay, silty, pebbly, moderate reddish brown, soft	1.9	7.2
Lower Keuper Marl	Mudstone, pale green, very hard	1.3+	8.5

SJ 44 NE 29 4955 4886 Ebnal

Block E

Surface level +98.4 m (+323 ft)
 Water struck at +90.4 m
 October 1981

Overburden 11.3 m
 Mineral 4.2 m
 Waste 0.7 m
 Bedrock 2.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Till	Clay with sandy layers and sporadic cobbles, moderate brown, soft	0.5	1.0
	Clay, silty, sandy, pebbly, with shell fragments, moderate reddish brown, firm	2.2	3.2
	Clay, sandy, pebbly, greyish red, soft to 4.5 m, firm below, clasts of Keuper sandstone and sand balls common	4.0	7.2
	Clay, silty, pebbly, moderate brown, very hard	0.8	8.0
Glacial Silt and Clay	Silt with clay and sandy laminae	3.3	11.3
Glacial Sand and Gravel	Sand Sand: fine and medium, subrounded to rounded quartz Fines: moderate reddish brown silt and clay	4.2	15.5
Till	Clay, silty, moderate reddish brown, very hard, with clasts of Keuper Marl	0.7	16.2
Tarporley Siltstone	Siltstone, very hard	2.0+	18.2

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines			Sand		Gravel	
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
7	92	1	11.3-13.3	7	37	55	1	0	0	0
			13.3-15.5	7	57	33	2	1	0	0
			Mean	7	48	43	1	1	0	0

SJ 44 NE 30	4938 4743	Leadgate	Block E
Surface level +98.8 m (+324 ft)			Overburden 0.3 m
Water not struck			Mineral 4.2 m
October 1981			Bedrock 1.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvio-glacial Gravel	<p>a 'Very clayey' pebbly sand Gravel: fine and coarse with cobbles, rounded, Permo-Triassic and Palaeozoic arenites with Palaeozoic argillites Sand: fine with medium, subrounded quartz Fines: brown silt and clay</p> <p>b Gravel Gravel: coarse and fine, rounded Permo-Triassic arenites with Palaeozoic arenites and argillites, fine- and coarse-grained igneous rocks and quartz Sand: medium and fine quartz Fines: brown silt and clay</p>	2.2	2.5
Lower Keuper Marl	Mudstone, reddish brown, very hard	1.2+	5.7

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages							
Fines	Sand	Gravel		Fines			Sand		Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm	
a	31	63	6	0.3-1.5	32	44	16	1	2	2	3
				1.5-2.5	29	49	16	1	3	2	0
				Mean	31	46	16	1	2	2	2
b	6	40	54	2.5-3.5	6	12	21	7	24	30	0
				3.5-4.5	6	13	18	11	28	19	5
				Mean	6	12	19	9	28	24	2
a+b	19	52	29	Mean	19	29	18	5	14	13	2

Surface level +37.2 m (+122 ft)
 Water struck at +19.6 m
 November 1981

Waste 23.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Silt and Clay	Clay, silty, moderate brown, with coal fragments	1.7	2.0
	Clay, slightly pebbly, pale brown with pale blue streaks, laminated, firm to hard	3.8	5.8
	Clay, silty, with thin (1-2mm) sand laminae, pale brown	1.5	7.3
	Clay, silty, pebbly, moderate brown, firm; boulder of granite at 12.0 m	4.7	12.0
Till	Clay, sandy, moderate reddish brown becoming moderate brown with depth, hard	3.7	15.7
	Clay, pebbly, with thin silty layers, moderate brown, very hard	1.9	17.6
Glacial Sand and Gravel	Silt, sandy, with some Permo-Triassic pebbles	0.7	18.3
	Sand Sand: medium, subrounded to rounded, quartz, some shell fragments Fines: moderate reddish brown silt and clay	2.0	20.3
	Sandy gravel Gravel: fine and coarse; Palaeozoic arenites with fine-grained igneous rocks, Permo-Triassic arenites and argillites, Palaeozoic argillites, quartz and limestone, some coarse-grained igneous rocks and a trace of flint and chert Sand: medium, quartz	3.3+	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 mm
43	57	0	17.6-18.3	43	27	29	1	trace	0	0
3	72	25	18.3-20.3	3	23	61	12	1	0	0
			20.3-23.6	3	15	32	12	26	12	0
			Mean	3	18	42	12	17	8	0

SJ 44 SW 7 4073 4257 Adra-felin

Surface level +49.4 m (+162 ft)
 Water not struck
 November 1981

Waste 19.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Silt and Clay	Clay, silty, some pebbles, moderate brown, hard, weathered to 0.8 m	1.7	2.0
	Clay, silty, few pebbles, finely laminated, moderate brown, hard becoming firm with depth, some shell fragments	10.0	12.0
Till	Clay, silty, pebbly, moderate brown, hard	7.0	19.0
	Clay, silty, sandy, moderate brown, soft	0.2+	19.2

SJ 44 SW 8 4159 4490 Emral Lodge

Surface level +33.8 m (+111 ft)
 Water not struck
 November 1981

Waste 14.7 m
 Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Silt and Clay	Clay, silty, pebbly, mottled moderate yellowish brown and light brown with streaks of medium bluish grey, sporadically laminated, hard	1.3	1.5
	Clay, silty, stoneless, moderate brown, laminated, rare shell fragments, very hard to 7.0 m, becoming firm below	13.2	14.7
Sherwood Sandstone Group	Sandstone, moderate yellow, very hard but friable	0.3+	15.0

SJ 44 SW 9 4166 4227 Halghton Hall

Block B

Surface level +44.3 m (+145 ft)
 Water struck at +25.6 m
 November 1981

Overburden 18.7 m
 Mineral 6.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Silt and Clay	Clay with sporadic angular clasts, moderate brown, poorly laminated, very hard to 7.3 m, firm below	7.7	8.0
	Clay with rare pebbles and some shell fragments, poorly laminated, moderate brown, firm	8.8	16.8
Till	Clay, silty, sandy, pebbly, some shell fragments, sand lenses and pods, moderate brown, very hard	1.9	18.7
Glacial Sand and Gravel	'Clayey' sand Sand: fine and medium, quartz Fines: brown silt and clay	6.3+	25.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
18	82	0	18.7-21.0	20	70	10	0	0	0	0
			21.0-22.5	30	62	8	0	0	0	0
			22.5-24.0	12	56	32	0	0	0	0
			24.0-25.0	6	69	25	0	0	0	0
			Mean	18	65	17	trace	0	0	0

SJ 44 SW 10 4134 4056 Hollybush Lane Farm

Block B

Surface level +62.1 m (+204 ft)
 Water struck at +55.3 m
 November 1981

Overburden 6.8 m
 Mineral 9.2 m
 Waste 4.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial Silt and Clay	Clay, sandy, silty, jointed, moderate brown with a greenish grey film on some joints, firm and friable	1.1	1.5
	Clay, sandy, silty, slightly pebbly, some shell fragments, laminated in part, moderate brown	5.3	6.8

Glacial Sand and Gravel	a Sand Gravel: fine, Palaeozoic, and Permo-Triassic arenites and argillites Sand: medium and fine, subangular to rounded quartz Fines: moderate reddish brown silt and clay	1.2	8.0
	b Pebbly sand Gravel: fine and coarse, subrounded Palaeozoic and Permo-Triassic arenites and argillites Sand: medium and fine Fines: moderate reddish brown silt and clay	2.0	10.0
	c Sand Sand: fine and medium quartz	6.0	16.0
Glacial Silt and Clay	Silt, with thin clay and sand bands	0.8	16.8
Till	Clay, silty, slightly sandy and pebbly, moderate brown, very hard	2.0	18.8
Glacial Silt and Clay	Silt with sandy laminae, moderate reddish brown, firm	1.4	20.2
Glacial Sand and Gravel	Sand Sand: medium, subrounded to rounded quartz Fines: light brown silt and clay	0.1+	20.3

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages								
	Fines	Sand	Gravel										
					Fines			Sand			Gravel		
					- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{4}$	$+\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm		
a	4	94	2	6.8-8.0	4	32	60	2	2	0	0		
b	7	78	15	8.0-10.0	7	24	50	4	8	7	0		
c	4	96	0	10.0-11.0	4	62	34	0	0	0	0		
				11.0-16.0	4	48	47	1	0	0	0		
				Mean	4	50	45	1	trace	0	0		
a+b+c	5	91	4	Mean	5	42	48	1	2	2	0		

SJ 44 SW 11 4210 4410 Emral Hall

Surface level +25.5 m (+84 ft)
Water not struck
November 1981

Waste 18.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, silty, rare clasts, moderate brown, some shell fragments, hard	5.8	6.0
Glacial Silt and Clay	Clay, silty, rare pebbles, finely laminated, moderate brown with pale brown silt partings, firm	12.8+	18.8

SJ 44 SW 12 4296 4283 Rodger's Rough

Surface level +40.7 m (+134 ft)
 Water not struck
 November 1981

Waste 14.2 m
 Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, silty, some pebbles, moderate brown, weathered to 0.8 m, very hard below	2.2	2.5
Glacial Silt and Clay	Clay, silty, sandy, laminated, moderate brown clay, moderate reddish brown sand and pale yellowish brown silt, increasingly pebbly with depth, hard	4.0	6.5
Till	Clay, pebbly, pale brown, some shell fragments, firm	1.0	7.5
Glacial Silt and Clay	Clay, laminated, becoming more silty and stony with depth, moderate brown with medium bluish grey film on joints, firm to hard	6.7	14.2
Keuper Waterstones	Sandstone, red, very hard	0.1+	14.3

SJ 44 SW 13 4393 4335 Whalebone Farm

Surface level +44.7 m (+147 ft)
 Water not struck
 November 1981

Waste 11.0 m
 Bedrock 2.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Silt and Clay	Clay, pebbly, moderate brown, laminated with shell fragments, weathered to 1.0 m, hard	10.8	11.0
Tarporley Siltstone	Siltstone	2.0+	13.0

SJ 44 SW 14 4335 4032 Pant

Block B

Surface level +65.6 m (+215 ft)
 Water struck but level not recorded
 November 1981

Overburden 0.3 m
 Mineral 11.9 m
 Waste 9.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Sand and Gravel	a 'Clayey' sand with some fine gravel Sand: fine and medium , quartz Fines: brown silt and clay	1.4	1.7
	b 'Very clayey' sand Sand: fine, quartz Fines: brown silt and clay	1.0	2.7

	c Sand	4.0	6.7
	Sand: fine and medium quartz		
	Fines: brown silt and clay		
	d Pebbly sand	2.0	8.7
	Gravel: fine with medium, subrounded Palaeozoic arenites with fine-grained igneous rocks, Permo-Triassic arenites, quartz and some Palaeozoic argillites, coarse-grained igneous rocks, flint and trace Permo-Triassic argillites and limestone		
	Sand: medium, quartz		
	Fines: brown silt and clay		
	e Sand with some fine gravel	3.5	12.2
	Sand: medium and fine quartz		
	Fines: brown silt and clay		
Glacial Silt and Clay	Silt, sandy, stoneless, greyish red, soft, laminated	9.6+	21.8
	Borehole abandoned due to poor recovery		

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines			Gravel			
					- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{4}$	$+\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
a	14	83	3	0.3-1.7	14	56	27	trace	3	0	0
b	32	68	0	1.7-2.7	32	65	2	1	trace	0	0
c	7	93	0	2.7-3.7	10	57	33	0	0	0	0
				3.7-4.7	5	43	52	0	0	0	
				4.7-6.7	7	34	58	1	0	0	
				Mean	7	42	50	1	trace	0	0
d	3	84	13	6.7-8.7	3	14	54	16	11	2	0
e	4	95	1	8.7-10.7	4	30	64	1	1	0	0
				10.7-12.2	4	29	61	5	1	0	0
				Mean	4	29	64	2	1	0	0
a-e	8	90	2	Mean	8	37	49	4	2	trace	0

SJ 44 SW 15 4365 4193 Peartree House

Surface level +57.0 m (+187 ft)
 Water not struck
 November 1981

Waste 19.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Silt and Clay	Clay, silty, stoneless, light brown mottled with light olive grey and light grey, hard	0.8	1.0
	Clay with shell and coal fragments and sand balls, moderate brown with bluish grey streaks	1.0	2.0
	Clay, silty, sandy, pebbly, laminated at 6.0 m, moderate brown, hard	11.8	13.8
Glacial Sand and Gravel	'Very clayey' sand Sand: fine quartz Fines: moderate brown silt and clay	1.0	14.8
	'Clayey' sand Sand: fine quartz Fines: moderate reddish brown silt and clay	1.7	16.5
Till	Clay, moderate brown, laminated, hard	0.5	17.0
	Clay, silty, sandy, very pebbly, moderate brown to 18.0 m, dark greenish grey below, very hard	2.0+	19.0

SJ 44 SW 16 4092 4390 Hollybush Farm

Surface level +41.9 m (+137 ft)
 Water not struck
 November 1981

Waste 19.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, sandy, slightly silty, rare pebbles, moderate brown and very hard below 0.7 m, weathered and firm above	1.6	1.9
Glacial Silt and Clay	Clay, silty, stoneless, laminated, moderate brown with brownish grey silt laminae between 6.2 and 6.4 m, firm to hard	11.1	13.0
Till	Clay, sandy, silty, pebbly, crudely laminated in part, moderate brown clay, moderate reddish brown sand, hard	0.4	13.4
Glacial Silt and Clay	Clay, silty, sandy, stoneless, laminated, moderate brown clay, moderate reddish brown sand, moderate dark grey silt layers, dark yellowish orange film on joints, firm	3.1	16.5
Till	Clay, silty, moderate brown, hard	2.5+	19.0

Surface level +57.8 m (+190 ft)
 Water struck at +53.8 m
 November 1981

Overburden 5.3 m
 Mineral 3.2 m
 Waste 0.3 m
 Mineral 0.7 m
 Waste 2.0 m
 Bedrock 2.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till (weathered)	'Very clayey' sand with sporadic fine pebbles Sand: fine to medium, subangular to rounded, quartz Fines: light brown clay increasing with depth	0.5	0.9
Till	Clay, sandy and pebbly, moderate reddish brown, firm	2.0	2.9
Glacial Silt and Clay	Clay, laminated, moderate reddish brown, firm	0.6	3.5
	Silt, laminated, with sandy partings, moderate reddish orange	0.5	4.0
	Silt, sandy, moderate brown	1.3	5.3
Glacial Sand and Gravel	a Gravel Gravel: fine with coarse, angular to rounded, Palaeozoic arenites with fine- and coarse -grained igneous rocks, Palaeozoic argillites, limestone, quartz and some Permo-Triassic arenites and argillites Sand: coarse with medium, angular to rounded, lithic grains with quartz	3.2	8.5
	Till	Clay, sandy and pebbly, moderate reddish brown	0.3
Glacial Sand and Gravel	b Gravel Gravel: coarse with fine, angular to rounded, Palaeozoic arenites and argillites with coarse- and fine-grained igneous rocks, Permo- Triassic arenites, limestone, quartz and some Permo-Triassic argillites Sand: fine to medium, angular to rounded, quartz and lithic grains	0.7	9.5
	Till	Clay, sandy with rare pebbles, moderate brown, hard	0.5
Clay, very sandy and pebbly, moderate brown with patches of greenish grey silty clay		0.8	10.8
Clay, sandy, moderate brown and locally dominant greenish grey clay, very hard		0.7	11.5
Lower Keuper Marl	Siltstone (fragments), greenish grey	0.5	12.0
	Siltstone with thin sandstone bands, locally micaceous, moderate brown	2.0+	14.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages									
	Fines	Sand	Gravel		Fines			Sand				Gravel		
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ - 1	+1 - 4	+4 - 16	+16 - 64	+64 mm			
	58	42	0	4.0-5.3	58	39	3	trace	0	0	0			
a	3	36	61	5.3-5.8	3	14	13	14	39	17	0			
				5.8-8.5	3	2	9	23	33	25	5			
				Mean	3	4	10	22	33	24	4			
b	4	43	53	8.8-9.5	4	17	19	7	16	28	9			
a+b	3	37	60	Mean	3	6	12	19	30	25	5			

SJ 44 SE 9

4559 4057

Little Arowry

Block C

Surface level +77.7 m (+255 ft)
 Water struck at +74.7 m
 November 1981

Overburden 0.2 m
 Mineral 20.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	a 'Very clayey' pebbly sand Gravel: fine with coarse, Palaeozoic and Permo-Triassic arenites and argillites, fine and coarse-grained igneous rocks and some quartz, flint and limestone Sand: fine with medium, subrounded, quartz Fines: moderate brown to 0.9 m, then pale yellowish brown - greyish orange	1.8	2.0
	b Sand, 'clayey' in parts: medium to fine subrounded quartz	18.5+	20.5
Borehole abandoned because unable to case borehole farther			

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages									
	Fines	Sand	Gravel		Fines			Sand				Gravel		
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ - 1	+1 - 4	+4 - 16	+16 - 64	+64 mm			
a	24	67	9	0.2-0.9	No grading data available									
				0.9-2.0	24	28	33	6	6	3	0			
				Mean	24	28	33	6	6	3	0			
b	6	94	0	2.0-3.0	7	64	28	1	0	0	0			
				3.0-6.0	5	46	47	1	1	0	0			
				6.0-8.0	17	50	33	0	0	0	0			
				8.0-10.0	2	39	58	1	0	0	0			
				10.0-12.0	13	28	58	1	0	0	0			
				12.0-15.0	3	47	48	2	0	0	0			
				15.0-18.0	2	45	52	1	0	0	0			
				18.0-20.5	2	41	57	0	0	0	0			
				Mean	6	44	49	1	trace	0	0			
a+b	7	92	1	Mean	7	43	48	1	1	trace	0			

Surface level +63.2 m (+207 ft)
 Water struck at +53.7 m
 October 1981

Overburden 9.5 m
 Mineral 9.7 m
 Waste 1.0 m
 Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Clay, silty, mottled moderate yellowish brown, hard	0.3	0.7
	Clay, silty, moderate brown with a medium grey film on joints, hard	1.2	1.9
	Silt, sandy, pebbly, some shell fragments, moderate brown silt with moderate reddish brown sand, hard	1.3	3.2
Glacial Silt and Clay	Clay, silty, stoneless, laminated, moderate brown at first, becoming moderate brown with moderate orange pink and olive grey partings, hard	5.8	9.0
	Silt, sandy, slightly pebbly, moderate reddish brown, silt and sand laminae, firm	0.5	9.5
Glacial Sand and Gravel	a 'Very clayey' sand Gravel: fine, subangular to rounded, coarse- and fine-grained igneous rocks, arenites, argillites, quartz chert and flint Sand: fine and medium quartz Fines: light brown silt and clay	1.0	10.5
	b Sand with some fine gravel: fine and medium quartz with light brown silt and clay	8.7	19.2
Glacial Silt and Clay	Clay, sandy, silty, moderate brown, with sporadic sandy partings and a large quartzite cobble, firm	0.3	19.5
	Clay with fine sand laminae, stoneless, moderate brown fines, moderate orange pink sand, firm	0.5	20.0
	Clay, sandy and silty, granules common, moderate brown, hard	0.2	20.2
Lower Keuper Marl	Mudstone, pale green, very hard	0.1+	20.3

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16} - \frac{1}{4}$	$+\frac{1}{4} - 1$	$+1 - 4$	$+4 - 16$	$+16 - 64$	$+64$ mm
a	23	75	2	9.5-10.5	23	51	20	4	2	0	0
b	2	97	1	10.5-11.5	8	61	28	3	0	0	0
				11.5-17.5	1	30	65	3	1	0	0
				17.5-19.2	No grading data available						
				Mean	2	34	60	3	1	0	0
a+b	4	95	1	Mean	4	36	56	3	1	0	0

Surface level +78.7 m +(258 ft)
 Water struck at +66.7 m
 November 1981

Overburden 2.5 m
 Mineral 2.0 m
 Waste 0.5 m
 Mineral 4.5 m
 Waste 1.0 m
 Mineral 14.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Till (weathered)	Clay, sandy, poorly laminated, moderate brown and light brown	0.5	1.0
Till	Clay, sandy and pebbly, dark reddish brown, hard	1.5	2.5
Glacial Sand and Gravel	a Sand, locally 'clayey', medium with fine, subangular to rounded, quartz	2.0	4.5
Glacial Silt and Clay	Clay, silty, and sand, interlaminated, moderate reddish brown and moderate reddish orange	0.5	5.0
Glacial Sand and Gravel	b 'Clayey' pebbly sand Gravel: coarse with fine, subrounded, fine- and coarse-grained igneous rocks and quartz Sand: fine with medium, subangular to rounded, quartz Fines: laminae of sandy clay, moderate brown	1.0	6.0
	c 'Very clayey' sand: fine with medium, subangular to rounded, quartz; with laminae of moderate reddish brown sandy clay	3.5	9.5
Till	Clay, very sandy and pebbly, moderate reddish brown, soft	1.0	10.5
Glacial Sand and Gravel	d Sand: fine with medium, subangular to rounded, quartz with scattered lithic grains	14.5+	25.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
						- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
a	7	93	0	2.5-4.5	7	37	55	1	trace	0	0	
	53	46	1	4.5-5.0	53	28	17	1	1	0	0	
b	11	70	19	5.0-6.0	11	50	19	1	2	3	14	
c	26	73	1	6.0-7.5	27	55	17	1	0	0	0	
7.5-8.0				45	37	17	1	0	0	0		
8.0-9.5				17	48	30	2	1	2	0		
Mean				26	50	22	1	trace	1	0		
d	8	92	0	10.5-11.5	26	63	9	1	1	0	0	
11.5-14.0				15	71	14	0	0	0			
14.0-16.0				5	67	28	0	0	0			
16.0-18.0				2	27	69	2	0	0			
18.0-20.8				2	43	55	0	0	0			
20.8-22.3				20	68	12	0	0	0			
22.3-25.0				3	74	23	0	0	0			
Mean				8	60	32	trace	trace	0			
a-d	11	88	1	Mean	11	55	32	1	trace	trace	1	

Surface level +79.4 m (+260 ft)
 Water struck; level not recorded
 November 1981

Overburden 0.4 m
 Mineral 2.1 m
 Waste 5.5 m
 Mineral 11.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial Sand and Gravel	a 'Clayey' pebbly sand Gravel: coarse with fine, subrounded Palaeozoic arenites and fine-grained igneous rocks Sand: fine with medium, subrounded quartz Fines: clayey silt band at 2.5 m	2.1	2.5
Glacial Silt and Clay	Silt, sandy, with bands of very sandy, pebbly, silty clay, moderate brown	2.2	4.7
Till	Clay, very sandy, silty and sporadically pebbly, moderate reddish brown, very hard to firm	3.3	8.0
Glacial Sand and Gravel	b Sand, fine with medium, subrounded, quartz with lithic grains and sporadic pebbles	11.5+	19.5

Borehole abandoned because unable to case hole farther

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines			Gravel			
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
a	15	77	8	0.4-2.5	15	41	35	1	2	6	0
b	5	94	1	8.0-11.0	8	38	53	1	0	0	0
				11.0-14.0	3	54	39	1	2	1	0
				14.0-17.0	2	55	43	0	0	0	0
				17.0-19.5	6	85	9	0	0	0	0
				Mean	5	56	37	1	1	trace	0
a+b	7	91	2	Mean	7	53	37	1	1	1	0

Surface level +80.5 m (+264 ft)
 Water struck at +72.2 m
 November 1981

Overburden 2.5 m
 Mineral 1.0 m
 Waste 2.0 m
 Mineral 1.5 m
 Waste 4.0 m
 Mineral 14.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till (weathered)	Clay, sandy, banded moderate yellowish brown, greyish brown and moderate reddish orange, soft	0.5	0.8
Till	Clay, sandy and pebbly, locally poorly laminated, moderate reddish brown, hard	1.7	2.5
Glacial Sand and Gravel	a Sand, fine with medium, subangular to rounded, quartz	1.0	3.5
Till	Clay, sandy and pebbly, locally poorly laminated, moderate reddish brown	0.5	4.0
Glacial Silt and Clay	Silt, laminated at top, becoming massive, light brown	1.5	5.5
Glacial Sand and Gravel	b Clayey sand, fine, subangular to rounded, quartz	1.5	7.0
Glacial Silt and Clay	Silt, sandy, light brown	0.8	7.8
Till	Clay, sandy and pebbly, locally laminated with sand-rich partings, somewhat contorted, moderate reddish brown, very hard	0.5	8.3
Glacial Sand and Gravel	'Clayey' sand, fine, subangular to subrounded, quartz, rare fine pebbles become more common near base	0.7	9.0
Till	Clay, pebbly and sandy, moderate reddish brown, hard; crudely laminated and very hard at base	2.0	11.0
Glacial Sand and Gravel	c Sandy gravel Gravel: fine and coarse, angular to rounded, Palaeozoic arenites fine- and coarse-grained igneous rocks with Palaeozoic argillites and Permo-Triassic arenites, some limestone, quartz and Permo-Triassic argillites; gravelly between 12.0-14.0 m and 20.0-25.0 m Sand: medium, subangular to rounded, quartz	14.0+	25.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages							
	Fines	Sand	Gravel			Fines			Gravel			
						- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
a	7	93	0	2.5-3.5	7	66	26	1	trace	0	0	
b	13	87	0	5.5-6.0	13	85	2	0	0	0	0	
				6.0-7.0	13	83	4	0	0	0		
				Mean	13	84	3	trace	trace	0	0	
	48	52	0	7.0-7.8	48	48	4	trace	0	0	0	
	12	87	1	8.3-9.0	12	67	19	1	1	0	0	
c	2	50	48	11.0-11.5	10	24	54	4	5	3	0	
				11.5-12.0	8	27	51	5	4	5	0	
				12.0-14.0	1	6	15	11	26	35	6	
				14.0-15.0	4	10	38	8	17	19	4	
				15.0-15.5	1	11	83	2	1	2	0	
				15.5-16.0	1	16	68	9	3	3	0	
				16.0-17.5	1	5	27	16	39	12	0	
				17.5-18.0	2	16	60	12	9	1	0	
				18.0-20.0	0	6	26	18	28	20	2	
				20.0-22.0	2	4	16	15	24	35	4	
				22.0-25.0	1	5	22	12	24	33	3	
Mean	2	8	30	12	22	23	3					
a+b+c	3	56	41	Mean	3	18	27	11	19	20	2	

SJ 44 SE 14

4797 4278

Higher Lanes

Block B

Surface level +85.5 m (+281 ft)
Water not struck
October 1981

Waste 19.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, pebbly, moderate brown with moderate reddish brown, sandy pods	0.8	1.0
Glacial Sand and Gravel	Sand: medium quartz, moderate reddish brown fines	0.3	1.3
Glacial Silt and Clay	Clay, sandy, stoneless, moderate reddish brown, soft	1.0	2.3
	Clay, silty, pebbly, dark reddish brown, soft	1.0	3.3
	Clay, silty, stoneless, moderate reddish brown, sporadic organic fragments above 8.1 m, firm	10.2	13.5
	Clay, sandy, stoneless, moderate reddish brown	6.0+	19.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages							
	Fines	Sand	Gravel			Fines			Gravel			
						- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
	19	81	0	1.0-1.3	19	35	46	trace	trace	0	0	

Surface level +94.7 m (+311 ft)
 Water struck at +92.0 m
 September 1981

Overburden 1.3 m
 Mineral 3.8 m
 Waste 2.4 m
 Mineral 17.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Clay, sandy, pebbly, dark reddish brown with greenish grey streaks, hard	0.9	1.3
Glacial Sand and Gravel	a Pebbly sand, 'clayey' in part Gravel: fine and coarse, subangular to subrounded, Permo-Triassic arenites and argillites, igneous rocks, quartz Sand: medium and fine, subrounded, quartz with coarse lithic grains Fines: dark reddish brown silt and clay	3.8	5.1
Till	Clay, sandy, pebbly, with lenses of medium sand, reddish brown, soft	1.0	6.1
	Clay, sandy, pebbly, reddish brown, hard	1.0	7.1
	Clay, sandy, pebbly, greyish red, hard	0.4	7.5
Glacial Sand and Gravel	b Sand Gravel: fine, subangular, igneous rocks Sand: fine and medium, quartz Fines: moderate reddish brown	17.5+	25.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines		Sand		Gravel		
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ - 1	+1 - 4	+4 - 16	+16 - 64	+64 mm
a	10	81	9	1.3-2.3	12	24	61	1	2	0	0
				2.3-3.3	18	21	48	3	5	5	0
				3.3-4.3	6	28	42	6	11	7	0
				4.3-5.1	3	23	60	6	7	1	0
				Mean	10	24	53	4	6	3	0
b	5	95	0	7.5-8.5	4	86	10	0	0	0	0
				8.5-9.5	15	73	12	0	0	0	0
				9.5-10.5	5	53	38	2	2	0	0
				10.5-11.5	3	51	43	1	2	0	0
				11.5-12.2	6	74	20	0	0	0	0
				12.2-13.5	4	71	25	0	0	0	0
				13.5-14.5	4	62	32	1	1	0	0
				14.5-16.5	4	76	20	0	0	0	0
				16.5-17.5	6	71	23	0	0	0	0
				17.5-18.5	5	81	14	0	0	0	0
				18.5-19.5	No grading data available						
				19.5-20.5	5	85	10	0	0	0	0
				20.5-21.5	4	70	26	0	0	0	0
				21.5-22.5	5	74	21	0	0	0	0
				22.5-23.5	4	60	36	0	0	0	0
				23.5-24.5	4	51	45	0	0	0	0
				24.5-25.0	3	57	40	0	0	0	0
				Mean	5	70	25	trace	trace	trace	0
a+b	6	92	2	Mean	6	61	30	1	1	1	0

Surface level +71.6 m (+235 ft)
 Water struck at +67.4 m
 October 1981

Overburden 0.4 m
 Mineral 1.6 m
 Waste 18.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial Sand and Gravel	'Very clayey' pebbly sand Gravel: fine and coarse, subangular to rounded, Palaeozoic arenites and argillites, fine-grained igneous rocks and Permo-Triassic arenites Sand: fine and medium, quartz	1.6	2.0
Till	Clay, silty, pebbly, reddish brown, very hard	2.2	4.2
Glacial Silt and Clay	Silt, sandy, reddish brown	4.6	8.8
	Clay with sand and silt laminae, firm	7.7	16.5
Till	Clay, sandy, pebbly, reddish brown, very hard	3.7+	20.2

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{3}{16}$	+ $\frac{3}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
20	72	8	0.4-2.0	20	32	35	5	5	3	0

Surface level +82.3 m (+270 ft)
 Water struck at +76.5 m
 September 1981

Waste 22.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Peat	Peat	0.5	0.7
Till	Clay, silty, sandy and pebbly, moderate brown with grey patches, firm	0.8	1.5
	Clay, silty, moderate brown, some sand, only sporadic pebbles, very hard	4.3	5.8
Glacial Sand and Gravel	'Very clayey' sand: fine quartz with dark reddish brown silt	0.5	6.3
Till	Clay, gritty and pebbly, dark reddish brown	0.5	6.8

Glacial Sand and Gravel	Sand: fine and medium quartz; thin silt band at c8.0 m; sporadic fine pebble and shell fragments	2.0	8.8
Glacial Silt and Clay	Clay, silty, massive, stoneless, moderate reddish brown	6.5	15.3
	Silt, sandy, some clay lenses, moderate reddish brown	5.0	20.3
	Clay	2.2+	22.5

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{4}$	$+\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
2	98	0	6.8-8.8	2	52	45	1	trace	0	0

SJ 44 SE 18	4959 4422	Wigland	Block F
Surface level +79.2 m (+260 ft)			Overburden 0.3 m
Water struck at +74.7 m			Mineral 7.1 m
November 1981			Waste 8.8 m
			Bedrock 8.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Sand and Gravel	a 'Clayey' sand Sand: fine with medium quartz Fines: silt and clay bands	5.7	6.0
	b Pebbly sand Gravel: fine to coarse, subrounded, Permo-Triassic arenites and argillites and some fine- and coarse-grained igneous rocks, quartz, flint and Palaeozoic arenites Sand: medium, subrounded, quartz with lithic grains	1.4	7.4
Till	Clay, silty, pebbly, greyish brown, sheared, very hard	2.2	9.6
Glacial Silt and Clay	Clay, with rare pebbles, finely laminated but much sheared and disturbed, greyish brown, hard	1.2	10.8
Till	Clay, silty and pebbly but appears laminated in basal 0.1 m	1.0	11.8
Glacial Silt and Clay	Clay, silty, laminated, undisturbed, stonefree, with sheared clay band at 12.0 m and massive silt band at 12.2 m, greyish brown and moderate brown with light brown silt partings	0.7	12.5
Glacial Sand and Gravel	'Clayey' sand Sand: fine, quartz Fines: greyish brown	0.4	12.9
Glacial Silt and Clay	Clay, silty, laminated but some shearing	0.4	13.3

Glacial Sand and Gravel	'Clayey' sand Sand: fine, quartz Fines: greyish brown	0.3	13.6
Till	Clay, pebbly, sandy, moderate brown	0.9	14.5
Glacial Silt and Clay	Clay, silty, finely laminated but much disturbed, moderate brown, very hard	1.7	16.2
Wilkesley Halite	Clay, silty, moderate reddish brown with patches and lenses of medium bluish grey, very hard; brecciated veins of gypsum	8.7+	24.9

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Sand				Gravel		
					- $\frac{1}{16}$	+- $\frac{1}{16}$ - $\frac{1}{4}$	+- $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
a	13	86	1	0.3-3.0	15	58	25	0	1	1	0
				3.0-4.1	22	39	39	0	0	0	0
				4.1-4.3	29	71	0	0	0	0	0
				4.3-6.0	3	33	59	3	2	0	0
				Mean	13	48	37	1	trace	trace	0
b	4	73	23	6.0-7.4	4	22	43	8	11	9	3
a+b	11	83	6	Mean	11	43	38	2	3	2	1

Surface level +70.5 m (+231 ft)
 Water struck at +55.5 m
 September 1981

Waste 20.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.7	0.7
Glacial Sand and Gravel	'Very clayey' pebbly sand Gravel: fine and coarse, subangular quartz and lithic pebbles Sand: fine and medium, quartz Fines: moderate brown silt and clay	0.4	1.1
Till	Clay, slightly pebbly, moderate brown, sporadic sand lenses, firm	5.9	7.0
	Clay, sandy, very pebbly, moderate brown, subangular Permo-Triassic arenites and argillites prominent as clasts, very hard	0.9	7.9
	Clay, silty, pebbly, laminated, friable, moderate brown, clasts of basic igneous rocks prominent	1.0	8.9
	Silt, clayey, crudely laminated, quartz pebbles common, hard	0.3	9.2
	Clay, silty, pebbly, moderate brown, pebbles more common with depth, very hard	5.8	15.0
Glacial Sand and Gravel	Pebbly sand Gravel: coarse with fine, subangular fine-grained igneous rocks, subrounded coarse-grained igneous rocks, Palaeozoic argillites and Permo-Triassic arenites Sand: medium and fine, quartz Fines: moderate reddish brown silt and clay	0.7	15.7
Glacial Silt and Clay	Clay, sandy and silty, laminated, dark reddish brown sand, greyish brown fines, soft	4.3+	20.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{4}$	$+\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
5	78	17	15.0-15.7	5	30	47	1	1	16	0

SJ 44 SE 20 4981 4177 Iscoyd Villa

Block B

Surface level +65.2 m (+214 ft)
 Water struck at +64.2 m
 October 1981

Waste 12.1 m
 Bedrock 1.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Clay, silty, organic, brownish grey	0.7	1.0
	'Very clayey' sandy gravel Gravel: fine and coarse subrounded Palaeozoic and Permo-Triassic arenites and argillites Sand: fine and medium, quartz Fines: greyish brown silt and clay	1.0	2.0
Glacial Silt and Clay	Silt with thin layers of sand, sandy clay and clayey silt, moderate reddish brown	8.0	10.0
Till	Clay with some pebbles, greyish red, very hard	2.1	12.1
Wilkesley Halite	Mudstone, reddish brown, very hard	1.6+	13.7

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines			Sand		Gravel	
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
20	45	35	1.0-2.0	20	19	19	7	16	19	0

SJ 44 SE 21 4896 4018 New Hall Lane

Block B

Surface level +81.2 m (+266 ft)
 Water struck at +70.9 m
 October 1981

Overburden 10.3 m
 Mineral 1.0 m
 Waste 0.5 m
 Mineral 5.8 m
 Waste 0.9 m
 Mineral 1.8 m
 Waste 1.4 m
 Mineral 1.5 m
 Waste 1.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Silt and Clay	Clay, silty, sandy, stoneless, moderate brown, weathered and very hard to 0.5 m, becoming firm with depth	1.2	1.5
	Clay, silty, moderate reddish brown, friable, some organic fragments, firm	1.0	2.5
	Clay, stoneless, moderate brown, firm becoming soft with depth	3.8	6.3
	Clay, silty, micaceous, pebbly, dark reddish brown, small-scale deformation, soft, becoming firm with depth	3.2	9.5
	Clay silty, laminated, some sandy partings, dark reddish brown, hard	0.8	10.3

Glacial Sand and Gravel	a Pebbly sand Gravel: fine, subrounded Palaeozoic and Permo-Triassic arenites and argillites Sand: medium and coarse, quartz Fines: moderate reddish brown silt and clay	1.0	11.3
Glacial Silt and Clay	Silt, clayey, moderate reddish brown	0.5	11.8
Glacial Sand and Gravel	b 'Clayey' sand with some fine gravel Sand: medium and fine, quartz Fines: moderate reddish brown silt and clay	5.8	17.6
Glacial Silt and Clay	Clay laminated with pods of sand, moderate reddish brown	0.9	18.5
Glacial Sand and Gravel	c Sand with some fine gravel Sand: medium and fine, quartz with some lithic grains Fines: moderate reddish brown silt and clay	1.8	20.3
Till	Clay, some sand, moderate reddish brown	1.4	21.7
Glacial Sand and Gravel	d Sand Sand: medium and fine, quartz Fines: moderate reddish brown silt and clay	1.5	23.2
Till	Clay, sandy, pebbly, moderate reddish brown	1.8+	25.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages							
	Fines	Sand	Gravel		Fines		Sand			Gravel		
					-16	+16 -1/4	+1/4 -1	+1 -4	+4 -16	+16 -64	+64 mm	
a	6	82	12	10.3-11.3	6	5	49	28	12	0	0	
b	12	88	0	11.8-17.6	12	36	51	1	trace	0	0	
c	7	93	0	18.5-20.3	7	28	64	1	trace	0	0	
d	6	94	0	21.7-23.2	6	39	54	1	0	0	0	
a+d	10	89	1	Mean	10	32	54	3	1	0	0	

SJ 54 NW 20 5048 4958 Hampton House Block E

Surface level +114.3 m (+375 ft) Waste 7.8 m
Water not struck Bedrock 2.7 m+
November 1981

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and hardcore	0.1	0.1
Till	Clay, silty and sandy with sporadic pebbles; moderate reddish brown mottled with light olive grey to 1.0 m, moderate brown with weathered green siltstone clasts below; soft	2.4	2.5
	Silt, clayey, sandy in parts with sporadic pebbles, moderate brown, sheared and disturbed, soft	1.3	3.8
	Clay and silt, slightly sandy with sporadic pebbles, moderate brown; between 6.5 m and 7.6 m moderate reddish brown and very silty with clasts of Permo-Triassic siltstone; hard to very hard	4.0	7.8
Wilkesley Halite	Mudstone (disturbed), moderate reddish brown and greenish grey	2.7+	10.5

SJ 54 NW 21 5058 4675 Bradley Brook

Block E

Surface level +88.5 m (+290 ft)
 Water struck at +76.4 m
 November 1981

Waste 19.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Head	Clay, sandy, pebbly in part, variegated, firm	1.4	1.6
Glacial Silt and Clay	Clay, silty, with only rare pebbles, moderate brown with medium bluish grey subvertical faces, disturbed and sheared at top but lamination apparent with depth, firm to very hard	10.5	12.1
Glacial Sand and Gravel	'Clayey' sand, with sporadic pebbles Sand: fine and medium subrounded quartz Fine: light brown silt and clay	1.9	14.0
Glacial Silt and Clay	Clay, silty, sandy and pebbly, moderate brown	0.2	14.2
	Clay, silty, stoneless, moderate brown, laminated but sheared and disturbed especially at top, hard	4.0	18.2
	Silt, clayey, rare fragment of siltstone at top, moderate brown, laminated but massive in parts	1.3+	19.5

SJ 54 NW 22 5147 4909 Broomy Bank

Block E

Surface level +115.6 m (+379 ft)
 Water struck at +111.1 m
 November 1981

Overburden 0.4 m
 Mineral 7.1 m
 Waste 13.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial Sand and Gravel	a Sand, with some thin silt and clay bands; fine to medium subrounded quartz	5.5	5.9
	b Sandy gravel, with thin silt bands Gravel: fine and coarse with cobbles, subrounded, Permo-Triassic arenites with quartz, Palaeozoic arenites, fine-grained igneous rocks and some flint and chert Sand: medium, subrounded quartz with coarse lithic grains	1.6	7.5
Till	Clay very sandy, silty and pebbly, moderate reddish brown, with some thin laminated clay bands	1.8	9.3
	Clay, silty, sandy and pebbly, moderate brown; at 10.0 m moderate reddish brown with angular clasts of Permo-Triassic mudstone and siltstone; some sheared surfaces at 14.0 m and wood fragment at 17.4 m; firm to very hard	10.5	19.8

Silt, with fine sand partings, moderate brown	0.2	20.0
Clay, sandy, silty and pebbly, moderate reddish brown, very hard	0.1	20.1
Clay, very sandy and pebbly, moderate brown	0.9+	21.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16} - \frac{1}{4}$	$+\frac{1}{4} - 1$	$+1 - 4$	$+4 - 16$	$+16 - 64$	$+64$ mm
a	6	94	0	0.4-3.0 3.0-5.9 Mean	9 3 6	50 31 40	40 65 54	1 0 trace	0 1 trace	0 0 0	0 0 0
b	9	48	43	5.9-7.5	9	10	32	6	18	20	5
a+b	7	83	10	Mean	7	33	48	2	4	5	1

SJ 54 NW 23 5157 4787 Birch Pits

Block E

Surface level +104.7 m (+343 ft)
Water not struck
November 1981

Waste 19.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Made Ground	Fill: brick and concrete debris, timber, clay and sand	1.0	1.0
Alluvium	Mud, unconsolidated, soft, organic, brownish black to greyish brown, some admixed quartz sand, foetid	0.5	1.5
Till (weathered)	'Clayey' pebbly sand (probably represents sandy pebbly clay when unweathered), pale reddish brown with some discolourants from overlying mud	0.5	2.0
Till	'Very clayey' pebbly sand (probably sandy pebbly clay in situ), moderate reddish brown	3.0	5.0
Glacial Silt and Clay	Clay, sandy with silty laminae, greyish brown, hard	1.5	6.5
Till	Clay, sandy and pebbly, moderate reddish brown	0.2	6.7
Till	Clay, sandy and pebbly, becoming less sandy with depth, highly sheared, greyish brown becoming moderate brown below 10.0 m, very hard	11.3+	19.0

Surface level +100.6 m (+330 ft)
 Water struck at +98.6 m
 November 1981

Overburden 1.5 m
 Mineral 8.0 m
 Waste 12.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, very sandy and silty with some pebbles, moderate reddish brown, soft	1.2	1.5
Glacial Sand and Gravel	a Sand with rare pebbles, medium subrounded quartz	6.0	7.5
	b Pebbly sand Gravel: fine and coarse, subrounded to rounded, fine-grained igneous rocks, Palaeozoic arenites and argillites and quartz Sand: medium, subrounded quartz with some lithic grains	2.0	9.5
Glacial Silt and Clay	Clay, silty, pebbly to base, moderate brown mottled with dark yellowish orange, well laminated but much disturbed, firm	0.2	9.7
	Clay, silty, sporadically pebbly, with sandy, pebbly lense at 12.8 m, moderate brown, laminated but disturbed, firm to very hard	6.8	16.5
Till	Clay, sandy, silty and pebbly, moderate brown to greyish brown	0.2	16.7
Glacial Silt and Clay	Clay, silty (especially at 18.0 m), pebbly at top, moderate brown, well laminated but disturbed, very hard	2.0	18.7
Till	Clay, silty, slightly sandy, pebbly, moderate brown, very hard	3.3+	22.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages												
	Fines	Sand	Gravel		Fines Sand Gravel												
					- $\frac{1}{16}$		+ $\frac{1}{16}$ - $\frac{1}{4}$		+ $\frac{1}{4}$ -1		+1 -4		+4 -16		+16 -64		+64 mm
a	2	98	0	1.5-4.5	2	32	66	0	0	0	0	0	0	0			
				4.5-7.5	1	22	75	1	1	0	0	0	0	0			
				Mean	2	27	71	trace	trace	0	0	0	0	0			
b	7	82	11	7.5-9.5	7	20	57	5	5	6	0	0	0	0			
a+b	3	95	2	Mean	3	25	68	2	1	1	0	0	0	0			

Surface level +78.4 m (+257 ft)
 Water struck at +75.9 m
 November 1981

Overburden 0.4 m
 Mineral 4.9 m
 Waste 2.7 m
 Bedrock 4.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
River Terrace Deposits	a 'Clayey' pebbly sand Gravel: fine, subangular to rounded, quartz with fine- and coarse-grained igneous rocks Sand: medium and fine, subangular to subrounded quartz Fines: irregular colour banding, light brown and greyish brown	0.6	1.0
Glacial Sand and Gravel	b 'Clayey' sand, medium and fine, subangular to rounded, quartz	1.5	2.5
	c Pebbly sand - less gravelly to base Gravel: fine and coarse, angular to rounded, Palaeozoic and Permo-Triassic arenites and coarse- and fine-grained igneous rocks with Palaeozoic argillites and quartz Sand: medium, subangular to rounded quartz with lithic grains	2.8	5.3
Till	Clay, very sandy and pebbly, dark reddish brown	0.1	5.4
Glacial Sand and Gravel	Sand, medium with fine, subangular to rounded, quartz	0.3	5.7
Till	Clay, sandy and pebbly, dark reddish brown	0.8	6.5
Glacial Silt and Clay	Silt, massive, pale reddish brown	0.5	7.0
Till	Clay, sandy and pebbly, moderate reddish brown, with small clasts of pale green marl, very hard	0.5	7.5
	Clay with rare pebbles and minor sand, moderate reddish brown, with abundant bands, clasts and pods of pale green marl	0.5	8.0
?Lower Keuper Marl	Clay, silty, moderate reddish brown, locally hard silty mudstone with subconchoidal fracture	3.5	11.5
Lower Keuper Marl	Mudstone, slightly silty, greyish red, brittle, very hard	0.5+	12.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages								
	Fines	Sand	Gravel										
					Fines			Sand			Gravel		
					- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{4}$	$+\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm		
a	11	77	12	0.4-1.0	11	33	35	9	9	3	0		
b	16	83	1	1.0-2.5	16	40	42	1	1	0	0		
c	4	75	21	2.5-4.0	4	12	40	10	12	22	0		
				4.0-4.8	4	18	63	8	7	0			
				4.8-5.3	3	28	65	2	2	0			
				Mean	4	17	50	8	9	12	0		
a+b+c	8	79	13	Mean	8	26	47	6	6	7	0		

Surface level +80.8 m (+265 ft)
 Water struck at +75.0 m
 November 1981

Overburden 4.0 m
 Mineral 10.0 m
 Waste 7.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	'Clayey' pebbly sand (probably representing very sandy pebbly clay in situ), weathered above 1.5 m	1.7	2.0
	Clay, very sandy and pebbly, moderate reddish brown, soft	2.0	4.0
Glacial Sand and Gravel	Sand, initially medium with fine, becoming fine with medium downwards, subangular to rounded, quartz with some lithic grains; thin clay bands in lowest 0.8 m	10.0	14.0
Glacial Silt and Clay	Clay, sandy, laminated, moderate brown	0.3	14.3
Till	'Clayey' pebbly sand (reduced to slurry by drilling, probably moderate reddish brown sandy pebbly clay in situ)	1.7	16.0
	Clay, pebbly and sandy, moderate brown, very hard, locally sheared	5.3+	21.3

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{3}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
17	74	9	0.5-1.5	17	26	43	5	7	2	0
8	92	0	4.0-5.0	6	28	64	1	1	0	0
			5.0-5.8	8	26	65	1	0	0	0
			5.8-8.0	3	38	58	1	0	0	0
			8.0-10.0	6	59	35	0	0	0	0
			10.0-12.0	9	70	21	0	0	0	0
			12.0-13.2	9	53	38	0	0	0	0
			13.2-14.0	32	61	7	0	0	0	0
			Mean	8	51	41	trace	trace	0	0
11	60	29	14.3-16.0	11	36	22	2	3	12	14

Surface level +109.0 m (+358 ft)
 Water struck at +106.0 m
 November 1981

Overburden 1.0 m
 Mineral 5.8 m
 Waste 0.5 m
 Mineral 2.2 m
 Waste 1.0 m
 Mineral 4.2 m
 Waste 0.3 m
 Mineral 2.0 m
 Waste 4.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Head	'Clayey' sand, laminated, with rare fine pebbles	0.4	1.0
Glacial Sand and Gravel	a 'Clayey' sand, fine with medium, angular to rounded, quartz, sporadic fine and coarse pebbles 3.5 m to 4.5 m; thin layer of moderate reddish brown sandy clay at 4.7 m	5.8	6.8
Glacial Silted and Clay	Clay, sandy, laminated, moderate brown and light brown, locally contorted, firm	0.5	7.3
Glacial Sand and Gravel	b 'Very clayey' sand, fine, quartz	2.2	9.5
Glacial Silt and Clay	Clay, sandy, crudely laminated, moderate brown, firm	0.2	9.7
	Clay with sandy bands, very well laminated, moderate brown, hard	0.3	10.0
Till	Clay, sandy and pebbly, dark reddish brown, hard	0.5	10.5
Glacial Sand and Gravel	c 'Clayey' sand, fine and medium, subangular to rounded, quartz	1.5	12.0
	d Pebbly sand Gravel: coarse with fine, angular to rounded, Palaeozoic arenites and argillites and Permo-Triassic arenites with igneous rocks, flint and quartz Sand: medium and fine, subangular to rounded, quartz	2.7	14.7
Till	Clay, sandy and pebbly, moderate reddish brown	0.3	15.0
Glacial Sand and Gravel	e Sandy gravel Gravel: coarse with fine, angular to rounded, Palaeozoic arenites, Permo-Triassic arenites, fine-grained igneous rocks and Palaeozoic argillites with coarse-grained igneous rocks and quartz Sand: medium and fine, angular to rounded, quartz	2.0	17.0
Till	Clay, sandy, scattered coal granules, moderate reddish brown	0.5	17.5
Glacial Sand and Gravel	'Clayey' pebbly sand Gravel: fine with coarse, angular to rounded, Palaeozoic and Permo Triassic arenites and argillites, igneous rocks and flint Sand: fine with medium, subangular to rounded, quartz Fines: moderate reddish brown	0.5	18.0
Till	Clay, very sandy, crude banding, moderate brown	0.3	18.3
	Clay, sandy and pebbly, moderate brown, very hard	3.2+	21.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines		Sand		Gravel		
					- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{4}$	$+\frac{1}{4}$ - 1	+1 - 4	+4 - 16	+16 - 64	+64 mm
a	12	86	2	1.0-1.8	8	87	4	1	0	0	0
				1.8-2.5	36	41	22	1	0	0	0
				2.5-3.0	8	46	41	1	1	3	0
				3.0-3.5	5	32	58	3	2	0	0
				3.5-4.5	8	50	38	1	1	2	0
				4.5-6.8	12	53	34	1	0	0	0
				Mean	12	53	32	1	1	1	0
b	27	73	0	7.3-8.0	23	45	32	0	0	0	0
				8.0-9.5	29	60	11	0	0	0	0
				Mean	27	55	18	trace	0	0	0
c	11	89	0	10.5-11.0	15	40	44	1	0	0	0
				11.0-12.0	9	49	40	1	1	0	0
				Mean	11	47	41	1	trace	0	0
d	5	80	15	12.0-13.0	6	42	33	1	5	13	0
				13.0-14.0	3	28	45	2	4	12	6
				14.0-14.7	8	43	43	3	1	2	0
				Mean	5	38	40	2	3	10	2
e	5	52	43	15.0-16.0	2	15	37	5	19	22	0
				16.0-17.0	8	23	19	4	18	24	4
				Mean	5	19	28	5	18	23	2
	11	82	7	17.5-18.0	11	48	29	5	5	2	0
a-e	12	78	10	Mean	12	44	32	2	4	5	1

SJ 54 NW 28

5286 4525

Lloyd's Tenement

Block E

Surface level +84.0 m (+276 ft)
 Water struck at +81.5 m
 October 1981

Overburden 1.0 m
 Mineral 4.3 m
 Waste 4.2 m
 Mineral 11.5 m
 Waste 2.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Head	'Clayey' pebbly sand, crudely laminated	0.5	1.0
Glacial Sand and Gravel	a Sand, medium with fine, subangular to rounded, quartz, some coarse and fine pebbles between 2.5 m and 3.5 m	4.3	5.3
Glacial Silt and Clay	Silt, sandy, partly laminated, moderate brown	0.3	5.6
	Clay, laminated, moderate brown, soft	1.2	6.8
Till	Clay, sandy and pebbly, moderate reddish brown, firm	1.5	8.3
Glacial Silt and Clay	Clay, laminated, moderate brown, soft	1.2	9.5
Glacial Sand and Gravel	b 'Very clayey' sand, fine, quartz, with abundant moderate brown silt and thin clay bands	11.5	21.0
Till	Clay, sandy and pebbly, moderate brown, very hard	2.0+	23.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines				Gravel		
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ - 1	+1 - 4	+4 - 16	+16 - 64	+64 mm
a	5	91	4	1.0-2.5	6	18	73	1	1	1	0
				2.5-3.5	4	71	13	1	4	7	0
				3.5-5.0	5	30	62	2	1	0	0
				5.0-5.3	3	28	66	2	1	0	0
				Mean	5	35	55	1	2	2	0
b	37	63	0	9.5-20.0	37	62	1	0	0	0	0
				20.0-21.0	No grading data available						
				Mean	37	63	trace	trace	0	0	0
a+b	28	72	0	Mean	28	57	15	trace	trace	trace	0

SJ 54 NW 29

5400 4945

Moss Farm

Block E

Surface level +83.7 m (+275 ft)
Water struck at +78.7 m
November 1981

Overburden 0.3 m
Mineral 1.0 m
Waste 0.5 m
Mineral 5.5 m
Waste 3.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
River Terrace Deposits	a 'Clayey' pebbly sand Gravel: coarse, subrounded Palaeozoic argillites and arenites Sand: medium with fine, subrounded quartz Fines: clay band at 0.5 m, olive grey	1.0	1.3
	Clay, silty, pebbly and very sandy, moderate to pale brown, crudely laminated in part	0.5	1.8
Glacial Sand and Gravel	b Pebbly sand, less gravel to base Gravel: fine, subrounded, Palaeozoic arenites and argillites and Permo-Triassic argillites with fine-grained igneous rocks, quartz and some coarse-grained igneous rocks Sand: medium with fine, subrounded, quartz with some lithic grains	5.5	7.3
Till	'Clayey' to 'very clayey' pebbly sand (sand and very sandy pebbly clay bands in situ?) Gravel: coarse with fine, subangular to subrounded Palaeozoic and Permo-Triassic argillites and quartz Sand: fine with medium, subrounded, quartz with lithic grains Fines: moderate brown	3.9+	11.2
Borehole abandoned: unable to case hole farther			

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
a	11	81	8	0.3-1.3	11	32	47	2	1	7	0
b	2	91	7	1.8-3.0	4	18	59	7	7	5	0
				3.0-4.0	1	60	18	10	9	2	0
				4.0-5.0	2	34	48	9	6	1	0
				5.0-7.3	2	25	66	6	1	0	0
				Mean	2	31	53	7	5	2	0
	13	75	12	7.3-9.1	13	44	29	2	3	9	0
a+b	3	91	6	Mean	3	32	53	6	4	2	0

SJ 54 NW 30

5393 4698

Willey Farm

Block E

Surface level +75.3 m (+247 ft)
Water struck at +71.3 m
September 1981

Overburden 0.4 m
Mineral 15.3 m
Waste 2.8 m
Mineral 1.8 m
Waste 0.2 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
River Terrace Deposits	a 'Clayey' sand, rare pebbles Sand: fine with medium, subrounded quartz Fines: yellowish brown	0.7	1.1
Glacial Sand and Gravel	b Pebbly sand with clay band at 3.0 m Gravel: fine with coarse, subangular to subrounded, Palaeozoic and Permo-Triassic arenites and argillites, fine-grained igneous rocks and some quartz and flint Sand: medium, subrounded, quartz with lithic grains	3.2	4.3
	c 'Clayey' sand Sand: fine to medium, subrounded, quartz Fines: moderate reddish brown silt	9.0	13.3
	d Sandy gravel Gravel: fine with coarse, subangular to subrounded, Permo-Triassic argillites, Palaeozoic arenites and argillites, coarse- and fine-grained igneous rocks and some flint, quartz and limestone Sand: fine with medium, subrounded quartz	2.4	15.7
Glacial Silt and Clay	Clay and silt with thin sandy partings, finely laminated, moderate brown	1.6	17.3
	Silt, very sandy, moderate brown to moderate reddish brown	1.2	18.5
Glacial Sand and Gravel	e 'Clayey' sand Sand: fine, subrounded quartz Fines: moderate brown and moderate reddish brown silt with laminated silty clay band at base	1.8	20.3
Till	Clay, silty, sandy and pebbly, moderate brown, hard	0.2	20.5
Wilkesley Halite	Clay and siltstone fragments, moderate reddish brown	1.0+	21.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines		Sand			Gravel	
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
a	13	85	2	0.4-1.1	13	45	39	1	1	1	0
b	8	75	17	1.1-2.1	9	13	51	12	11	4	0
				2.1-3.1	4	8	58	14	10	6	0
				3.1-4.3	10	21	36	12	10	11	0
				Mean	8	14	49	12	10	7	0
c	14	86	0	4.3-7.3	24	21	52	2	1	0	0
				7.3-10.3	11	71	17	1	0	0	0
				10.3-13.3	9	47	43	1	0	0	0
				Mean	14	48	37	1	trace	0	0
d	4	65	31	13.3-14.5	6	35	28	3	20	8	0
				14.5-15.7	3	31	28	4	18	16	0
				Mean	4	34	28	3	19	12	0
e	15	85	0	18.5-20.3	15	71	14	trace	trace	0	0
a-e	12	80	8	Mean	12	40	36	4	5	3	0

SJ 54 NW 31

5385 4633

Moorend Tenement

Block E

Surface level +73.0 m (+239 ft)
 Water struck at +69.0 m
 October 1981

Overburden 4.0 m
 Mineral 5.0 m
 Waste 6.4 m
 Mineral 2.6 m
 Waste 1.0 m
 Mineral 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Head	'Very clayey' sand, colour banded, weathered	0.6	1.0
Glacial Sand and Gravel	'Clayey' sand, medium with fine, subangular to rounded, quartz	0.5	1.5
Glacial Silt and Clay	Silt, sandy, massive to laminated, moderate reddish brown	2.5	4.0
Glacial Sand and Gravel	a 'Clayey' sand, fine, quartz, laminated with silty bands	5.0	9.0
Glacial Silt and Clay	Silt, massive, moderate brown	0.2	9.2
	Silt, very sandy, moderate reddish brown	5.8	15.0
	Silt with laminae of fine quartz sand, moderate brown	0.4	15.4
Glacial Sand and Gravel	b 'Clayey' sand, fine, subangular to rounded, quartz	2.6	18.0

Glacial Silt and Clay	Clay, silty, massive becoming poorly laminated near base, moderate reddish brown, firm	1.0	19.0
Glacial Sand and Gravel	c 'Clayey' sand, fine, subangular to subrounded, quartz	1.0+	20.0
	Borehole stopped due to slow progress		

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines		Sand		Gravel		
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
	34	64	2	1.0-1.5	34	27	34	3	1	1	0
a	16	84	0	4.0-9.0	16	80	4	trace	trace	0	0
	52	48	0	9.2-15.0	52	48	trace	0	0	0	0
b	16	84	0	15.4-18.0	16	83	1	0	0	0	0
c	19	81	0	19.0-20.0	19	80	1	trace	0	0	0
a+b+c	16	84	0	Mean	16	81	3	trace	trace	0	0

SJ 54 NW 32	5356 4511	Willemoor Lock	Block E
Surface level +74.3 m (+244 ft)			Overburden 2.0 m
Water struck at 72.5 m			Mineral 1.0 m
September 1981			Waste 3.8 m
			Mineral 13.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Peat	Peat, fibrous, spongy, damp, black	1.5	1.7
Glacial Silt and Clay	Clay, very sandy, medium dark grey, soft	0.3	2.0
Glacial Sand and Gravel	a 'Clayey' sandy gravel Gravel: fine, subrounded, Permo-Triassic and Palaeozoic arenites and argillites, some fine and coarse-grained igneous rocks and quartz Sand: fine and medium, quartz with lithic grains	1.0	3.0
Glacial Silt and Clay	Silty clay interbedded with clayey pebbly sands, moderate brown	2.0	5.0
	Silt, sandy, clayey, moderate brown, laminated? sheared	1.8	6.8
Glacial Sand and Gravel	b Sandy gravel Gravel: coarse with fine, Palaeozoic arenites and argillites, Permo-Triassic arenites, coarse- and fine-grained igneous rocks and limestones, with Permo-Triassic argillites and quartz Sand: medium	6.5	13.3
	c Pebbly sand Gravel: fine, Permo-Triassic arenites and argillites, with Palaeozoic arenites and argillites Sand: fine with medium	6.7+	20.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages								
	Fines	Sand	Gravel		Fines		Sand			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16} - \frac{1}{4}$	$+\frac{1}{4} - 1$	$+1 - 4$	$+4 - 16$	$+16 - 64$	$+64$ mm		
a	14	62	24	2.0-3.0	14	28	26	8	15	9	0		
b	6	62	32	6.8-9.8	7	13	34	9	12	25	0		
				9.8-10.5	10	8	23	9	21	29	0		
				10.5-12.0	5	30	41	10	9	5	0		
				12.0-13.3	4	26	32	9	11	14	4		
				Mean	6	19	34	9	12	19	1		
c	5	89	6	13.3-16.0	7	52	34	5	2	0	0		
				16.0-17.0	5	41	36	10	5	3	0		
				17.0-18.0	4	36	46	11	3	0	0		
				18.0-18.5	3	25	46	7	9	10	0		
				18.5-20.0	No grading data available								
				Mean	5	44	38	7	4	2	0		
a+b+c	6	76	18	Mean	6	32	36	8	8	10	trace		

SJ 54 NW 33 5489 4985 Bickley Moss

Block E

Surface level +86.1 m (+282 ft)
Water struck at +85.1 m
November 1981

Overburden 4.0 m
Mineral 6.4 m
Waste 9.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
River Terrace Deposits	Pebbly sand Gravel: mainly fine, subrounded to well rounded, quartz and fine-grained igneous rocks Sand: medium with fine, subrounded, quartz with lithic grains	0.8	1.0
Till	Clay, sandy, silty and pebbly, moderate brown with pale green patches, soft	3.0	4.0
Glacial Sand and Gravel	a Pebbly sand, with thin silt and clay bands Gravel: fine to coarse, subrounded Permo-Triassic and Palaeozoic argillites and well rounded quartz Sand: medium, subrounded quartz	3.9	7.9
	b Sand, medium, subrounded quartz, with clay and silt bands	2.5	10.4
Till	Clay and silt with clasts of Permo-Triassic siltstone, moderate brown to moderate reddish brown, sheared, very hard	4.4	14.8
Glacial Silt and Clay	Clay, silty, stoneless, greyish brown to 15.2 m then moderate brown, very well laminated, very hard	1.4	16.2
Till	Clay with bands of Permo-Triassic siltstone gravel, moderate reddish-brown	2.6	18.8
Glacial Silt and Clay	Silt, clayey, stoneless, moderate reddish brown, very hard	1.2+	20.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages								
	Fines	Sand	Gravel		Fines			Sand			Gravel		
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm		
a	7	83	10	4.0-5.9	6	18	53	15	8	0	0		
				5.9-7.9	8	21	54	5	5	7	0		
				Mean	7	20	53	10	6	4	0		
b	7	93	0	7.9-10.4	7	27	64	2	trace	0	0		
a+b	7	87	6	Mean	7	22	59	6	4	2	0		

SJ 54 NW 34 5441 4802 Swanwick Green Block E

Surface level +85.0 m (+279 ft) Overburden 5.4 m
 Water struck at +75.5 m Mineral 13.8
 November 1981 Waste 2.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and fill	0.4	0.4
Till	Clay, silty, sandy with sporadic pebbles, moderate brown, mottled with brown and greenish grey	0.2	0.6
	Clay, silty with sandy pockets and sporadic pebbles, moderate reddish brown, greenish grey along joint planes; disturbed finely laminated lense at 5.0 m; hard to very hard	4.7	5.3
Glacial Silt and Clay	Clay, silty, stoneless, moderate brown, finely laminated	0.1	5.4
Glacial Sand and Gravel	a Sand, 'clayey' in part, with a band of coarse pebbles at 6.5 m; fine with medium, subrounded quartz	3.0	8.4
	b 'Very clayey' sand Sand: fine with medium, subrounded quartz Fines: moderate brown; bands of silt and clay at 9.0 m and 12.0 m	10.8	19.2
Till	Clay, silty, sandy and pebbly, moderate brown, very hard	2.8+	22.0
	Borehole abandoned due to drilling difficulties		

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages								
	Fines	Sand	Gravel		Fines			Sand			Gravel		
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm		
a	10	82	8	5.4-8.4	10	56	25	1	1	7	0		
b	20	80	0	8.4-11.4	23	62	15	0	0	0	0		
				11.4-14.4	18	45	37	0	0	0	0		
				14.4-17.4	18	63	18	1	0	0	0		
				17.4-19.2	22	65	13	0	0	0	0		
				Mean	20	59	21	trace	trace	0	0		
a+b	18	81	1	Mean	18	58	22	1	trace	1	0		

SJ 54 NW 35 5426 4671 Quoisley Bridge

Block E

Surface level +72.6 m (+238 ft)
 Water struck at +64.1 m
 September 1981

Waste 18.4 m

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Alluvium	Clay, very sandy, olive grey mottled with brown	0.3	0.8
Glacial Silt and Clay	Silt, very sandy at top with rare pebbles, moderate reddish brown, finely laminated in part, firm	5.4	6.2
Till	Clay, pebbly, sandy, moderate brown, with thin lenses of laminated clay, sheared, firm	1.2	7.4
Glacial Silt and Clay	Clay, silty, moderate brown, well laminated, hard	0.9	8.3
Till	Clay, pebbly, sandy, moderate brown, very hard, with thin layers of sand and gravel; below 10.5 m matrix appears to be sheared and disturbed finely laminated clay	3.0	11.3
	Clay, silty, moderate brown, very hard, with pockets of sandy pebbly clay	0.3	11.6
	Clay, sandy and pebbly, moderate reddish brown, very hard	0.4	12.0
	Silt, clayey, with sporadic pebbles, moderate reddish brown	1.0	13.0
	Clay, silty, pebbly, moderate brown, sheared	0.8	13.8
	Clay, silty, with Permo-Triassic clasts, moderate reddish brown, very hard	0.6	14.4
Glacial Silt and Clay	Clay, silty, stoneless, moderate brown to moderate reddish brown, laminated but much disturbed, very hard	4.0+	18.4

SJ 54 NW 36 5452 4591 Mere Farm

Block E

Surface level +80.6 m (+264 ft)
 Water struck at +78.1 m
 October 1981

Overburden 0.6 m
 Mineral 1.9 m
 Waste 22.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Glacial Sand and Gravel	'Clayey' sand, somewhat banded, fine, subangular to rounded, quartz; more 'clayey' near base	1.9	2.5
Glacial Silt and Clay	Clay, silty, laminated, some organic debris, becoming sandy towards base, strong brown	1.0	3.5
Glacial Sand and Gravel	'Very clayey' sand, fine, angular to rounded, quartz	0.5	4.0

Glacial Silt and Clay	Silt, clayey, bedded, moderate brown	2.5	6.5
	Clay, silty, laminated, moderate brown	0.5	7.0
	Silt, sandy, massive, moderate brown	4.5	11.5
	Clay, silty, poorly laminated and graded, moderate brown	1.0	12.5
	Silt with minor fine quartz sand, massive, moderate brown	0.5	13.0
Glacial Sand and Gravel	'Very clayey' sand, fine, subangular to rounded, quartz	0.7	13.7
Glacial Silt and Clay	Clay, silty, massive but with sporadic laminae of fine quartz sand	11.3+	25.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
10	90	0	0.6-2.0	9	64	26	1	0	0	0
			2.0-2.5	13	21	62	3	0	1	0
			Mean	10	54	35	1	trace	trace	0
22	78	0	3.5-4.0	22	73	5	trace	0	0	0
23	77	0	13.0-13.7	23	75	2	trace	0	0	0

SJ 54 NE 5 5554 4846 Norbury Common

Surface level +80.9 m (+265 ft)
Water not struck
October 1981

Waste 18.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, silty, sandy, pebbly, moderate reddish brown and very hard to 2.1 m, moderate brown and hard below	3.2	3.5
	Clay, silty, moderate brown, soft	3.3	6.8
	Clay, silty, pebbly, moderate brown to 13.2 m, greyish brown below, coal fragments, very hard	12.0+	18.8

Surface level +93.8 m (+308 ft)
 Water struck at +88.4 m
 October 1981

Overburden 8.9 m
 Mineral 8.1 m
 Waste 6.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, silty, pebbly, brownish grey with moderate brown sandy patches	1.2	1.5
	Clay, silty, moderate brown with streaks of yellowish grey and reddish brown, soft	0.5	2.0
	Clay, silty, pebbly, moderate brown, firm	0.7	2.7
	Clay, silty, with rare pebbles and sand balls, moderate brown	0.3	3.0
	Clay, silty, sandy and pebbly, moderate brown, very hard becoming hard	2.4	5.4
	'Very clayey' sand Sand: medium, quartz Fines: moderate brown	0.5	5.9
	Clay, silty, moderate brown with greenish grey silty partings, ?laminated, hard	0.3	6.2
	'Very clayey' sand, as above	1.2	7.4
Glacial Sand and Gravel	Clay, silty, pebbly, greyish brown to moderate reddish brown, hard	1.5	8.9
	a 'Clayey' pebbly sand Gravel: fine and coarse, subangular to subrounded, fine-grained igneous rocks, quartz and Permo-Triassic argillites and arenites Sand: medium, quartz	1.4	10.3
	b Sand, medium, subangular to rounded quartz	6.0	16.3
	c 'Very clayey' gravel Gravel: coarse with fine Sand: mainly medium, quartz	0.7	17.0
Till	Clay, silty, pebbly, very hard	6.0+	23.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages									
	Fines	Sand	Gravel		Fines			Sand				Gravel		
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm			
a	10	72	18	8.9-10.3	10	22	46	4	10	8	0			
b	6	94	0	10.3-12.0	7	32	60	1	0	0	0			
				12.0-14.0	7	22	70	1	0	0	0			
				14.0-16.3	6	33	61	0	0	0	0			
				Mean	6	29	64	1	trace	0	0			
c	27	20	53	16.3-17.0	27	5	10	5	17	33	3			
a+b+c	9	84	7	Mean	9	26	56	2	3	4	trace			

SJ 54 NE 7 5581 4625 Hadley Hall

Block E

Surface level +71.2 m (+234 ft)
 Water struck at +70.2 m
 October 1981

Overburden 1.0 m
 Mineral 6.5 m
 Waste 13.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Silt, organic-rich, brownish black	0.7	1.0
Glacial Sand and Gravel	Sand Gravel: coarse, basic igneous rocks dominant Sand: fine and medium quartz with lithic grains Fines: moderate reddish brown silt and clay	6.5	7.5
Till	Clay, silty, sandy, pebbly, moderate brown, sporadic clasts of grey argillites and red sandstone throughout with grey marl very common below 16.0 m, very hard	13.0+	20.5

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
9	90	1	1.0-2.0	9	61	29	1	0	0	0
			2.0-3.0	12	64	19	0	0	5	0
			3.0-4.0	4	43	53	0	0	0	0
			4.0-5.0	6	41	53	0	0	0	0
			5.0-6.0	12	59	29	0	0	0	0
			6.0-7.0	13	62	25	0	0	0	0
			7.0-7.5	No grading data available						
			Mean	9	56	34	trace	trace	1	0

SJ 54 NE 8 5613 4884 Parkside Farm

Block E

Surface level +79.3 m (+260 ft)
 Water struck at +76.7 m
 October 1981

Overburden 0.6 m
 Mineral 4.6 m
 Waste 2.8 m
 Bedrock 2.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Fluvio-glacial Gravel	Sand with some fine gravel Sand: fine and medium quartz Fines: moderate brown silt and clay	4.6	5.2
Till	Clay, silty, stony, dark reddish brown, hard	2.8	8.0
Lower Lias	Mudstone, dark blue grey, with shell fragments	2.9+	10.9

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines		Sand			Gravel	
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ - 1	+1 - 4	+4 - 16	+16 - 64	+64 mm
6	93	1	0.6-1.6	6	31	56	3	3	1	0
			1.6-2.6	10	44	45	1	0	0	0
			2.6-3.6	No grading data available						
			3.6-4.6	5	55	39	1	0	0	0
			4.6-5.2	5	46	44	2	2	1	0
			Mean	6	44	47	2	1	trace	0

SJ 54 NE 9 5616 4856 Holtridge

Surface level +86.4 (+283 ft) Waste 21.6 m+
 Water struck at +65.2 m
 October 1981

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, pebbly with sand balls, greyish brown, gleyed to 5.0 m, very hard below 1.5 m	20.2	20.5
Glacial Silt and Clay	Clay, silty and sandy layers, brown to moderate reddish brown, laminated	0.7	21.2
Till?	Clay, pebbly (poor recovery)	0.2	21.4
Glacial Sand and Gravel	Sand, medium and fine, subangular to rounded quartz; some reddish brown fines	0.2+	21.6

SJ 54 NE 10 5621 4552 Big Mere

Surface level +75.0 m (+246 ft) Waste 17.0 m+
 Water struck at 71.5 m
 October 1981

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Lacustrine Alluvium	Clay, laminated, moderate brown	0.8	1.0
Till	Clay, sandy and pebbly, moderate reddish brown, firm	2.5	3.5
Glacial Silt and Clay	Clay, very sandy, pebbly in part, moderate brown, mainly recovered as slurry	1.5	5.0
Glacial Sand and Gravel	Pebbly sand Gravel: fine, angular to rounded, fine and coarse-grained igneous rocks and Palaeozoic and Triassic arenites and argillites with quartz Sand: medium, angular to rounded, quartz	1.0	6.0
Till with Glacial Silt and Clay	Clay, sandy and pebbly, dark brown, with bands of sandy clay, 'clayey' sand and oriented pebbles; very wet throughout	11.0+	17.0
Hole abandoned due to loss of drilling tool			

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
9	81	10	5.0-6.0	9	26	48	7	6	4	0

SJ 54 NE 11 5769 4856 Bank Farm Block E

Surface level +80.8 m (+265 ft) Overburden 3.5 m
 Water struck at +78.3 m Mineral 11.5 m
 October 1981 Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Head on Till	Clay, silty to base, pale brown but mottled, some fragments of wood at 1.5 m	3.0	3.5
Glacial Sand and Gravel	Sandy gravel Gravel: fine, subrounded, Palaeozoic arenites and argillites with fine-and coarse-grained igneous rocks, quartz and some Permo-Triassic arenites, flint and limestone Sand: medium, subrounded quartz	11.5	15.0
Wilkesley Halite	Clay, silty, moderate brown, with some gypsum crystals	1.0+	16.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
5	57	38	3.5-4.5	11	16	35	13	15	6	4
			4.5-5.5	8	16	57	8	7	4	0
			5.5-6.5	13	12	12	11	28	24	0
			6.5-7.5	4	13	40	17	19	7	0
			7.5-8.5	2	6	26	17	29	16	4
			8.5-9.5	3	3	19	16	27	27	5
			9.5-11.0	1	2	11	15	32	20	19
			11.0-15.0	5	3	41	23	20	8	0
			Mean	5	7	33	17	22	13	3

Surface level +70.4 m (+231 ft)
 Water struck at +57.9 m
 October 1981

Waste 25.0 m
 Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, sandy, silty, pebbly, moderate reddish brown to 3.0 m, moderate brown below, some shell fragments, hard	4.8	5.0
Glacial Silt and Clay	Silt, stoneless, medium dark grey, laminated	0.3	5.3
Till	Clay, silty and sandy, moderate brown, coarse green marl clasts below 8.4 m, very hard	4.5	9.8
Glacial Silt and Clay	Silt, sandy, laminated, dusky brown with bluish grey partings to 10.0 m, becoming moderate reddish brown with bluish grey partings with depth	1.4	11.2
Till	Clay, silty with some sand, pebbly, well rounded quartz and angular flint, dark reddish brown flecked with grey and brown, very hard	1.3	12.5
Glacial Sand and Gravel	'Clayey' sandy gravel Gravel: coarse with fine and cobbles, rounded quartz and angular flint with Permo-Triassic rocks Sand: fine and medium quartz Fines: reddish brown silt and clay	2.6	15.1
Glacial Silt and Clay	Silt, sandy, moderate brown silt, moderate yellowish brown sand, laminated, very hard	0.5	15.6
	Clay, slightly sandy, dark yellowish brown, some organic fragments, firm	1.8	7.4
Till	Clay, silty, sandy with marl fragments, dark reddish brown, hard, coal fragments common below 22.5 m	6.6	24.0
Laminated Clay	Clay with silt laminae, clasts of grey and green silty clay, abundant peat and twigs, bluish black, soft	1.0	25.0
Wilkesley Halite	Mudstone, red brown, hard	0.2+	25.2

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
11	65	24	12.5-15.1	11	22	39	4	6	14	4

SJ 54 NE 13 5788 4657 Marbury Heys

Surface level +72.8 m (+239 ft)
 Water struck at +54.3 m
 October 1981

Waste 21.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
River Terrace Deposits	Silt, sandy, clayey at top, greyish red	1.4	1.9
	Clay, silty, with some pebbles, brown, soft	0.9	2.8
Till	Clay, very sandy, with some pebbles, silty below 5.0 m with sandy patches, moderate brown, firm	4.7	7.5
	Clay, silty, sandy, with rare pebbles and thin silt layers, moderate brown	9.5	17.0
	Clay, with sandy wisps, moderate brown, very hard	1.5	18.5
Glacial Sand and Gravel	'Clayey' sand Sand: fine with medium quartz Fines: moderate brown and light brown	3.0+	21.5

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines			Sand		Gravel	
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
13	87	0	18.5-19.0	27	42	30	1	0	0	0
			19.0-20.0	7	50	42	1	0	0	0
			20.0-21.5	13	48	38	1	0	0	0
			Mean	13	48	38	1	trace	0	0

SJ 54 NE 14 5772 4505 Marley Hall Covert

Surface level +100.9 m (+331 ft)
 Water not struck
 October 1981

Waste 18.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	1.4	1.4
Till	Clay, silty, with some pebbles, moderate reddish brown, very hard	9.6	11.0
	Silt, sandy, pebbly, with thin interbedded clays, moderate reddish brown	1.0	12.0
	Clay, sandy, moderate reddish brown, very hard	6.7+	18.7

Surface level +82.0 m (+269 ft)
 Water not struck
 October 1981

Overburden 0.3 m
 Mineral 2.9 m
 Waste 10.9 m
 Bedrock 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Sand and Gravel	'Clayey' sand Sand: medium, quartz Fines: moderate brown	2.9	3.2
Till	Clay, silty, sandy and pebbly, moderate brown, very hard to 4.5 m then firm	4.3	7.5
Glacial Silt and Clay	Clay, with thin sandy partings, greyish red, laminated, hard	3.5	11.0
Till	Clay, pebbly, moderate brown, very hard, laminated and sheared below 13.8 m	3.1	14.1
Lias	Clay, silty, with mudstone clasts, dark grey mottled with olive grey; mudstone at base	1.5+	14.8

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
38	60	2	0.3-1.0	No grading data available						
			1.0-2.0	No grading data available						
			2.0-3.2	38	36	22	2	2	0	0
			Mean	38	36	22	2	2	0	0

Surface level +73.1 m (+240 ft)
 Water not struck
 October 1981

Overburden 0.2 m
 Mineral 2.5 m
 Waste 17.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	'Clayey' pebbly sand Gravel: fine, subrounded quartz and lithic pebbles Sand: medium and fine, quartz Fines: dusky yellowish brown silt and clay	2.5	2.7
Till	Clay, silty, sandy, pebbly, moderate brown, firm to 5.6 m becoming hard with depth	14.3	17.0
Glacial Silt and Clay	Clay, silty and sandy, with moderate brown clay, greyish brown silt and light brown sand laminae, very hard	2.9+	19.9

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16} - \frac{1}{4}$	$+\frac{1}{4} - 1$	$+1 - 4$	$+4 - 16$	$+16 - 64$	$+64$ mm
12	83	5	0.2-1.5	13	21	55	6	5	0	0
			1.5-2.7	10	32	49	4	4	1	0
			Mean	12	26	52	5	5	trace	0

SJ 54 NE 17

5835 4616

Marley Green

Block G

Surface level +74.0 m (+243 ft)
Water struck at +61.5 m
October 1981

Overburden 0.6 m
Mineral 4.3 m
Waste 7.6 m
Mineral 6.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
River Terrace Deposits	Clay, dusky brown, soft	0.3	0.6
	a 'Very clayey' pebbly sand Gravel: fine with coarse subrounded quartz, basic igneous rocks, Palaeozoic argillites and Permo-Triassic arenites Sand: medium and fine, quartz Fines: moderate brown silt and clay	2.4	3.0
	b Pebbly sand Gravel: fine and coarse, rounded to subrounded Permo-Triassic arenites with quartz, chert and subangular basic igneous rocks Sand: medium with fine, subrounded quartz Fines: moderate brown silt and clay	1.9	4.9
Till	Clay, silty, sandy, pebbly, moderate brown, very hard to 6.0 m, firm below	2.6	7.5
	Clay, slightly silty, sandy and pebbly, moderate brown, soft to 8.5 m, hard below	1.3	8.8
Glacial Silt and Clay	Clay, sandy, laminated, stoneless, moderate brown, soft, disturbed	3.7	12.5
Glacial Sand and Gravel	c Sand Gravel: fine Sand: medium and fine, rounded quartz with lithic grains including coal fragments Fines: light brown silt and clay	6.0+	18.5
Borehole abandoned due to slow progress			

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16} - \frac{1}{4}$	$+\frac{1}{4} - 1$	$+1 - 4$	$+4 - 16$	$+16 - 64$	$+64$ mm
a	31	64	5	0.6-1.5	23	31	26	8	10	2	0
				1.5-3.0	35	10	51	2	1	1	0
				Mean	31	18	42	4	4	1	0
b	5	89	6	3.0-4.0	1	15	80	3	1	0	0
				4.0-4.5	5	9	65	7	7	7	0
				4.5-4.9	16	12	55	9	6	2	0
				Mean	5	13	71	5	4	2	0
c	6	92	2	12.5-17.0	7	37	53	2	1	0	0
				17.0-18.5	5	19	54	14	8	0	0
				Mean	6	32	55	5	2	trace	0
a+b+c	12	84	4	Mean	12	25	54	5	3	1	0

SJ 54 NE 18 5914 4912 Wrenbury Wood

Surface level +81.7 m (+268 ft)
 Water not struck
 October 1981

Waste 18.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Till	Clay, pebbly, sandy in parts	2.5	3.0
Glacial Sand and Gravel	'Very clayey' sand Sand: medium with fine, quartz Fines: moderate reddish brown	1.0	4.0
Glacial Silt and Clay	Silt, very sandy, moderate reddish brown	1.2	5.2
Till	Clay, sandy, silty and pebbly, moderate brown, firm	6.8	12.0
Glacial Sand and Gravel	Sand, medium and fine, subangular to rounded quartz, some thin interbedded clays	0.9	12.9
Glacial Silt and Clay	Clay, sandy, with silty layers, vague lamination at 16.0 m, moderate to greyish brown, hard	3.8	16.7
Till	Clay, rare pebbles and some sandy wisps, moderate brown, very hard	0.8	17.5
Glacial Silt and Clay	Clay, stoneless, vaguely laminated, some sandy wisps, moderate brown, very hard	1.2+	18.7

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16} - \frac{1}{4}$	$+\frac{1}{4} - 1$	$+1 - 4$	$+4 - 16$	$+16 - 64$	$+64$ mm
	20	79	1	3.0-4.0	20	30	48	1	1	trace	0
	43	55	2	4.0-5.2	43	24	30	1	1	1	0

SJ 54 NE 19 5920 4838 Sprostonwood House

Surface level +74.9 m (+246 ft)
 Water not struck
 October 1981

Waste 9.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, sandy, silty, with some pebbles, moderate reddish brown but mottled, weathered	0.7	1.0
	Clay, sandy, pebbly, moderate reddish brown, firm	1.5	2.5
	Clay, silty, pebbly, moderate reddish brown, very hard	6.5+	9.0
	?Boulder at 9.0 m; borehole abandoned		

SJ 54 NE 20 5958 4764 Oaklands

Surface level +72.4 m (+238 ft)
 Water struck at +70.2 m
 October 1981

Block G

Overburden 1.0 m
 Mineral 3.0 m
 Waste 2.2 m
 Mineral 1.1 m
 Waste 7.7 m
 Mineral 2.8 m
 Waste 5.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Fill	1.0	1.0
Glacial Sand and Gravel	a Pebbly sand Gravel: fine, subrounded, Palaeozoic and Permo-Triassic arenites and argillites with fine- and coarse-grained igneous rocks, quartz, flint and limestone Sand: medium, subangular to rounded, quartz and lithic grains	3.0	4.0
Till	Clay, very sandy, pebbly, moderate brown, soft	2.2	6.2
Glacial Sand and Gravel	b Pebbly sand Gravel: fine and coarse, constituents as above Sand: fine with medium, subangular to rounded, quartz with lithic grains	1.1	7.3
Till	Clay, pebbly, silty, moderate brown, very hard	7.7	15.0
Glacial Sand and Gravel	c 'Clayey' sand Sand: fine, quartz	2.8	17.8
Till	Clay, pebbly, with silty layers, moderate brown, very hard	5.4+	23.2

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines		Sand			Gravel	
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ - 1	+1 - 4	+4 - 16	+16 - 64	+64 mm
a	6	84	10	1.0-2.0	9	17	63	3	4	4	0
				2.0-3.0	5	14	70	3	4	4	0
				3.0-4.0	3	6	61	15	13	2	0
				Mean	6	12	65	7	7	3	0
b	9	80	11	6.2-7.3	9	43	33	4	5	6	0
c	11	86	3	15.0-17.8	11	74	12	trace	trace	3	0
a+b+c	8	84	8	Mean	8	42	38	4	4	4	0

SJ 54 NE 21 5917 4754 Wrenbury

Surface level +69.4 m (+228 ft)
 Water struck at +64.9 m
 October 1981

Waste 19.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, silty, pebbly, dark reddish brown with a greenish grey film on joints above 1.5 m, becoming moderate brown throughout below, hard	4.2	4.5
	Clay, silty, sandy, pebbly, moderate brown, very hard	9.0	13.5
	Clay, moderate brown, crudely laminated with fine light brown sand, very hard, some clasts of medium bluish grey marl and moderate reddish brown sandstone	1.1	14.6
	Clay, silty, pebbly, moderate brown, very hard	0.4	15.0
Glacial Silt and Clay	Clay, silty and sandy, moderate brown with light brown fine sand laminae, very hard	0.6	15.6
	Clay, sandy, pebble free, moderate brown	1.3	16.9
	Clay, silty and sandy, moderate brown with light brown fine sand laminae, very hard	0.9	17.8
Till	Clay, silty, pebbly, moderate brown, very hard	0.7	18.5
	Clay, sandy, moderate brown	0.5+	19.0

SJ 54 SW 21 5084 4438 Agden Hall

Surface level +94.8 m (+311 ft)
 Water struck at +88.4 m
 November 1981

Waste 19.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, silty, with sandy patches to 0.6 m and sporadic pebbles throughout; moderate reddish brown with greyish yellow green streaks and clasts, firm to very hard	3.5	3.8
Glacial Sand and Gravel	Sand, medium with fine, subrounded, quartz, with a thin layer of coarse sand and fine gravel at 4.4 m	1.2	5.0
Till	Clay, sandy, silty and pebbly, moderate to dark reddish brown and moderate brown below 9.0 m, firm, some layers of 'clayey' pebbly sand below 6.4 m	5.2	10.2
Glacial Sand and Gravel	'Clayey' sand Sand: medium with fine, quartz Fines: moderate brown; silt band at 11.2 m	3.2	13.4
Glacial Silt and Clay	Silt, clayey, with sporadic pebbles, moderate brown, some bedding apparent, very hard	1.1	14.5
Till	Silt, clayey and pebbly, with discrete thin silt layers and a band of sand and gravel at 16.0 m, moderate brown, very hard	4.5	18.5
Glacial Silt and Clay	Silt, with rare pebbles, moderate brown, very hard	0.5+	19.0

GRADING

Mean for deposit percentages	Depth below surface (m)	Percentages						
		Fines			Sand		Gravel	
		-16	+16 -4	+4 -1	+1 -4	+4 -16	+16 -64	+64 mm
	3.8-5.0	8	34	54	2	2	0	0
	10.2-11.5	13	37	49	1	0	0	0
	11.5-13.4	8	31	60	1	0	0	0

SJ 54 SW 22 5049 4264 Bryn Owen

Block F

Surface level +89.9 m (295 ft)
 Water struck at +74.9 m
 October 1981

Overburden 0.5 m
 Mineral 16.7 m
 Waste 4.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Glacial Sand and Gravel	a Sand, 'very clayey' between 2.3 m and 2.8 m Sand: medium with fine, subrounded quartz Fines: varying shades of brown silt and clay	2.8	3.3

	b Pebbly sand	3.2	6.5
	Gravel: fine, subrounded to rounded, Palaeozoic arenites with fine- and coarse-grained igneous rocks, Permo-Triassic argillites and some limestone and quartz		
	Sand: medium, subrounded quartz with some coarse lithic grains		
	c Sand, with sporadic pebbles below 9.5 m; fine with medium subrounded quartz	10.7	17.2
Glacial Silt and Clay	Silt, clayey and sandy with rare pebbles, moderate brown, micaceous, soft	2.9	20.1
Till	Clay, sandy and pebbly, with sandy pockets, moderate brown, firm	1.7+	21.8
Borehole abandoned due to slow progress			

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines		Sand			Gravel	
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
a	11	88	1	0.5-1.5	7	28	63	1	1	0	0
				1.5-2.3	7	50	42	0	1	0	0
				2.3-2.8	29	35	32	2	2	0	0
				2.8-3.3	6	40	45	3	3	3	0
				Mean	11	38	49	1	1	trace	0
b	5	85	10	3.3-4.5	6	20	50	12	9	3	0
				4.5-5.5	5	27	51	5	7	5	0
				5.5-6.5	4	18	66	4	6	2	0
				Mean	5	21	57	7	7	3	0
c	9	91	0	6.5-9.5	3	42	54	1	0	0	0
				9.5-12.0	8	65	25	1	1	0	0
				12.0-15.0	15	67	18	0	0	0	0
				15.0-17.2	7	62	31	0	0	0	0
				Mean	9	59	32	trace	trace	0	0
a+b+c	8	89	3	Mean	8	47	40	2	2	1	0

SJ 54 SW 23 5095 4241 Wolvesacre Hall

Block F

Surface level +67.8 m (+222 ft)
Water struck at +66.4 m, subsequently artesian

Waste 21.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Alluvium	'Very clayey' sand Sand: fine with medium quartz Fines: yellowish brown, greyish brown and medium bluish grey	1.0	1.4
	Pebbly sand Gravel: fine and coarse, subangular to rounded Palaeozoic and Permo-Triassic arenites and argillites and fine- and coarse-grained igneous rocks with quartz and some flint Sand: fine and medium, quartz	1.6	3.0

Till	Clay, pebbly, moderate brown, very hard, with sand and pebbly bands, increasingly silty below 5.5 m, with sheared surfaces below 6.1 m	6.8	9.8
Glacial Silt and Clay	Clay, stoneless, dark brown, sheared and disturbed, but originally laminated, hard	5.2	15.0
	Clay, with silt and sand laminae, moderate reddish brown, very well laminated and much less disturbed than above, hard	3.7	18.7
?	?Sand and gravel Gravel: fine and coarse, subangular to subrounded Palaeozoic and Permo-Triassic arenites and argillites and fine- and coarse-grained igneous rocks with some quartz and flint Sand: medium subrounded quartz	1.3	20.0
Strong artesian water flow affects sampling			
?	?Clay and sand with rare pebbles Borehole abandoned due to artesian conditions	1.0+	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 mm
26	74	0	0.4-1.1	21	46	33	0	0	0	0
			1.1-1.4	39	44	15	1	1	0	0
			Mean	26	46	28	trace	trace	0	0
8	69	23	1.4-3.0	8	32	30	7	11	12	0
15	71	14	Mean	15	38	29	4	7	7	0

SJ 54 SW 24 5178 4219 Bubney

Block F

Surface level +88.9 m (+292 ft)
Water struck at +79.9 m
September 1981

Overburden 3.2 m
Mineral 3.6 m
Waste 0.2 m
Mineral 1.3 m
Waste 1.7 m
Mineral 1.0 m
Waste 5.0 m
Mineral 2.0 m
Waste 6.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till (leached and weathered)	'Clayey' pebbly sand (probably very sandy pebbly clay when unweathered), moderate reddish brown to moderate brown, downward increase in clay fines	2.8	3.0
Till	'Clayey' sand with rare pebbles	0.2	3.2
Glacial Sand and Gravel	a Pebbly sand, more sandy 5.0 m to 6.0 m Gravel: fine with coarse, subrounded, Palaeozoic arenites, Permo-Triassic arenites, fine- and coarse-grained igneous rocks and Palaeozoic argillites with flint and quartz Sand: medium with fine, subrounded, quartz	3.6	6.8

Glacial Silt and Clay	Silt with laminae of fine quartz sand, moderate brown	0.2	7.0
Glacial Sand and Gravel	b 'Clayey' sand with rare fine pebbles Sand: medium and fine, subrounded, quartz	1.3	8.3
Glacial Silt and Clay	Silt, sandy, with hint of bands of laminated to massive silt and fine quartz sand, moderate brown and moderate reddish brown	1.7	10.0
Glacial Sand and Gravel	c Sand, fine with medium, subrounded, quartz, with thin bands of laminated silt	1.0	11.0
Glacial Silt and Clay	Silt, sandy, with rare pebbles, laminated, moderate brown and moderate reddish brown	1.1	12.1
	Clay, silty, laminated, moderate brown and greyish olive, rare pebbles below 15.4 m	3.9	16.0
Glacial Sand and Gravel	d 'Very clayey' sand with rare pebbles Sand: fine with medium, subrounded, quartz Fines: silt, moderate brown	2.0	18.0
Till	'Very clayey' pebbly sand (probably sandy pebbly clay in situ), dark reddish brown	4.0	22.0
Till	Clay, sandy with pebbles, moderate reddish brown	1.4	23.4
Till	Clay, sandy and pebbly, considerably harder than that above, moderate brown	1.1+	24.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages								
	Fines	Sand	Gravel										
					Fines			Sand			Gravel		
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm		
				0.2-2.0	14	22	44	7	7	6	0		
				2.0-2.5	15	28	46	4	3	4	0		
				2.5-3.0	26	24	34	3	9	4	0		
a	7	85	8	3.2-4.0	8	17	57	8	7	3	0		
				4.0-5.0	9	36	38	5	3	2	7		
				5.0-6.0	8	39	48	3	2	0	0		
				6.0-6.8	5	27	55	6	5	2	0		
				Mean	7	31	49	5	4	2	2		
b	14	82	4	7.0-8.3	14	37	42	3	4	0	0		
				8.3-9.0	58	41	1	0	0	0	0		
				9.0-10.0	74	25	1	0	0	0	0		
c	5	94	1	10.0-11.0	5	51	43	trace	1	0	0		
				11.0-12.1	44	51	5	11.0-12.1	44	22	28	1	4
d	25	72	3	16.0-18.0	25	49	20	3	2	1	0		
				18.0-20.0	33	36	20	4	3	4	0		
				20.0-22.0	12	26	46	2	5	9	0		
a-d	13	82	5	Mean	13	39	39	4	3	1	1		

Surface level +81.2 m (+266 ft)
 Water struck at +70.7 m
 October 1981

Overburden 0.5 m
 Mineral 13.0 m
 Waste 10.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Glacial Sand and Gravel	a 'Clayey' pebbly sand Gravel: coarse with fine, subrounded, fine-grained igneous rocks, Palaeozoic and Permo-Triassic arenites and argillites Sand: fine and medium, quartz Fines: reddish brown silt	3.5	4.0
	b 'Clayey' sand Sand: fine with medium quartz	6.5	10.5
	c Pebbly sand Gravel: fine, subrounded, Palaeozoic and Permo-Triassic arenites and argillites and fine- and coarse-grained igneous rocks with some quartz Sand: medium, quartz with some lithic grains	3.0	13.5
Glacial Silt and Clay	Silt, sandy, fine quartz with moderate reddish brown silt	4.5	18.0
	Silt, clayey with sporadic pebbles and sandy patches to base, firm, moderate brown	3.7	21.7
	Clay, silty, some sandy partings and rare pebbles, moderate brown, soft	2.4+	24.1

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand		Gravel			
						$-\frac{1}{16}$	$+\frac{1}{16} - \frac{1}{4}$	$+\frac{1}{4} - 1$	$+1 - 4$	$+4 - 16$	$+16 - 64$
a	13	71	16	0.5-2.0	11	23	30	10	8	18	0
				2.0-3.0	17	35	34	5	6	3	0
				3.0-4.0	11	43	36	2	3	5	0
				Mean	13	32	33	6	6	10	0
b	16	84	0	4.0-7.5	17	67	16	0	0	0	0
				7.5-10.5	15	60	25	0	0	0	0
				Mean	16	64	20	trace	trace	0	0
c	5	82	13	10.5-13.5	5	12	56	14	10	3	0
				13.5-18.0	40	60	1	trace	0	0	0
a+b+c	13	80	7	Mean	13	43	32	5	4	3	0

Surface level +78.0 m (+256 ft)
 Water struck at +74.2 m
 September 1981

Overburden 3.8 m
 Mineral 3.2 m
 Waste 17.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.8	0.8
Alluvium	Clay, silty, structureless, greenish grey, soft	1.2	2.0
Glacial Silt and Clay	Clay, sandy, poorly laminated, moderate brown	1.8	3.8
Glacial Sand and Gravel	'Clayey' pebbly sand Gravel: fine to coarse, angular to subrounded, Palaeozoic arenites and argillites and fine- and coarse-grained igneous rocks with quartz and limestone; increasing downwards Sand: fine with medium, subangular to subrounded, quartz Fines: moderate brown	3.2	7.0
Till	Clay, pebbly, moderate brown becoming greyish brown	2.4	9.4
Glacial Silt and Clay	Clay, with silty laminae, locally sheared, moderate brown and yellowish grey, firm. Laminae and pods of fine to coarse sand below 11.0 m	4.6	14.0
Till	Clay, sandy and pebbly, moderate brown, hard	0.3	14.3
Glacial Silt and Clay	Silt, massive, moderate reddish brown with laminae of fine quartz sand and silty clay below 15.0 m	2.2	16.5
Till	Clay, sandy and pebbly, moderate brown, hard	4.9	21.4
Glacial Sand and Gravel	'Very clayey' sand Gravel: fine with coarse, subangular to rounded, Palaeozoic arenites and argillites and fine- and coarse-grained igneous with quartz Sand: medium, subrounded, quartz Fines: clay, moderate brown	0.6	22.0
Till	Clay, sandy and pebbly, moderate reddish brown	2.0+	24.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
12	76	12	3.8-6.3	13	51	31	3	2	0	0
			6.3-6.8	7	28	18	2	5	40	0
			6.8-7.0	3	12	20	5	22	16	22
			Mean	12	44	29	3	4	7	1
34	63	3	21.4-22.0	34	27	32	4	2	1	0

Surface level +93.8 m (+308 ft)
 Water stuck at +83.8 m
 December 1981

Overburden 1.0 m
 Mineral 1.5 m
 Waste 0.5 m
 Mineral 2.0 m
 Waste 1.5 m
 Mineral 17.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
'Head'	Clay, sandy, with rare pebbles, moderate brown	0.7	1.0
Glacial Sand and Gravel	a 'Clayey' sand Sand: medium with fine, subangular to rounded, quartz Fines: moderate brown	1.5	2.5
Glacial Silt and Clay	Silt, massive, with some fine sand, moderate reddish orange	0.5	3.0
Glacial Sand and Gravel	b Gravel Gravel: coarse with fine, angular to rounded, Palaeozoic arenites, Permo-Triassic arenites, Palaeozoic argillites, coarse- and fine-grained igneous rocks with quartz Sand: medium, angular to rounded, quartz	2.0	5.0
Till	Clay, sandy and pebbly, moderate brown, soft	1.5	6.5
Glacial Sand and Gravel	c Pebbly sand, less pebbly in upper part Gravel: coarse and fine, angular to rounded, Palaeozoic arenites and argillites, fine- and coarse-grained igneous rocks with quartz and limestone Sand, medium, subangular to rounded, quartz	4.5	11.0
	d Sand, medium with fine, subangular to rounded, quartz, scattered shell debris	7.0	18.0
	e Pebbly sand Gravel: fine with coarse, angular to rounded, Palaeozoic arenites and argillites, fine- and coarse-grained igneous rocks, quartz and limestone with Permo-Triassic arenites and argillites Sand: medium with fine, subangular to rounded, quartz	5.5+	23.5
Borehole abandoned due to slow progress			

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages							
	Fines	Sand	Gravel		Fines		Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16} - \frac{1}{4}$	$+\frac{1}{4} - 1$	$+1 - 4$	$+4 - 16$	$+16 - 64$	$+64$ mm	
a	15	84	1	1.0-2.5	15	35	46	3	1	0	0	
b	5	23	72	3.0-5.0	5	5	13	5	25	47	0	
c	6	89	5	6.5-8.0	10	35	48	4	1	2	0	
				8.0-9.3	5	18	68	5	4	0	0	
				9.3-9.8	2	6	83	8	1	0	0	
				9.8-11.0	2	13	74	3	1	7	0	
				Mean	6	21	64	4	2	3	0	
d	1	99	0	11.0-14.5	1	15	83	1	0	0	0	
				14.5-18.0	2	25	72	1	0	0	0	
				Mean	1	20	78	1	trace	0	0	
e	4	91	5	18.0-18.5	0	23	58	9	5	5	0	
				18.5-19.0	1	14	55	9	12	9	0	
				19.0-20.0	1	19	70	5	4	1	0	
				20.0-21.5	12	29	57	1	1	0	0	
				21.5-22.5	3	84	5	2	4	2	0	
				22.5-23.5	0	46	53	1	0	0	0	
Mean	4	38	50	3	3	2	0					
a-e	4	86	10	Mean	4	25	58	3	4	6	0	

SJ 54 SW 28 5257 4134 Bridge House

Block D

Surface level +94.5 m (+310 ft)
 Water struck at +77.5 m
 September 1981

Waste 25.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	'Very clayey' pebbly sand (probably sandy pebbly clay in situ), weathered and reworked near surface	16.5	16.8
Glacial Silt and Clay	Clay, silt and sand, interlaminated, firm	0.2	17.0
Glacial Sand and Gravel	Sandy gravel Gravel: fine and coarse, angular to subrounded, Palaeozoic and Permo-Triassic arenites and argillites, fine-grained igneous rocks with quartz Sand: medium, angular to subrounded, quartz	1.5	18.5
Glacial Silt and Clay	Clay, homogeneous, with sporadic pebbles	0.5	19.0
Glacial Sand and Gravel	Sand, medium with fine, subangular to subrounded, quartz	6.0+	25.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
			0.3-1.3	31	31	17	3	8	4	6
			1.3-2.0	27	29	19	3	6	4	12
			2.0-3.0	22	31	19	2	10	16	0
			3.0-3.5	33	33	24	4	4	2	0
			3.5-8.0	35	33	22	3	5	2	0
			8.0-10.0	41	36	17	2	3	1	0
			10.0-12.0	37	29	21	4	3	6	0
			12.0-14.0	35	30	22	4	3	6	0
			14.0-16.8	19	38	28	5	5	5	0
			16.8-17.0	51	26	14	2	4	3	0
			17.0-18.5	3	13	38	10	19	17	0
			19.0-25.0	6	33	60	1	0	0	0

SJ 54 SW 29

5228 4044

Pan Castle

Block D

Surface level +113.5 m (372 ft)
 Water struck at +108.5 m
 September 1981

Waste 21.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Till (leached and weathered)	Sand, fine to medium, subangular to subrounded quartz, with rare pebbles and some clay (probably represents very sandy pebbly clay when unweathered)	0.3	0.8
Till	Clay, sandy and pebbly, moderate reddish brown, crudely laminated below 3.0 m	3.2	4.0
	Clay with minor sand and pebbles, unlaminated, moderate brown, hard	1.1	5.1
	Clay, sandy and pebbly, moderate brown to dark brown, soft	2.4	7.5
	Clay, stoneless, greyish brown, soft. Thin sandy laminae near base	0.2	7.7
	Clay, sandy with pebbles and scattered sand balls, moderate brown, firm. Thin band of medium, subrounded quartz sand at 15.5 m	8.3	16.0
	'Very clayey' pebbly sand (probably represents very sandy pebbly clay in situ)	1.5	17.5
	Clay, sandy and pebbly, moderate reddish brown, firm. Sporadic bands and lenses of medium to coarse quartz sand becoming more common with depth	4.0+	21.5

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
			0.8-3.0	32	34	23	3	3	5	0
			16.0-17.5	34	30	28	3	3	2	0

Surface level +121.3 m (+398 ft)
 Water struck at +112.6 m
 October 1981

Overburden 0.4 m
 Mineral 2.0 m
 Waste 6.3 m
 Mineral 3.7 m
 Waste 5.1 m
 Mineral 8.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
? 'Head'/Glacial Sand and Gravel	a 'Clayey' sand with sporadic pebbles Sand: medium with fine quartz	2.0	2.4
	Clay, sandy and pebbly, dark reddish brown, firm	1.1	3.5
	'Very clayey' sand with sporadic pebbles Sand: medium subrounded quartz Fines: dark reddish brown	0.6	4.1
? Alluvium	Clay, silty, virtually stoneless, moderate brown with contorted laminations and organic debris in parts, firm to hard	4.6	8.7
Glacial Sand and Gravel	b Sandy gravel, 'clayey' to 10.0 m Gravel: fine with coarse, subrounded, fine-grained igneous rocks and Palaeozoic and Permo-Triassic arenites and argillites Sand: medium, subrounded quartz with some lithic grains	3.7	12.4
Till	Clay, silty, slightly sandy and pebbly, moderate brown, hard	0.5	12.9
Glacial Sand and Gravel	Sand, medium, subrounded quartz	0.5	13.4
Glacial Silt and Clay	Clay, silty, rare pebbles, moderate brown, laminated in parts and sheared, firm	4.0	17.4
Till	Clay, silty, slightly sandy, pebbly, moderate brown, firm	0.1	17.5
Glacial Sand and Gravel	c Sand, 'clayey' to 20.0 m, medium with fine, subrounded quartz with some lithic grains and sporadic pebbles	8.0+	25.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages								
	Fines	Sand	Gravel										
					Fines			Sand			Gravel		
					- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{4}$	$+\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm		
a	17	81	2	0.4-2.4	17	32	47	2	1	1	0		
b	5	64	31	8.7-10.0	No grading data available								
				10.0-11.0	6	16	42	9	13	7	7		
				11.0-12.4	4	17	40	7	19	13	0		
				Mean	5	16	40	8	17	11	3		
c	8	91	1	17.5-19.0	19	36	37	4	4	0	0		
				19.0-20.0	10	42	43	4	1	0	0		
				20.0-21.0	2	41	53	2	1	1	0		
				21.0-25.5	5	42	52	1	0	0	0		
Mean	8	41	48	2	1	trace	0						
a+b+c	8	83	9	Mean	8	33	46	4	5	3	1		

Surface level +106.7 m (+350 ft)
 Water struck at +100.7 m
 October 1981

Waste 23.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
'Head'	'Clayey' sand with pebbles (probably represents sandy pebbly clay when unweathered)	1.3	1.5
Till	Clay, sandy and pebbly, moderate reddish brown and dark reddish brown, soft. Band of 'clayey' pebbly sand 2.5 m to 2.7 m	6.0	7.5
Glacial Sand and Gravel	Sandy gravel Gravel: coarse and fine, angular to rounded, Palaeozoic and Permo-Triassic arenites and argillites, fine- and coarse-grained igneous rocks, with quartz Sand: medium with fine, subangular to subrounded, quartz	1.5	9.0
	'Very clayey' pebbly sand, laminated and graded, fine to coarse, subangular, quartz	0.2	9.2
Till	Clay, sandy and pebbly, moderate brown, firm	4.3	13.5
	Clay, pebbly, with some sand, dark reddish brown, firm	1.4	14.9
Glacial Silt and Clay	Clay, originally laminated but intensely deformed, moderate brown, very hard	0.1	15.0
Till	Clay, sandy and pebbly, moderate reddish brown, hard becoming very hard below 17.5 m	3.0	18.0
Glacial Sand and Gravel	Pebbly sand Gravel: fine with coarse, angular to rounded, Palaeozoic and Permo-Triassic arenites and argillites, fine- and coarse-grained igneous rocks with quartz Sand: medium with fine, subrounded, quartz	2.0	20.0
Till	Clay, sandy and pebbly, moderate brown, hard	1.4	21.4
	Clay, pebbly, with minor sand, greyish brown, very hard	0.6	22.0
Glacial Sand and Gravel	Pebbly sand, 'clayey' at top Gravel: fine and coarse, angular to rounded, Palaeozoic and Permo-Triassic arenites and argillites, fine- and coarse-grained igneous rocks and quartz Sand: medium with fine, subangular to rounded, quartz	1.5+	23.5

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand		Gravel			
				- $\frac{1}{8}$	$+\frac{1}{8}$ - $\frac{1}{4}$	$+\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
			7.5-9.0	7	22	41	6	11	13	0
			18.0-19.0	5	23	37	10	13	8	4
			19.0-20.0	5	31	51	7	5	1	0
			20.0-22.5	15	26	34	6	13	6	0
			22.5-23.5	9	19	34	22	14	2	0

Surface level +99.2 m (+325 ft)
 Water struck at +97.2 m
 October 1981

Overburden 0.9 m
 Mineral 4.1 m
 Waste 17.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
'Head'	Clay, sandy, laminated, moderate brown	0.4	0.9
Glacial Sand and Gravel	Sand, medium with fine, subrounded, quartz. Sporadic pebbles, more common below 4.5 m	4.1	5.0
Till	Clay, sandy and pebbly, moderate brown, soft	2.0	7.0
Glacial Silt and Clay	Clay, very sandy, moderate brown	0.2	7.2
Till	Clay, very sandy and pebbly, moderate brown	4.3	11.5
Glacial Silt and Clay	Clay, silty, moderate brown	0.5	12.0
Till	Clay, sandy and pebbly, greyish brown, soft	2.5	14.5
Glacial Silt and Clay	Silt, vaguely laminated, moderate brown	0.5	15.0
Glacial Sand and Gravel	'Clayey' sand, fine, quartz	3.0	18.0
Glacial Silt and Clay	Clay, laminated, greyish brown and moderate brown, thin sandy partings, soft	1.0	19.0
	Clay and sand, interlaminated, with rare pebbles	2.0	21.0
	Silt, sandy, moderate reddish brown	0.3	21.3
Till	Clay, sandy and pebbly, abundant shear surfaces, moderate brown, firm	0.7+	22.0

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16} - \frac{1}{4}$	$+\frac{1}{4} - 1$	$+1 - 4$	$+4 - 16$	$+16 - 64$	$+64$ mm
9	87	4	0.9-2.0	18	26	50	2	3	1	0
			2.0-3.0	3	17	71	4	4	1	0
			3.0-4.5	6	23	66	4	1	0	0
			4.5-5.0	15	12	55	8	7	3	0
			Mean	9	21	62	4	3	1	0
			15.0-17.0	16	75	9	0	0	0	0
			17.0-18.0	20	72	8	0	0	0	0
			21.0-21.3	41	52	3	0	0	4	0

SJ 54 SE 43 5594 4471 Fox Hall

Block F

Surface level +112.5 m (+369 ft)
 Water struck at +91.5 m
 October 1981

Overburden 13.2
 Mineral 8.6 m
 Waste 1.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, silty, sandy and pebbly, dark reddish to moderate reddish brown, firm	7.8	8.0
	Clay, silty and pebbly, moderate to greyish brown; some fine sand partings below 12.1 m, firm to hard	5.2	13.2
Glacial Sand and Gravel	'Clayey' sand Sand: fine to medium quartz Fines: thin, moderate brown, pebbly clay and silt bands	8.6	21.8
Till	Silt, clayey, pebbly and sandy, moderate brown to moderate reddish brown; some pockets of sand and gravel, cobble of granite at 23.3 m	1.9+	23.7

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
14	86	0	13.2-17.3	19	60	20	1	0	0	0
			17.3-21.8	10	19	71	0	0	0	0
			Mean	14	38	48	trace	trace	0	0

SJ 54 SE 44 5534 4130 Oaklands

Block D

Surface level +101.8 m (+334 ft)
 Water struck at +92.8 m
 October 1981

Overburden 1.0 m
 Mineral 1.5 m
 Waste 8.0 m
 Mineral 8.5 m
 Waste 4.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Till(weathered)	Pebbly sand with clay(probably represents sandy pebbly clay when unweathered)	0.5	1.0
Glacial Sand and Gravel	a 'Clayey' sand, medium, subrounded, quartz	1.5	2.5
Till	'Very clayey' pebbly sand Gravel: fine, subangular to rounded Sand: fine and medium, subrounded, quartz Fines: moderate reddish brown	0.2	2.7

	'Clayey' pebbly sand passing down to sandy pebbly clay	1.1	3.8
	Clay, sandy and pebbly, moderate reddish brown, soft	4.7	8.5
	'Very clayey' sand	0.8	9.3
	Clay, sandy and pebbly, moderate reddish brown (reduced to slurry in lower 1.0 m by drilling)	1.2	10.5
Glacial Sand and Gravel	b Pebbly sand Gravel: fine and coarse, angular to rounded, Palaeozoic argillites and arenites, fine- grained igneous rocks, Permo-Triassic arenites with coarse-grained igneous rocks, limestone and quartz Sand: medium with fine, angular to rounded, quartz with lithic grains	8.5	19.0
Till	Clay, sandy and pebbly, moderate brown, hard to very hard	4.5+	23.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines			Gravel			
					- $\frac{1}{8}$	+ $\frac{1}{8}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
a	17	81	2	1.0-2.5	17	29	50	2	2	0	0
				2.7-3.0	17	34	41	3	3	2	0
				3.0-3.8	16	34	37	5	5	3	0
				8.5-9.3	18	52	28	1	1	0	0
b	4	79	17	10.5-12.0	6	7	24	17	22	24	0
				12.0-13.0	4	24	60	10	2	0	0
				13.0-14.0	4	19	55	9	8	5	0
				14.0-15.0	3	20	58	7	5	7	0
				15.0-16.0	3	36	47	7	4	3	0
				16.0-17.0	4	30	47	7	11	1	0
				17.0-18.0	7	20	52	2	7	12	0
				18.0-19.0	3	24	57	2	1	13	0
				Mean	4	21	50	8	8	9	0
a+b	6	79	15	Mean	6	23	49	7	7	8	0

SJ 54 SE 45 5592 4092 Broughall House

Block D

Surface level +107.8 m (+354 ft)
Water struck at +105.8 m
October 1981

Overburden 0.6 m
Mineral 4.1 m
Waste 9.6 m
Mineral 9.0 m
Waste 1.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Glacial Sand and Gravel (?with Hill Wash at top	a 'Very clayey' pebbly sand Gravel: coarse with fine, subrounded to rounded quartz and fine-grained igneous rocks Sand: medium and fine, subrounded, quartz Fines: yellowish brown to brown	4.1	4.7
Till	Clay, sandy and pebbly, moderate brown, firm	9.6	14.3

Glacial Sand and Gravel	b Sandy gravel Gravel: fine and coarse, subangular to subrounded, fine-grained igneous rocks, with Palaeozoic arenites, coarse-grained igneous rocks, Permo- Triassic argillites, quartz, limestone, flint and some coal Sand: medium subrounded quartz with subangular coarse lithic grains	6.7	21.0
	c Sand, pebbly in first metre; medium subrounded quartz	2.3	23.3
Till	Clay, silty, with sporadic pebbles and granules, moderate brown, ?foliated texture	1.0	24.3
	Clay, silty, sandy and pebbly, moderate brown	0.2+	24.5

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines		Sand		Gravel		
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
a	21	70	9	0.6-1.6	26	24	31	4	3	12	0
				1.6-3.0	20	31	36	2	3	8	0
				3.0-4.7	19	41	33	2	1	4	0
				Mean	21	34	34	2	2	7	0
b	3	55	42	14.3-15.6	3	6	26	13	24	28	0
				15.6-16.6	3	9	47	14	19	8	0
				16.6-17.8	2	7	40	10	17	23	1
				17.8-18.8	4	8	41	7	17	23	0
				18.8-20.0	3	7	31	15	27	17	0
				20.0-21.0	4	7	32	15	27	15	0
				Mean	3	7	36	12	22	20	tr
c	4	93	3	21.0-22.0	2	23	66	3	3	3	0
				22.0-23.3	6	30	59	3	2	0	0
				Mean	4	27	63	3	2	1	0
a+b+c	9	67	24	Mean	9	19	40	8	12	12	tr

SJ 54 SE 46 5623 4251 Blake Mere

Block D

Surface level +102.0 m (+335 ft)
 Water struck at +100.5 m
 October 1981

Overburden 0.5 m
 Mineral 2.5 m
 Waste 17.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Glacial Sand and Gravel	Sand, medium with fine, subrounded, quartz; peaty at top with silty bands at base	2.5	3.0
Till	'Clayey' sandy gravel (?very sandy pebbly clay in situ) Gravel: fine and coarse, angular to rounded, Palaeozoic and Permo-Triassic argillites and arenites, fine- and coarse-grained igneous rocks and quartz Sand: medium with fine quartz and coarse lithic grains Fines: dark yellowish brown becoming moderate brown	3.5	6.5
	Clay, very sandy, pebbly and silty, moderate brown, firm to hard	14.1+	20.6

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
9	91	0	0.5-3.0	9	38	53	trace	trace	0	0
			3.0-4.6	12	22	30	7	14	15	0
			4.6-5.6	8	17	25	9	20	18	3
			5.6-6.5	11	14	30	18	14	13	0

SJ 54 SE 47 5716 4472 Hollyhurst

Block F

Surface level +109.0 m (+358 ft)
 Water struck at +90.5 m
 October 1981

Overburden 5.8 m
 Mineral 6.2 m
 Waste 8.0 m
 Mineral 5.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till (weathered)	Clay, sandy and pebbly, variegated moderate brown and moderate reddish brown, soft	1.2	1.5
Till	Clay, sandy and pebbly, moderate reddish brown, firm	1.0	2.5
	Clay, sandy and pebbly, moderate reddish orange, firm becoming very hard near base	2.5	5.0
	'Clayey' pebbly sand	0.3	5.3
	Clay, pebbly and sandy, moderate reddish orange, hard	0.5	5.8
Glacial Sand and Gravel	a Sand, fine with medium, subangular to rounded, quartz	6.2	12.0
Glacial Silt and Clay	Silt, laminated, moderate reddish orange	3.0	15.0
	Clay, laminated, moderate brown	3.5	18.5
	Silt, massive and laminated, moderate brown, becoming more sandy to transitional base	1.5	20.0
Glacial Sand and Gravel	b Sand, fine with medium becoming coarser downwards, subrounded, quartz	5.0+	25.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages							
	Fines	Sand	Gravel		Fines			Sand				
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$		+ $\frac{1}{4}$ -1	+1 -4	Gravel		
						+4 -16	+16 -64			+64 mm		
a	7	93	0	5.8-6.5	11	66	23	0	0	0	0	
				6.5-7.0	4	54	39	1	1	1	0	
				7.0-8.0	7	51	41	1	0	0	0	
				8.0-9.0	5	59	35	1	0	0	0	
				9.0-10.0	16	39	45	0	0	0	0	
				10.0-11.0	3	57	39	1	0	0	0	
				11.0-12.0	4	57	39	0	0	0	0	
Mean	7	54	38	1	trace	trace	0					
b	8	92	0	20.0-22.0	11	72	17	0	0	0	0	
				22.0-25.0	6	46	46	2	0	0	0	
				Mean	8	57	34	1	trace	0	0	
a+b	8	92	0	Mean	8	55	36	1	trace	trace	0	

SJ 54 SE 48

5730 4318

Blackpark Farm

Block F

Surface level +99.3 m (+326 ft)

Water struck at +83.3 m

October 1981

Overburden 3.5 m

Mineral 3.5 m

Waste 9.0 m

Mineral 3.5 m

Waste 4.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till (weathered)	Clay, sandy, moderate brown, locally leached to greyish orange	0.3	0.5
Till	'Very clayey' sand	1.0	1.5
	Clay, sandy and very pebbly, moderate reddish brown, soft	1.3	2.8
	Clay, sandy and pebbly, moderate reddish brown, soft to firm	0.2	3.0
Glacial Silt and Clay	Clay, silty, locally showing contorted lamination, moderate reddish brown, hard	0.5	3.5
Glacial Sand and Gravel	a Sandy gravel Gravel: fine and coarse, angular to rounded, Palaeozoic arenites, coarse- and fine-grained igneous rocks, Palaeozoic argillites and quartz with Permo-Triassic arenites and limestone Sand: medium, subangular to rounded, quartz	3.5	7.0
Till	Clay, pebbly, with minor sand, moderate brown, firm	3.5	10.5
Glacial Silt and Clay	Clay, silty, moderate brown, interbanded with fine quartz sand	0.1	10.6
Till	Clay with sand and pebbles, moderate brown, soft at top, becoming hard	5.4	16.0
Glacial Sand and Gravel	b 'Clayey' sand, fine, quartz, locally laminated	3.5	19.5
Glacial Silt and Clay	Clay, silty and sandy, poorly laminated, locally silt, graded in part, moderate brown, firm	4.5+	24.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
a	3	64	33	3.5-5.5	3	15	30	13	21	16	2
				5.5-7.0	2	10	52	11	9	16	0
				Mean	3	12	40	12	16	16	1
b	14	86	0	16.0-19.5	14	62	23	1	trace	0	0
a+b	9	74	17	Mean	9	36	31	7	8	8	1

SJ 54 SE 49 5789 4263 Martin's Ash

Surface level +91.8 m (+301 ft)
 Water not struck
 October 1981

Waste 19.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till(weathered)	Clay, sandy, moderate reddish brown, locally gleyed	1.9	2.3
Till	Clay, very sandy and pebbly, reddish brown, very hard	7.6	9.9
	Clay, very sandy and pebbly, moderate brown, firm	8.1	18.0
	Clay, with rare pebbles and sand grains, moderate brown, very hard	1.0+	19.0

SJ 54 SE 50 5844 4176 Ivy Farm

Surface level +97.4 m (+320 ft)
 Water struck at +80.4 m
 October 1981

Waste 18.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, sandy and pebbly, dark reddish brown to moderate brown, soft to very hard	16.7	17.0
	'Very clayey' sandy gravel Gravel: fine, subrounded, Palaeozoic arenites, fine-grained igneous rocks, Permo-Triassic argillites and limestone Sand: mainly medium subrounded quartz	1.2	18.2
	Clay, very sandy, pebbly, dark reddish brown	0.5+	18.7

Surface level +113.2 (+371 ft)
 Water struck at +112.6 m
 October 1981

Waste 18.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and fill	1.6	1.6
Till	Clay, sandy and pebbly, moderate brown, hard	1.0	2.6
Glacial Silt and Clay	Clay, with only rare pebbles, brown with veins and patches of grey and bluish grey, laminated but with some sheared surfaces, firm	3.1	5.7
Till	Clay, sandy and pebbly, moderate brown, hard	1.3	7.0
Glacial Sand and Gravel	Gravel Gravel: fine with coarse and some cobbles, subangular to rounded, fine-grained igneous rocks, Palaeozoic and Permo-Triassic arenites, quartz, chert and limestone Sand: medium quartz and coarse lithic grains	1.4	8.4
Till	Clay, silty, slightly sandy and pebbly becoming increasingly sandy and pebbly below 10.0 m, brown, firm to hard	3.4	11.8
Glacial Sand and Gravel	Sand, fine with medium, subrounded quartz	2.2	14.0
Till	Clay, sandy and pebbly, with sand bands?, moderate brown, soft	3.0	17.0
Glacial Sand and Gravel	Pebbly sand, with sandy pebbly clay band between 17.4 m and 17.5 m Gravel: fine, subrounded, fine-grained igneous rocks, Palaeozoic and Permo-Triassic arenites and argillites and quartz Sand: fine and medium, quartz	1.5+	18.5

Borehole abandoned due to slow progress

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
			7.0-8.4	1	5	16	15	36	27	0
			11.8-14.0	4	65	31	0	0	0	0
			17.0-18.5	4	36	35	12	11	2	0

SJ 54 SE 52 5991 4407 Cocked Hat Block G
 Surface level +78.4 (+257 ft) Waste 21.5 m+
 Water struck at +71.9 m
 October 1981

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial Sand and Gravel	'Clayey' sand, fine to medium, subangular to subrounded, quartz	0.1	0.5
Glacial Silt and Clay	Clay, sandy, poorly laminated, moderate reddish brown	1.0	1.5
	Clay, silty, laminated, moderate reddish brown, more sandy near base	1.2	2.7
Till	Clay, sandy and pebbly, moderate brown, firm	3.8	6.5
Glacial Sand and Gravel	Pebbly sand Gravel: fine with coarse, angular to rounded, fine- and coarse-grained igneous rocks, Palaeozoic arenites and argillites, quartz Sand: medium, subangular to subrounded, quartz	1.5	8.0
Till	Clay, sandy and pebbly, dark reddish brown, firm at top becoming very hard at base	4.3	12.3
Glacial Silt and Clay	Clay, laminated and sheared, moderate brown, very hard	1.4	13.7
	Clay, moderate brown, with laminae of fine quartz sand	0.1	13.8
	Clay, silty, laminated and sheared, moderate brown, very hard	6.1	19.9
Till	Clay, sandy and pebbly, moderate brown, very hard	1.6+	21.5

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand		Gravel			
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
			6.5-7.5	6	25	49	8	9	3	0
			7.5-8.0	4	17	45	13	13	8	0

SJ 54 SE 53 5977 4284 Shropshire Lane Farm Block G
 Surface level +91.7 m (+301 ft) Overburden 4.3 m
 Water struck at 75.5 m Mineral 2.2 m
 September 1981 Waste 1.8 m
 Mineral 2.6 m
 Waste 1.1 m
 Mineral 13.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial Silt and Clay	Silt, sandy and clayey with sporadic pebbles, dark reddish brown, micaceous	4.0	4.3

Glacial Sand and Gravel	a 'Very clayey' sand Sand: fine, quartz Fines: moderate reddish brown silt	2.2	6.5
Glacial Silt and Clay	Silt, very sandy, with clayey bands, moderate brown to moderate reddish brown, laminated in part	1.8	8.3
Glacial Sand and Gravel	b 'Clayey' sand Sand: fine with medium, quartz Fines: silt and clay bands	2.6	10.9
Glacial Silt and Clay	Silt, sandy, moderate brown to moderate reddish brown	1.1	12.0
Glacial Sand and Gravel	c 'Clayey' sand, pebbly to base Gravel: fine, subangular to subrounded, Palaeozoic arenites with coarse- and fine-grained igneous rocks, Palaeozoic argillites, Permo-Triassic arenites and argillites and some quartz and limestone Sand: medium with fine, quartz	9.7	21.7
	d 'Sandy' gravel Gravel: fine with coarse, subangular to subrounded, constituents as above Sand: medium, quartz	3.3+	25.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	Percentages							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
						- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
a	28	72	0	4.3-5.3	21	75	4	0	0	0	0	
				5.3-6.5	34	65	1	0	0	0	0	
				Mean	28	70	2	0	0	0	0	
b	12	88	0	8.3-10.9	12	49	39	trace	trace	0	0	
				10.9-12.0	56	42	2	trace	0	0	0	
c	10	87	3	12.0-15.0	11	43	45	1	0	0	0	
				15.0-16.2	12	38	48	1	0	1	0	
				16.2-17.7	7	25	59	8	1	0	0	
				17.7-19.7	16	32	42	3	4	3	0	
				19.7-20.7	5	31	58	5	1	0	0	
				20.7-21.7	6	23	60	6	5	0	0	
			Mean	10	34	50	3	2	1	0		
d	2	64	34	21.7-23.0	2	12	46	16	18	6	0	
				24.0-25.0	1	5	36	17	22	14	5	
				Mean	2	9	39	16	21	11	2	
a-d	11	82	7	Mean	11	36	41	5	5	2	trace	

Surface level +108.6 m (+356 ft)
 Water struck at +100.1 m
 October 1981

Waste 20.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, silty, with some pebbles, mottled moderate brown and reddish brown with light olive grey seams becoming uniform moderate reddish brown, soft to firm	1.6	1.9
	Silt, very sandy, moderate brown	1.3	3.2
	Silt, clayey, pebbly, moderate brown mottled with moderate reddish brown and streaked with medium bluish grey, hard	1.3	4.5
	Silt, clayey, with only sporadic pebbles and sand pockets, soft	0.7	5.2
	Clay, silty, pebbly, moderate brown, very hard becoming firm with depth	3.3	8.5
	'Very clayey' pebbly sand Gravel: coarse and fine, subangular to subrounded, fine-grained igneous rocks, Palaeozoic and Permo-Triassic arenites and argillites, limestone and quartz Sand: medium and fine, quartz	2.5	11.0
Glacial Sand and Gravel	Sandy gravel Gravel: fine and coarse, subangular to subrounded, constituents as above Sand: medium, quartz	1.3	12.3
Till	Clay, silty, sandy and pebbly, dark reddish brown to 13.3 m moderate brown below, firm to hard; sandy silt band at 13.3 m	5.4	17.7
Glacial Silt and Clay	Silt, very sandy, clayey with sporadic pebbles, moderate brown	0.8	18.5
Till	Clay, very sandy, silty and pebbly, moderate brown to reddish brown, hard	1.7+	20.2

GRADING

Mean for deposit percentages			Depth below surface (m)	Percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1 -4	+4 -16	+16 -64	+64 mm
			8.5-11.0	23	34	28	2	6	7	0
			11.0-12.3	2	18	48	6	13	13	0

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Printed in England for Her Majesty's Stationery Office by
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THE SAND AND GRAVEL RESOURCES OF THE COUNTRY AROUND WHITCHURCH AND MALPAS (CLWYD, CHESHIRE AND SHROPSHIRE)

Scale 1:25 000 or about 2 1/2 Inches to 1 Mile

ORDNANCE SURVEY
SHEETS SJ44 & SJ 54
PROVISIONAL EDITION

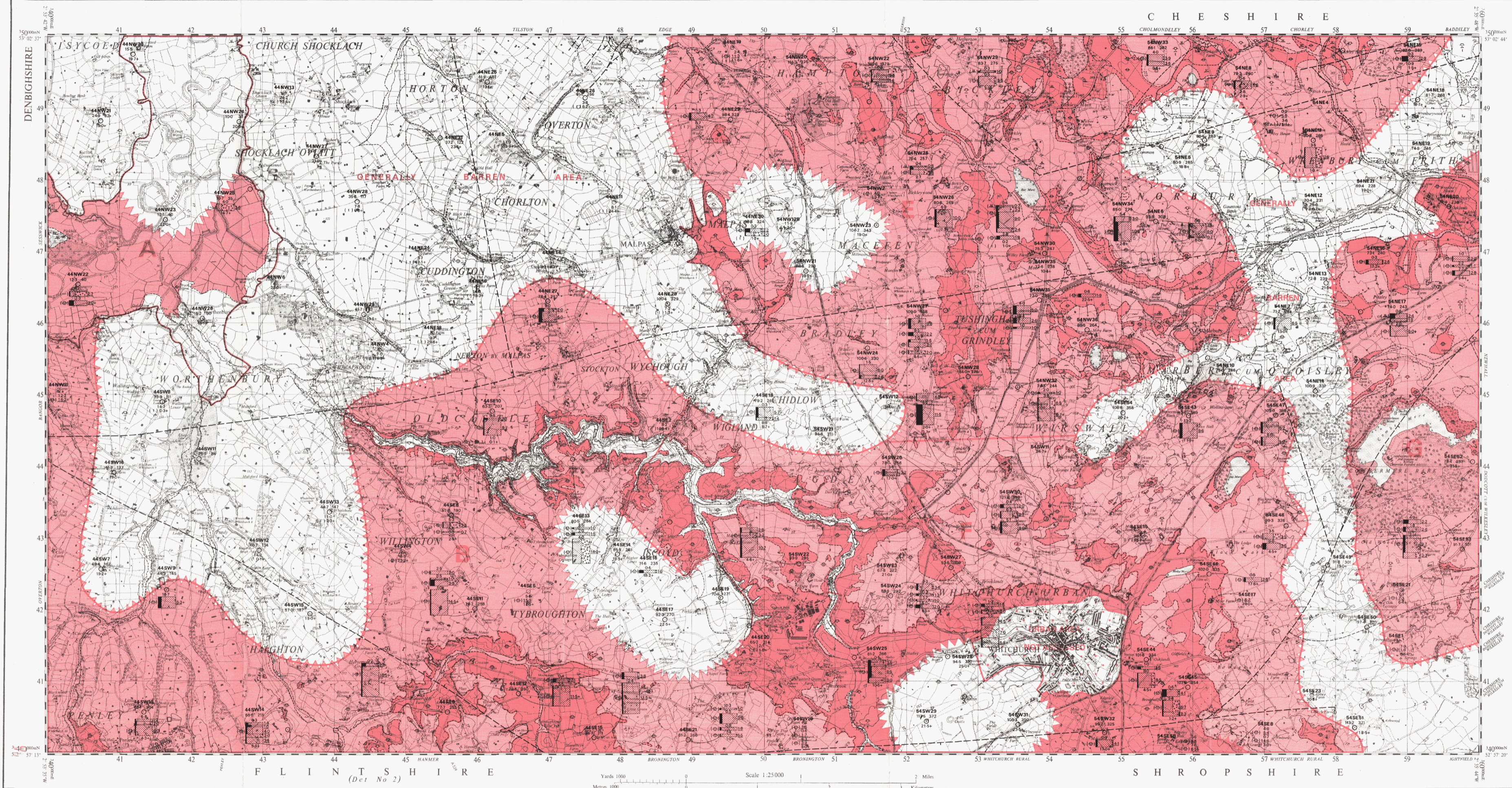
THE SAND AND GRAVEL RESOURCES OF THE COUNTRY AROUND WHITCHURCH AND MALPAS, (CLWYD, CHESHIRE AND SHROPSHIRE)

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

EXPLANATION OF SYMBOLS AND ABBREVIATIONS

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- DRIFT**
- Peat P-1
 - Alluvium - silt and clay with gravel and sand A-79
 - ▲ Alluvial Fan - variable deposits of sand with clay and gravel AF-8
 - ▲ River Terrace Deposits, undifferentiated - sand and clay with gravel
 - ◆ Fluvio-glacial Gravel - sand with clay and gravel FL-31
 - ◆ Glacial Sand and Gravel - sand with clay and gravel GS-88
 - Glacial Drift, undifferentiated - ill. glacial silt and clay and scattered small sand and gravel bodies GD-3
- SOLID**
- Jurassic, undivided
 - Triassic, undivided
- BOUNDARY LINES**
- Geological boundary, Drift
 - Geological boundary, Solid
 - - - Fault; crossmark indicates downthrow side
 - ~ ~ ~ Inferred boundary between recognised categories of deposits
 - Resource Block boundary
- Broken lines denote uncertainty
- BOREHOLE DATA**
- SITE LOCATIONS**
- Industrial Minerals Assessment Unit (I.M.A.U.) boreholes
 - Other boreholes
- I.M.A.U. BOREHOLES**
- Borehole Registration Number 44 SE 8
 - Borehole site 57.8
 - Geological Classification 23.3
 - Waste 2.2
 - Grading Diagram 2.9
- Note:
- Figures underlined denote thicknesses used in the assessment of resources.
 - The + sign indicates that the base of the deposit was not reached.
 - The Geological Classification is given for mineral and bedrock only.
- Borehole Registration Number**
- Each I.M.A.U. borehole is identified by a registration number, eg 44 SE 8. The first number and letters refer to the cover sheet and the last number to the I.M.A.U. borehole number in the cover sheet. The unique designation for borehole 44 SE 8 is SJ44 SE 8.
- Grading Diagrams**
- Each grading diagram shows the mean particle-size distribution in a distinct deposit of mineral.
- OTHER BOREHOLES**
- The layout of information is the same as for I.M.A.U. boreholes although data available may not be as comprehensive. They are registered in the same series.
- 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



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 published on OS Six-Inch Maps in 1885 and 1887. Reprinted on a scale by E. G. Poole, A. J. Whitman and D. Magraw and published on the one-inch scale in 1937 as New Series Sheet 122 (Whitchurch, E. & S. and V. Stephens, District Geologist). Solid lines revised by A. C. Wilson, 1982; P. Stevenson, District Geologist. Sand and gravel survey by J. Jackson, S. J. Matthews, D. J. Lowe and A. N. Morgan, 1981. R. G. Thorne, Head of Industrial Minerals Assessment Unit. 1:25,000 Sand and Gravel Resource Sheet published 1983. G. M. Brown, D.Sc. FRS, Director, Institute of Geological Sciences.

The GRID lines on this sheet are at 1 Kilometre intervals. Heights are in feet above Mean Sea Level at Swanage. Contours shown are in feet. 1 metre each on this map represents 0.984 metres on the ground.

Compiled from 6" sheets last fully revised 1920-24. Other systematic surveys 1949 have been incorporated. Some major roads revised 1961.

Made and printed by the Ordnance Survey, Southampton.

Data quoted for an individual borehole refer strictly to that site. No inductive conclusions should 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 that material are given in each Resource Block as given in the Report.

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SJ38	SJ45	SJ55	SJ65
SJ34	SJ44	SJ54	SJ64
SJ33	SJ43	SJ53	SJ63
SJ37			

Diagram showing the relationship of the National Grid 1:25,000 sheets to the Geological Sheets 106, 109, 110, 121, 122, 123, 127, 128, 129.

