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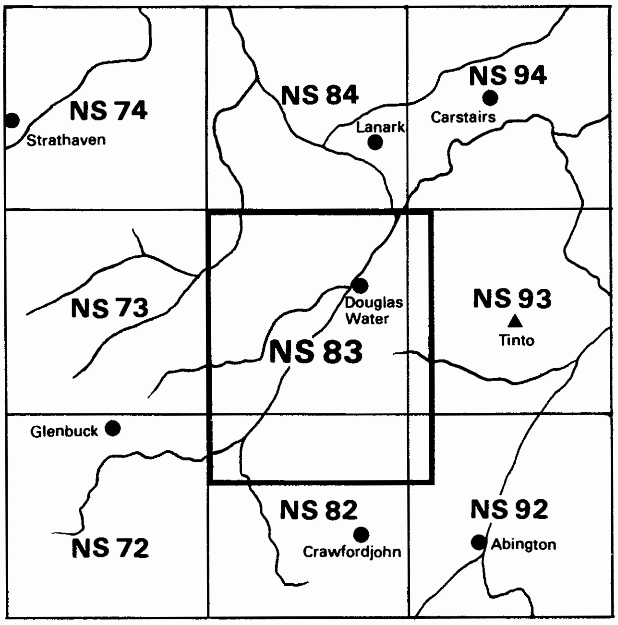

The sand and gravel resources of the valley of the Douglas Water, Strathclyde

Description of 1:25 000 resource sheet NS 83 and parts of NS 82, 92 and 93

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

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The asterisk on the cover indicates that parts of sheets adjacent to the one cited are described in this report.

PREFACE

National resources of many industrial minerals may seem so large that stock-taking 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 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. In 1968, following a short feasibility study initiated in 1966 by the Ministry of Land and National Resources the Industrial Minerals Assessment Unit (formerly the Mineral Assessment Unit) began systematic surveys which have been extended progressively through central and northern England. Work in Scotland, which began in 1975 in the Darvel area of Strathclyde Region, is being financed by the Department of the Environment, acting through the Scottish Development Department 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 143 km^2 of country in and around the valley of the Douglas Water, Strathclyde Region, shown on the accompanying resource map. The survey, conducted by A. J. Shaw, assisted in the drilling and sampling programme by M. D. Issaias, was controlled from the sub-unit in Edinburgh and supervised by E. F. P. Nickless (Officer-in-Charge). The work is based on the one-inch geological surveys of Sheets 15 and 23, published respectively in 1870 and 1872 and the revision surveys published in 1937 and 1927 respectively. The geological lines, now presented at the 1:25 000 scale, include a re-appraisal of the drift geology by I. B. Cameron based on field surveys during 1976.

The section of the report on the geology of the area was prepared by I. B. Cameron. J. D. Burnell, ISO, FRICS, (Land Agent) has been responsible for negotiating access to land for drilling. The ready co-operation of land owners and tenants and the assistance of officials of Lanark District is gratefully acknowledged.

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CONTENTS

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A. J. SHAW AND E. F. P. NICKLESS

SUMMARY

The geological maps of the Institute of Geological Sciences, pre-existing borehole information, thirty-five boreholes and thirty shallow pits sunk for the Industrial Minerals Assessment Unit, together with data from eight sections, form the basis of the assessment of sand and gravel resources in and around the valley of the Douglas Water, Strathclyde Region.

All deposits in the area which might be potentially workable for sand and gravel have been investigated and a simple statistical method 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 two resource blocks both of which are assessed statistically and contain 5.1 and 9.8 km² of potentially workable sand and gravel. The geology of the deposits is described and the mineral-bearing area, the mean thickness of overburden and mineral, and the mean grading of the various types of deposit are stated. Detailed borehole, pit and section data are given. The geology and the outlines of the resource blocks, the position of boreholes and sections considered in the assessment are shown on the accompanying 1:25000 scale resource map.

Notes

National grid references are given in square brackets. In this publication all lie within the 100 km square NS.

Only the sites of IMAU boreholes, sections and pits are shown on the resource sheet. The grid reference and abbreviated log of other boreholes used in the assessment are given at the end of Appendix E.

Bibliographical reference

SHAW, A. J. and NICKLESS, E. F. P. 1981. The sand and gravel resources of the valley of the Douglas Water, Strathclyde Region: description of 1:25 000 sheet NS 83 and parts of NS 82, 92 and 93. *Miner. Assess. Rep. Inst. Geol. Sci.,* No. 63.

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

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

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

The following arbitrary physical criteria have been adopted:

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

A deposit of sand and gravel which broadly meets these criteria is regarded as 'potentially workable' and is described and assessed as 'mineral' in this report. As the assessment is at the indicated level, parts of such a deposit may not satisfy all the criteria.

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

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

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

DESCRIPTION OF THE RESOURCE SHEET

GENERAL

The area assessed (Figure 1) covers 143 km² (about 89 miles²) of country around Douglas, Strathclyde Region, of which 14.9 km² or about 10 per cent is mineral-bearing. The area is situated in the central part of the former county of Lanark and includes the villages of Douglas [835 306], Douglas Water [874 365], Glespin [808 283], Rigside [873 348], Coalburn [812 345] and Lesmahagow [814 398]. By road, Douglas village lies about 14 km south-south-west of Lanark, 48 km south-east of Glasgow and 65 km south-west of Edinburgh. The land is mainly given over to agriculture which with forestry and some light industry provide employment. The Douglas coalfield formerly supported a group of mines in the valley of the Douglas Water, between Glespin and Rigside, and also around Coalburn. All the mines are now closed, but the possibility of further exploitation of coal, either by deep mining or open-cast working remains.

The sand and gravel deposits of the area have been briefly described in IGS reports by Goodlet (1970) and Cameron and others (1977). An assessment of the sand and gravel resources of the country around Lanark is given by Laxton and Nickless (1980).

To date, sand and gravel extraction in the area of this report has been very limited. In 1962 a 25-m-high kame-like spread of sand and gravel, still shown on Ordnance Survey maps at Boncastle Hill [857 328] was completely removed for use in the construction of adjacent sections of the A 74 dual carriageway. A small pit at Sandilands [8881 3824] is occasionally worked for local requirements.

TOPOGRAPHY

The broad deep valley of the Douglas Water constitutes the major physiographic depression of the area, which otherwise varies from rounded moorland hills 350 to 400 m (1150 to 1300 ft) above Ordnance Datum in the southern part of the resource sheet to more open, undulating countryside in the north where heights range from 200 to about 250 m (650 to 825 ft). The Douglas Water and the Poniel Water flow north-eastwards to meet the River Clyde west of Crookboat [8976 3943]. Extensive peat occupies a depression between Lesmahagow and Coalburn.

The distinctive topography reflects the varying degrees of resistance to erosion of the underlying rock types. Coal-bearing rocks of Carboniferous age form most of the low ground, and the Passage Group where not covered by drift gives rise to bleak moorlands as at Broken Cross Muir [843 371] and the Poniel Hills [836 332] (Geikie and others, 1873). Rocks of Silurian and Devonian age, particularly those of igneous origin, form the higher ground flanking the valley of the Douglas Water.

GEOLOGY

The resource sheet falls mainly within the 1:50 000 Geological Lanark 23E Sheet a narrow strip along the southern margin being included in Leadhills 15E Sheet. The area was originally geologically surveyed at 6-inch to one-mile scale by B. N. Peach and A. Geikie and the maps published in 1872 and 1870 respectively. G. Ross, L. W. Hinxman, J. Phemister, H. H. Read and E. M. Anderson made a revision survey which was incorporated in sheets 23 and 15, and published in 1929 and 1937 respectively. The drift geology was resurveyed in connexion with the present survey by I. B. Cameron during 1976.

SOLID

The solid rocks, which are undifferentiated on the resource map, range from Silurian to Tertiary in age. Their distribution and classification are shown in Figure 2.

The Carboniferous rocks are the most extensive. They occupy the low ground in the south of the valley of the Douglas Water and extend over much of the northern part of the resource sheet. Old Red Sandstone rocks crop out in the north-west, north-east and south-east of the area, and they flank an anticlinal core of Silurian rocks in the south-west.

In detail the structure and geological history are complex, but the main structural elements can be expressed in simple terms. In the northern part of the assessment area the Upper Old Red Sandstone and Carboniferous rocks form a broad shallow complex syncline resting on an eroded surface of folded and faulted Silurian and Lower Old Red Sandstone rocks. The Carboniferous rocks of the valley of the Douglas Water occupy a graben structure flanked on the west by a north-easterly-trending anticline of Silurian and Lower Old Red Sandstone rocks, and on the east by Lower Old Red Sandstone lavas. The area is crossed by the Carmichael Fault which trends north-east parallel with the Southern Upland Fault.

The Silurian rocks are exposed in a structural inlier on Windrow Hill [805 303] west-south-west of Douglas village and over the eastern part of the resource sheet to where the Carmichael Hill inlier extends from the north-east. The strata comprises hard grey or bluish grey shales interbedded with greywacke and some conglomerate bands, and they are overlain by reddish mudstones and flaggy sandstones.

There is no apparent angular discordance between the Silurian rocks and the basal strata of the overlying Lower Old Red Sandstone, but there is angular discordance elsewhere in the Midland Valley at this horizon.

The Lower Old Red Sandstone consists of massive reddish brown sandstone with lesser amounts of red mudstone and the sequence contains conglomerates

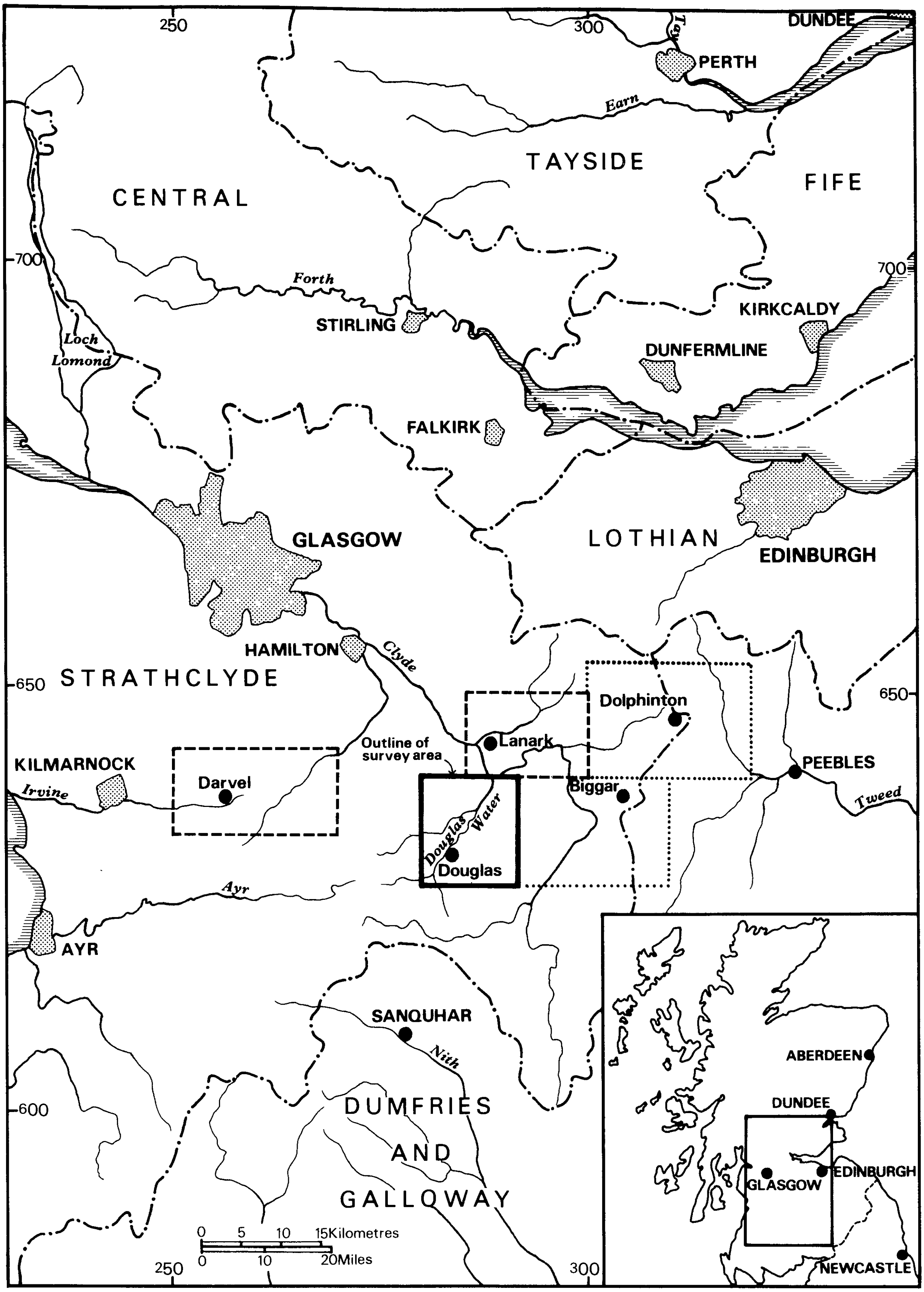


Figure 1 Sketch map showing the location of the resource sheet and its relationship with areas previously assessed (dashed outline) and areas for which reports are in preparation (dotted outline)

at the base and at higher horizons, with pebbles mainly of greywacke and quartzite.

Basalt and andesite lavas make up a significant part of the Lower Old Red Sandstone succession in the south-eastern part of the area, south of the Carmichael Fault. There are also numerous intrusions of felsite, acid porphyrite and quartz-porphyry emplaced within the sediments and lavas.

The sediments of Upper Old Red Sandstone facies are unconformable onto the Lower Old Red Sandstone and they overstep onto the Silurian rocks in places. The rocks consist of red sandstone and silty mudstone with some thin cornstone bands.

The Carboniferous rocks conformably overlie the

Upper Old Red Sandstone rocks and are composed of white or grey sandstones, grey mudstones and siltstones, a few thin limestone bands, some seams of coal and beds of fireclay.

The area is crossed by north-westerly-trending basaltic dykes of Tertiary age.

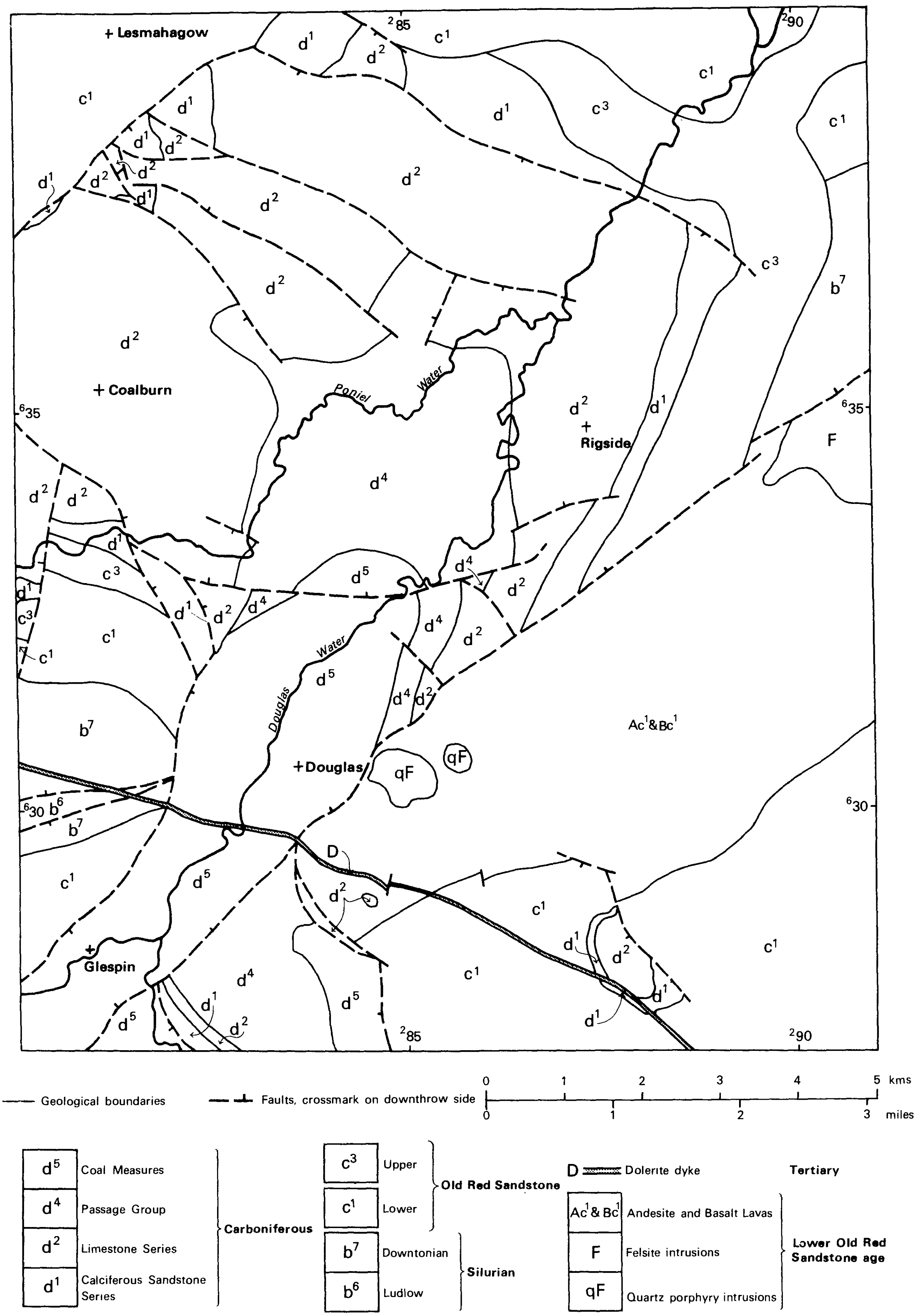


Figure 2 Sketch map of the solid geology

DRIFT

During the Pleistocene period the area was glaciated, probably on more than one occasion, the entire land surface, including the hill tops, being buried by ice during times of glacial maxima. The pre-glacial landscape has been modified by glacial erosion and by the deposition of sediment, either from glacial meltwater or as ground moraine.

Ice, generally of Southern Upland origin, moved from the south-west towards the north-east and was controlled, at least at lower levels, by the pre-glacial landscape. With amelioration of the climate, the ice thinned and the hill tops, were the first areas to become ice-free. As deglaciation progressed, meltwater drained north-eastwards on the surface of and within the rotting ice. A proportion of the sediment carried by meltwaters was deposited on the lower slopes of the valleys and over the low ground in the north of the resource sheet area. The ice finally disappeared about 12 500 years B.P. (Sissons, 1974).

Meltwater channels, eroded into till and bedrock and mainly aligned to the north-east but with a minor easterly trend near Coalburn, are present on the flanks of the valley of the Douglas Water. Usually the channels run obliquely to the regional slope and exhibit a sharp V-shaped cross profile, only rarely having a flat floor. They terminate at 15 to 30 m above the floor of the valley of the Douglas Water, the lower end of the channels indicating the upper limit of fluvioglacial deposition and their position, steep gradients, abrupt beginning and frequently more abrupt terminations suggesting a subglacial origin (McLellan, 1967).

Till covers much of the lower ground and extends uphill to an altitude of about 450 m (1475 ft) above Ordnance Datum. Generally, the deposit is unsorted, the particles ranging from clay to boulder size. Locally lenses of soft sandy till occur but generally the deposit is a plastic to stiff clay with clasts of Carboniferous, Old Red Sandstone and Silurian rocks. Overall the matrix colour varies according to the underlying rock-type: till overlying Carboniferous strata tends to be greyish blue and reddish brown over Old Red Sandstone rocks.

The glacial meltwater deposits consist mainly of sand and gravel, but silt and clay also occur. The sediments are the products of meltwater moving through and round stagnant ice, and termed glacial or fluvioglacial, or they were deposited from standing water temporarily impounded by ice or glacial debris (glaciolacustrine). Their distribution is limited to the floor and sides of the valley of the Douglas Water and the lower parts of the valley of the Poniel Water. Isolated patches occur elsewhere, for example, near Auchlochan [809 375] and Auldtoun [821 390].

The meltwater deposits now form dissected terraces on the valley sides and can be seen around Glespin, Hazelside [814 287], Douglas and elsewhere. In addition, a dissected flat of fluvioglacial deposits occurs around Poniel. Fluvioglacial terraces occur at more than one level, but the most common and widespread feature is at about 210 to 215 m (690 to 705 ft) above Ordnance Datum, presumably corresponding to a temporary meltwater outlet level further downstream. In section the deposits exhibit good stratification and are well sorted.

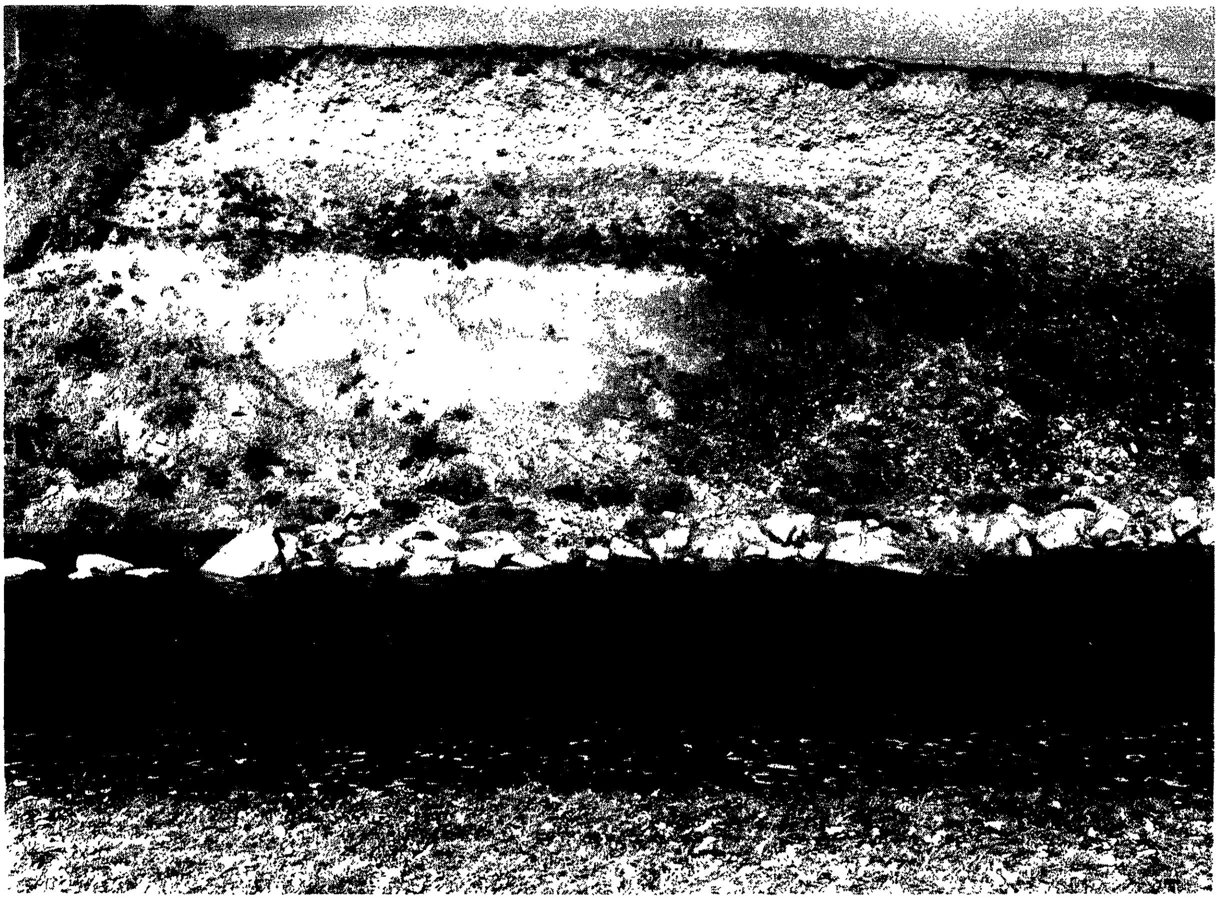


Plate 1 A river cliff, exposure NS 82 NW 163 [8100 2838], looking to the north-west. Coarse grained, poorly sorted fluvioglacial deposits overlie a stiff greyish brown till. (D 2772)

Plate 2 Valley of the Douglas Water near Gateside [834 303], looking to the south-west. The wide floodplain of the Douglas Water is bordered to the east by extensive deposits of fluvioglacial sand and gravel which form pronounced terrace features, and to the west by discontinuous fluvioglacial deposits and till. (D2777)

Glacial sand and gravel occurs as kames and eskers in which there is normally a higher content of coarse gravel than in other meltwater deposits. Elongate, steep-sided ridges with sharp crests may be seen at Birkhill [837 357] and Folkerton Mill [860 358], but are probably best developed in the area around Sandilands Station [892 386] where individual ridges branch and run at right angles to one another. These features indicate formation during the down-wasting of stagnant ice.

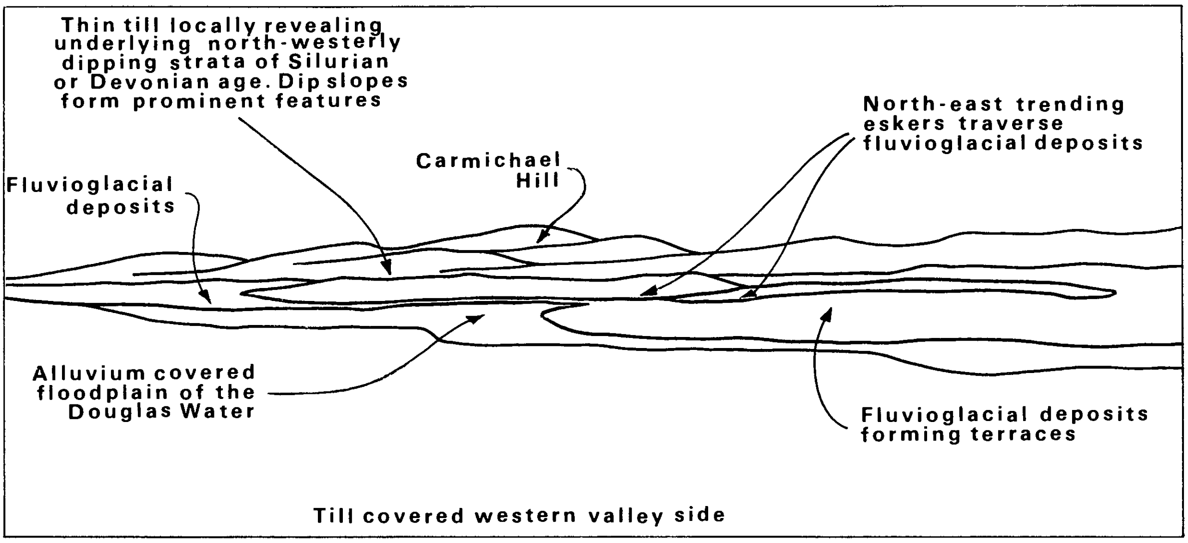
Boreholes show finer-grained sediments, presumably deposited in temporary lakes; they generally underlie coarser meltwater deposits. Exceptionally, however, laminated silt and clay is exposed in the banks of the Douglas Water, near Happendon [8610 3390 and 8510 3265].

Buried drift-filled channels at least 30 m deep occur between the villages of Douglas and Douglas Water. These channels, which are known only from boreholes drilled for coal exploration and for this survey, are either infilled pre-glacial valleys or pre-glacial valleys which were deepened by glacial erosion and subsequently filled with glacial debris.

In the later stages of deglaciation and more recently, the glacial deposits have been partly eroded, transported and redeposited as the present drainage system matured. The alluvial deposits comprise silty sand with banks of gravel and rarely patches of peat.

Plate 3 Esker near Sandilands [890 384], looking to the north-east. The cross profile of the north-east-trending esker is shown. Crookboat Farm is in the distance, Shields Burn is in the foreground. (D2773)

Plate 4 Landscape around Sandilands [878 384], looking to the east. Till covered valley slopes in the foreground abut the alluvium-lined valley floor of the Douglas valley. Fluvioglacial deposits forming a terrace feature on the eastern valley side are crossed by an esker. In the background, north-westerly inclined Silurian and Devonian-strata form dip slopes on Carmichael Hill. (D2775)



Explanation of Plate 4 Outline sketch of geological and topographical features around Sandilands Station

COMPOSITION OF THE MINERAL DEPOSITS

Particle size distribution

Recognising the complexity and the merging relationships of sediments in glacial outwash environments, criteria of form, composition and grain size have been applied to assist the recognition and distinction of drift deposits. The term glacial sand and gravel is restricted to eskerine deposits: glaciolacustrine deposits are defined by a sand to gravel ratio in excess of 19:1 and over 60 per cent by weight of material passing 0.25 mm. All other glacial meltwater deposits are described as fluvioglacial sand and gravel. Thin seams of sand and gravel with atypical grading are interpreted as forming part of the dominant deposit in a particular sequence as horizontal and vertical variations within glacial sediments are to be expected. Because of the paucity of data, in the assessment of resources, alluvial cone deposits have been grouped with the alluvium and head is included with till.

The weighted mean grading of each mineral deposit proved in boreholes and pits has been used to calculate the mean grading for each deposit type over the resource sheet. The data are presented in Table 1 and represented graphically in Figures 3 to 7 which also illustrate the range within which deposits are borehole sites grade and the frequency distribution of the mean grading for the resource as a whole. To demonstrate the variability in grading of the individual deposits the mean gradings for mineral deposits at each borehole, section and pit are also presented on triangular diagrams (Figure 8). Although till and glaciolacustrine deposits frequently have fines contents in excess of 40 per cent, only those parts judged potentially workable have been considered in the calculation of the mean grading and shown on the triangular plots.

Table 1 Mean grading of deposits (based on borehole, pit and section samples)

Deposit	Mean grading percentages						
	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$–$\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}$–1 mm	Coarse sand +1–4 mm	Fine gravel +4–16 mm	Coarse gravel +16–64 mm	Cobbles and boulders +64 mm
Alluvium	14	33	17	7	12	14	3
Glacial sand and gravel	6	6	11	13	11	32	21
Fluvioglacial sand and gravel	11	23	26	10	13	14	3
Glaciolacustrine deposits	21	59	19	1	trace	trace	0
Till	21	24	13	8	14	17	3

The percussion drilling method employed for this survey has been shown in the Lanark area to cause some comminution of particles especially the larger sizes (Laxton and Nickless, 1980). In addition the diameter of the borehole limits the maximum particle size that can be recovered. These factors indicate that samples obtained from boreholes may not be truely representative, particularly of oversize material. However, it is thought that clasts smaller than 120 mm are not so affected, as deposits generally finer than this which have been investigated both by boreholes and pits are directly comparable.

Alluvium: The alluvial deposits examined are restricted to the valleys of the Douglas Water, the Poniel Water and the Glespin Burn. The compositional diversity of the deposits, which vary from floodplain silts and sands in borehole 83 NE 75 to river gravels in borehole 82 NW 158 and pit 82 NW P2, is reflected by the wide envelope about the mean in Figure 3. Nevertheless, a gradual downstream fining is apparent. Near Glespin in boreholes 82 NW 158 and 82 NW 161 the resource grades as

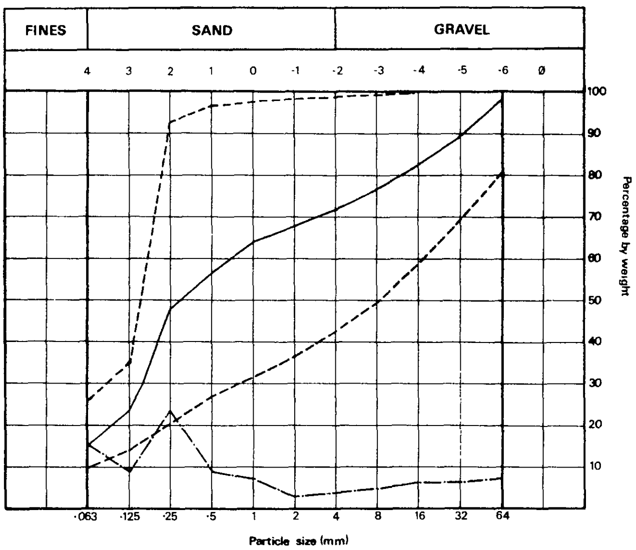


Figure 3 Grading characteristics of resources in the alluvium: the continuous line is the cumulative weighted mean; the broken lines denote the envelope containing the cumulative mean grading for each separately identified deposit proved to contain less than 40 per cent fines; the frequency distribution of the mean grading for the resource as a whole is shown by a dashed and dotted line

'clayey' gravel; at Happendon Wood [85 34] in borehole 83 SE 36 as 'clayey' sandy gravel and at Sandilands Station [892 386] in borehole 83 NE 75 as 'clayey' pebbly sand.

The alluvial cone deposit investigated by borehole 83 SE 31 has a grading similar to the mean for alluvium except that the fines content (26 per cent), is higher, a factor which is to be expected as the cone is primarily the product of the reworking of till, whereas all glacial deposits and bedrock have contributed to the alluvium. Because of the mode of origin and similarity in grading, the alluvial cone deposit has been included with the alluvium in the calculation of the mean grading.

The alluvial deposits have a mean grading of fines 14, sand 57 and gravel 29 per cent (for definition of terms see Table 8). The subrounded to well rounded gravel comprises coarse and fine with 3 per cent cobble and boulder material, and is composed of sandstone and greywacke with basalt, felsite, quartzite, vein quartz and some coal. The sand, fine with medium and some coarse grades, is mainly subrounded. Quartz predominates though some of the coarse fraction contains subangular, comminuted rock and coal fragments. Both silt and clay, disseminated and in seams, constitute the fines fraction which ranges from 10 to 26 per cent.

Glacial sand and gravel: Glacial sand and gravel occurs as small patches but was only sampled at section 83 NE 80 where a river cliff cut by the Poniel Water proved to be the only natural section in the area exposing the resource. Due to the difficulties in mounting drilling rigs on esker ridges no other investigation of these deposits was undertaken.

Details of the mean grading and a detailed log are presented in Appendix F. Glacial sand and gravel in section 83 NE 80 is coarser than all other meltwater deposits in the area, over 50 per cent comprising coarse gravel, cobble and boulder material. Stratification is absent, and the mean grading curve (Figure 4) reflects the poor sorting displayed by the deposits.

Fluvioglacial sand and gravel: The marked variability of the fluvioglacial deposits, reflected by the wide envelope about the mean (Figure 5), illustrates that caution should be employed when interpreting the succession or grading between sample points. Boreholes 83 SW 201 and 83 NE 78 and section 83 SW 203 show rapid vertical compositional changes. The

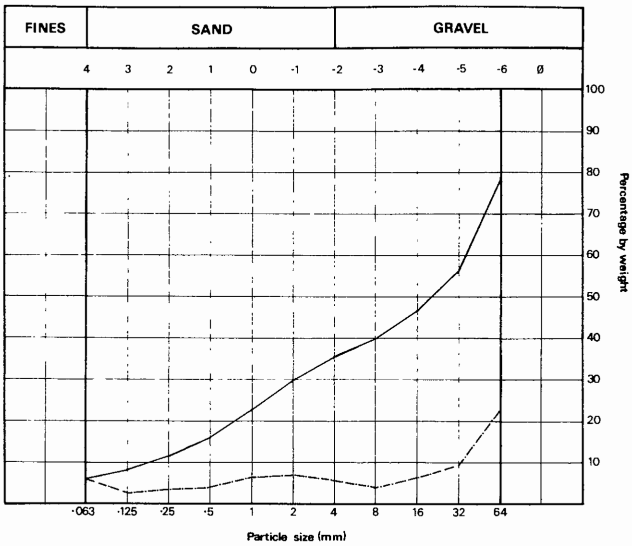


Figure 4 Grading characteristics of resources in the glacial sand and gravel: the continuous line is the grading curve; the frequency distribution of the fractions retained on sieves at phi intervals is shown by a dashed and dotted line

deposits range from fines-free coarse gravels at boreholes 82 NW 160 and 83 NE 69 to 'very clayey' pebbly sand at boreholes 83 SE 33 and 83 NE 71.

The complex merging relationship between sediment types, a function of the energy of the depositional environment is clearly shown by fluvioglacial (shallow water) and glaciolacustrine (deeper water) deposits. Downward fining from inferred fluvioglacial to glaciolacustrine sediment was proved by borehole 83 SW 200 and interbedded sequences by boreholes 82 NW 159, 83 SW 169, 83 SE 33 and 93 NW 1 and section 83 SW 203. In borehole 83 NE 70 glaciolacustrine deposits pass down into fluvioglacial sand and gravel. Seams of silty or clayey sand up to 1 m thick but usually averaging 0.1 m which on the basis of grading might be considered glaciolacustrine occur within fluvioglacial deposits (boreholes 82 NW 159, 83 NE 77A, 83 NE 78, 83 SW 198 and 83 SW 201 and sections 83 NE 82 and 83 SW 203). The dominance of coarser material at these sample points, however, allows the sequences to be classified as fluvioglacial.

The mean grading of the fluvioglacial deposits is fines 11, sand 59 and gravel 30 per cent. The gravel is coarse and fine with 3 per cent cobble material. Angular to well rounded, though the fine fraction tends to be more angular than the coarse, it is composed mainly of sandstone and greywacke with basalt, felsite, andesite, porphyry, quartzite, vein quartz, mudstone and coal. The sand is medium and fine with coarse grades, angular to rounded and composed of quartz with some comminuted coal and rock fragments, the coal tending to be concentrated in the finer seams. Silt and clay, disseminated and sometimes in seams constitute the fines content which ranges from 1 to 31 per cent.

In section the deposits appear poorly sorted at 82 NW 163, 82 NW 165 and 83 NE 81, and exhibit cross bedding and pebble imbrication at 82 NW 165, 83 NE 82, 83 SW 202 and 83 SW 203.

Glaciolacustrine deposits: These deposits occur throughout the area, usually concealed by alluvium or fluvioglacial deposits. Boreholes 83 SW 200, 83 SE 31, 83 SE 36 and 83 NE 75 which lie in the valley of the Douglas Water encountered glaciolacustrine deposits but the full thickness was not proved at any site.

Potentially workable glaciolacustrine sediment has a mean grading of fines 21 and sand 79 per cent with only traces of predominantly fine gravel. The sand is mainly fine grained but contains some medium and traces of the coarse fraction. The clasts are generally subrounded and composed of quartz but some mica and comminuted coal fragments are present especially in the fines-rich seams. Fines comprise both silt and clay. The narrowness of the envelope surrounding the mean grading, Figure 6, is illustrative of the homogeneity of these deposits. Potentially workable deposits may contain waste sequences, as in boreholes 83 SW 200, 83 NE 70 and 83 NE 75, or they may fine with depth to become non-mineral, as in borehole 83 SE 36. Of the glaciolacustrine sediments penetrated by assessment boreholes, 53 per cent of the total proved thickness, comprising laminated silt and clay, proved to be non-mineral.

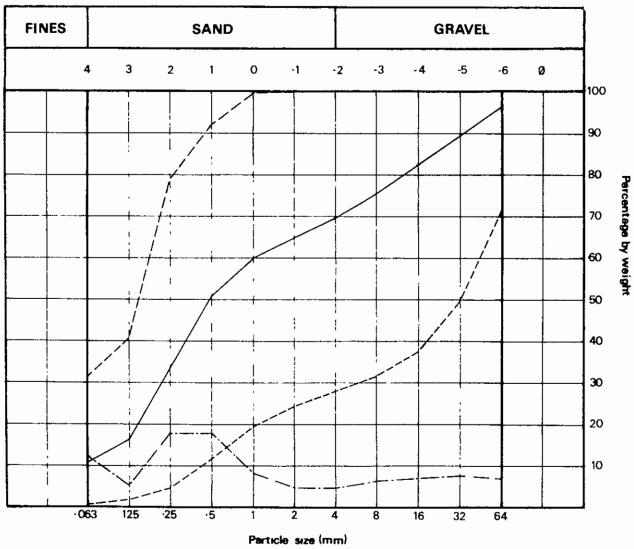


Figure 5 Grading characteristics of resources in the fluvioglacial sand and gravel (for explanation see Figure 3)

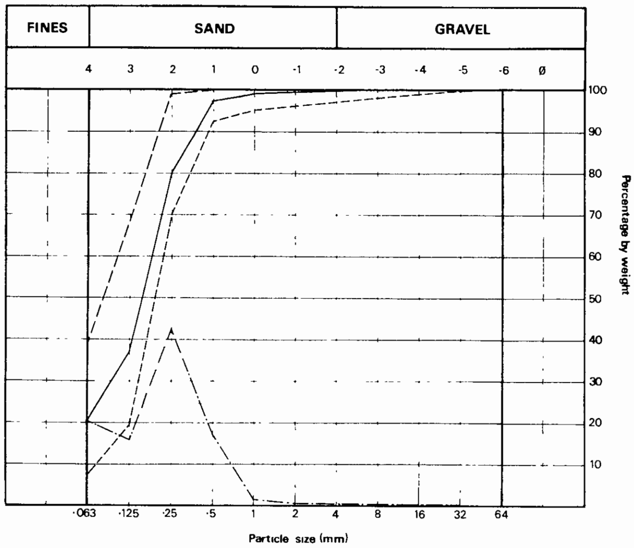


Figure 6 Grading characteristics of resources in the glaciolacustrine deposits (for explanation see Figure 3)

Till: A mantle of till drapes bedrock over much of the area, but in the valleys it is buried by meltwater deposits. The till appears to have been derived locally, lateral variations in clast composition and colour being largely dependent on the nature of the underlying bedrock. Generally, the deposit is stiff and tenacious, containing over 40 per cent fines, but in some places, particularly where it overlies sandstone, it contains sufficient sand or gravel to be judged potentially workable.

Those parts of the till sequence considered to be mineral have a mean grading of fines 21, sand 45 and gravel 34 per cent. The gravel fraction includes 3 per cent cobble and boulder material. Often angular though ranging to well rounded, coarse and fine gravel are equally developed. Sand, which is medium and fine with coarse grades, is angular to rounded and composed of quartz and comminuted rock fragments. Fines comprise mainly clay, the potentially workable till examined containing between 11 and 32 per cent. The very poor sorting of these deposits is reflected by the mean grading curve, Figure 7, the width of the envelope about the mean indicated the variability.

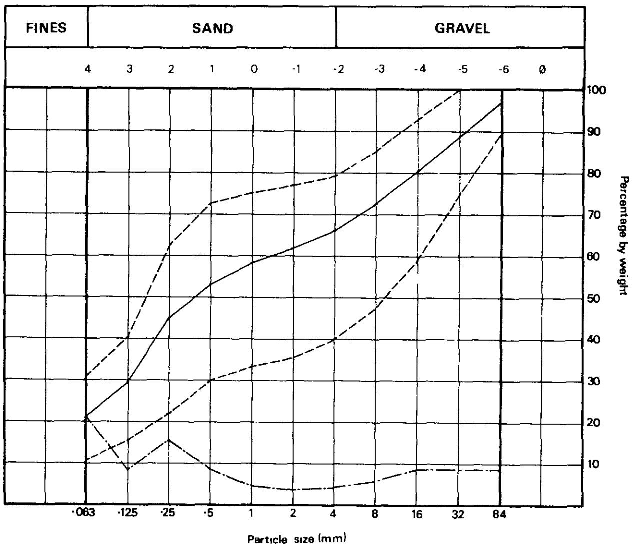


Figure 7 Grading characteristics of resources in the till (for explanation see Figure 3)

The petrography, mechanical and physical properties of the aggregate

Aggregate impact value (AIV), aggregate crushing value (ACV), 10 per cent fines value, relative density (on over-dried and surface-dried bases), apparent relative density and water absorption were determined in accordance with British Standard 812:1975 for a selection of samples representative of mineral deposits of different origin within the survey area. Composition analyses (pebble-counts) were carried out on the samples in an attempt to attribute differences in test results to lithologies.

The mechanical and physical tests were conducted on 10 to 14 mm sized material (BS 812:1975) but a drawback to this procedure is that the properties of pebbles in a restricted size range may not be characteristic of the gravel fraction as a whole. Consequently, all + 4 mm material retained from the sieve-grading of bulk samples was re-sieved to provide both 10 to 14 mm and 16 to 32 mm fractions. Pebble-counts of these fractions indicate generally similar compositions although the smaller size range includes slightly higher proportions of vein quartz, chert, basalt, argillaceous sediments, coal and limonitic ironstone nodules and lower amounts of gritstone and porphyry.

As about 15 kg of material is required for a complete series of mechanical and physical tests composites were prepared by grouping samples from boreholes, sections and pits (see Table 2). In addition four sections were each able to provide enough material for testing.

Composition analyses: A classification scheme based on the British Standard petrological groups (trade groups) as outlined in BS 812.1:1975 has been adopted, with minor amendments: microgranite is included in the granite group and quartzitic sandstone in the gritstone group. Both these rock types are minor constituents of the samples and form part of compositional series with granitic rocks and sandstones respectively, making separate classification difficult. Four rock-types not recognised in the Standard are listed under 'others'.

The composition analyses are presented in Table 3, in terms of weight per cent and per cent number of clasts. Ideally, approximately 300 pebbles are included in each analysis. The gravel examined consists chiefly of rocks belonging to the gritstone trade group: Carboniferous and Devonian sandstones and Ordovician and Silurian grits and greywackes. Pebbles of the basalt trade group are next most abundant, basalt predominating though andesite and dolerite occur. Rocks assigned to the porphyry trade group are almost as plentiful and comprise quartz and feldspar porphyries with felsite. Quartzite, argillaceous sediments, vein quartz and chert are present in all samples: limonitic ironstone nodules, coal, gabbro and granite occur in most but are rare. Three samples contain trace amounts of limestone and schist. Rocks representative of the hornfels trade group were not identified.

The overall pebble composition proportions appear broadly similar for all samples from the valley of the Douglas Water which is to be expected as the deposits share the same source areas. However, examination of the gritstone to basalt trade group and sandstone to greywacke ratios (using weight percentages of the 10 to 14 mm sized material) reveals differences between samples and highlights increases in amounts of potentially deleterious material.

The fluvioglacial deposits in the valley of the Douglas Water, samples A to D and J to O, generally show similar ratios ranging from 4.1:1 to 8.3:1 for the gritstone to basalt trade groups and from 1.1:1 to 2.0:1 for sandstone to greywacke. In comparison, samples P and Q from fluvioglacial deposits in the neighbourhood of Glespin which are buried by glaciolacustrine sediment, till or alluvium have ratios of 14.1:1 and 13.1:1 for the gritstone to basalt (due to a lower basalt content) although at 1.8:1 to 2.0:1 the sandstone to greywacke ratio is similar.

The fluvioglacial deposits in the valley of the Poniel Water (Sample E) have higher ratios than those of the valley of Douglas Water with 12.6:1 and 2.1:1 for gritstone to basalt and sandstone to greywacke ratios respectively, the former ratio reflecting

Table 2 Source and classification of aggregate-test samples

Sample	Geological classification	Source of samples	Depth range m
A	Fluvioglacial sand and gravel	82 NW 159	0.2–3.8
		82 NW 160	0.2–3.2
		82 NW P3	0.3–1.4
B	Fluvioglacial sand and gravel	82 NW 163*	0.4–2.5
C	Fluvioglacial sand and gravel	82 NW 164*	0.5–3.5
D	Fluvioglacial sand and gravel	82 NW 165*	0.3–6.7
E	Fluvioglacial sand and gravel	83 SW 198	0.4–17.7
		83 SW P4	0.4–1.9
		83 SW P5	0.3–1.7
		83 NW 149	0.6–6.4
F	Alluvium	82 NW 158	0.7–2.6
		82 NW 161	0.2–4.2
		83 SE 31	1.4–3.4
G	Alluvium	83 SE 36	0.8–4.3
		83 SE P7	0.3–2.0
		83 NE 69	0.4–3.7
		83 NE 75	1.0–4.5
H	Till	82 NW 162	9.2–12.3
		82 NW P4	0.2–1.7
		83 SW 199	1.1–4.7
		83 SW P3	0.6–1.6
		83 SW 34	0.4–2.0
		83 SE 37	0.5–4.1
		83 NE 72	0.1–4.5
		83 NE 74	0.3–3.9
I	Fluvioglacial sand and gravel	83 NW P1	0.6–1.5
		83 NW P2	1.0–1.8
J	Fluvioglacial sand and gravel	83 SW 165	0.7–13.7
		83 SW 196	0.4–2.2
			4.3–14.9
		83 SW P2	0.2–1.8
K	Fluvioglacial sand and gravel	82 NW 162	0.6–9.2
		82 NW P5	0.2–1.8
		82 NW P7	0.4–1.8
		83 SW 197	1.0–2.2
			3.8–8.7
		83 SW 202*	0.5–8.0
		83 SW 203*	0.6–3.5
			4.5–10.7
L	Fluvioglacial sand and gravel	83 SW 200	0.6–2.7
		83 SW 201	0.2–18.7
		83 SE 32	3.6–10.7
		83 SE 33	0.3–6.3
		83 SE P5	0.3–1.7
M	Fluvioglacial sand and gravel	83 SE 30	0.6–2.6
		83 SE P3	0.5–1.9
		83 NE 69	3.7–9.4
		83 NE 70	12.0–25.0
		83 NE 71	0.5–2.3
		83 NE 73	0.1–4.7
		83 NE P2	0.4–1.7
		83 NE P3	0.3–1.8
N	Fluvioglacial sand and gravel	83 NE 76	0.5–2.3
		83 NE 77	0.4–5.0
		83 NE 78	0.2–12.8
		83 NE 79	0.7–2.1
		83 NE 82*	0.6–5.7
		93 NW 1	0.2–23.5
		93 NW P1	0.7–1.9
O	Fluvioglacial sand and gravel	83 NE 81*	0.8–2.5
P	Fluvioglacial sand and gravel (buried)	82 NW 158	2.6–12.6
		82 NW 159	5.3–9.8
		82 NW 161	4.2–7.9
Q	Fluvioglacial sand and gravel (buried)	82 NW 162	16.2–18.8
		83 SW 195	17.5–19.3

* indicates a section. Pits are denoted by the letter prefacing the accession number for the quarter sheet. Otherwise sites are boreholes.

a below average basalt content. Those deposits associated with the valley of the River Nethan to the south of Lesmahagow have a very different lithological composition, sample I, containing less than the average for the resource sheet of gritstone, basalt and porphyry trade groups but with an exceptionally high proportion of green mudstone (argillaceous sediment of Table 3) which constitutes about 40 per cent. These clasts are thought to be derived from Silurian strata in the Lesmahagow inlier across which the River Nethan courses.

For block A south of the Happendon Bridge [8556 3338] alluvium (sample F) has a high gritstone to basalt ratio at 9.4:1: to the north of the bridge results for sample G are much lower at 3.0:1, but the sandstone to greywacke ratio for samples F and G is similar at 2.2:1 and 1.9:1 respectively. The difference in the gritstone to basalt ratio may be explained by the presence nearby of basaltic and andesitic lavas, of Lower Old Red Sandstone age, which form Parkhead Hill [857 302] and Robert Law [883 323]. Parkhall Burn draining this area joins the Douglas Water north of Uddington [864 333].

Potentially workable till from small isolated patches throughout the area has been combined in composite sample H, which shows a 'high' gritstone to basalt ratio of 8.9:1 but 'low' sandstone to greywacke ratio 1.2:1. Such a composite sample cannot be considered representative of a deposit as diverse as till but the results are presented as an indication of possible composition, mechanical and physical properties.

Mechanical and physical properties: Where sufficient material was available AIV, AVC, 10 per cent fines value, relative density, apparent relative density and water absorption were determined. As the compaction tests, ACV and 10 per cent fines value, require the most material both tests were possible for only six samples and for another five, neither could be undertaken. The results are presented in Table 4.

AIV, ACV and 10 per cent fines value are tests of the strength of an aggregate. AIV is a relative measure of the resistance of an aggregate to sudden shock or impact, which in some aggregates differs from its resistance to a slowly applied compressive load as indicated by ACV and 10 per cent fines value.

In measuring the resistance to a slowly applied compressive load the ACV and 10 per cent fines value tests differ in that the load is increased up to a fixed magnitude in a standard time in the former whilst the load is increased up to that required to produce a given degree of compaction in a standard time in the latter. The 10 per cent fines test, therefore, may measure the resistance of an aggregate to higher loads than the ACV test.

Table 3 Composition analyses (pebble-counts) of aggregate-test samples
(Results are given in frequency per cent with corresponding weight per cent in brackets)

British Standard Trade Groups	Rock type (modified after BS 812)	A		B		C		D		E		F		G		H		I	
		10–14 mm	16–32 mm	10–14 mm	16–32 mm	10–14 mm	16–32 mm	10–14 mm	16–32 mm	10–14 mm	16–32 mm	10–14 mm	16–32 mm	10–14 mm	16–32 mm	10–14 mm	16–32 mm	10–14 mm	16–32 mm
Number of pebbles counted:		245	277	343	223	354	313	231	290	433	230	381	298	216	261	279	427	252	209
Basalt	Basalt	11.8 (11.2)	7.2 (7.1)	8.2 (8.4)	8.5 (7.7)	8.2 (8.6)	6.4 (8.5)	11.7 (10.9)	4.5 (5.0)	4.6 (5.3)	6.1 (5.5)	5.0 (6.0)	5.8 (7.0)	12.5 (14.3)	6.5 (7.8)	6.5 (5.6)	8.0 (6.8)	4.8 (3.9)	4.3 (3.3)
	Andesite	2.9 (3.7)	2.2 2.2)	0.9 (1.1)	–	0.8 (0.5)	1.6 (2.1)	1.3 (1.2)	2.4 (2.7)	–	1.3 (1.6)	1.3 (0.9)	2.7 (3.1)	2.3 (2.3)	1.9 (1.4)	1.8 (1.9)	3.0 (2.7)	–	–
Flint	Chert	0.4 (0.8)	2.2 (1.6)	1.7 (1.6)	1.3 (0.9)	3.1 (3.3)	1.0 (0.7)	2.2 (2.4)	1.4 (1.1)	2.5 (2.6)	3.0 (2.1)	2.3 (2.2)	1.3 (1.5)	3.2 (3.3)	1.9 (1.9)	3.2 (3.2)	0.7 (0.5)	1.2 (0.9)	0.5 (0.9)
Gabbro	Undivided	0.4 (0.6)	2.5 (3.3)	0.6 (0.7)	2.2 (1.9)	0.6 (0.8)	2.6 (1.9)	0.4 (0.3)	1.4 (0.6)	0.7 (1.1)	–	1.6 (3.2)	1.3 (1.7)	–	–	0.4 (0.3)	0.9 (0.9)	0.4 (0.5)	–
Granite (inc. microgranite)	Undivided	–	1.1 (2.4)	0.6 (0.5)	–	–	0.6 (0.7)	–	1.0 (1.7)	0.2 (0.2)	1.4 (2.2)	0.3 (0.1)	–	0.5 (0.6)	0.4 (0.2)	0.4 (0.4)	–	–	–
Gritstone	Grit and greywacke (indurated)	20.8 (21.6)	27.8 (30.3)	26.2 (27.8)	28.7 (31.5)	20.1 (20.7)	26.2 (31.0)	24.7 (27.0)	27.2 (31.0)	19.4 (21.4)	16.1 (14.4)	20.2 (20.2)	22.1 (23.2)	19.4 (17.6)	23.4 (27.8)	27.6 (30.9)	30.7 (31.7)	15.1 (17.3)	13.4 (15.8)
	Sandstone (inc. quartzitic sandstone)	42.0 (41.3)	35.7 (33.7)	35.3 (32.1)	35.0 (35.1)	38.4 (37.0)	38.0 (34.0)	32.0 (30.4)	42.1 (41.5)	45.7 (45.5)	53.5 (55.1)	46.5 (44.7)	47.7 (45.6)	31.9 (32.7)	36.0 (31.7)	36.9 (35.7)	34.9 (34.6)	27.8 (25.2)	27.8 (28.6)
Limestone	Undivided	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Porphyry	Felsite	3.3 (3.2)	4.0 (3.4)	2.9 (2.7)	4.0 (4.2)	2.5 (2.8)	2.9 (3.4)	3.9 (4.5)	4.8 (4.8)	3.5 (3.7)	0.9 (1.7)	2.4 (3.2)	2.7 (3.0)	6.5 (6.4)	6.9 (7.2)	3.2 (3.4)	4.7 (3.2)	2.4 (2.2)	4.7 (4.1)
	Others	2.4 (1.9)	2.9 (3.1)	5.0 (5.5)	6.3 (6.9)	4.8 (4.7)	6.7 (6.4)	4.3 (4.2)	4.5 (3.3)	2.5 (2.6)	4.3 (4.4)	5.0 (4.9)	6.4 (6.1)	6.5 (6.3)	11.1 (10.4)	4.7 (5.1)	4.9 (7.4)	2.7 (2.8)	2.9 (2.4)
Quartzite	Undivided	4.1 (3.5)	3.2 (3.3)	6.1 (6.6)	4.6 (4.3)	5.6 (6.9)	5.0 (5.4)	6.1 (6.4)	3.8 (2.9)	3.6 (4.1)	6.1 (6.5)	4.7 (4.9)	6.4 (6.1)	8.3 (8.0)	5.4 (4.9)	3.8 (3.5)	5.4 (5.0)	4.0 (4.7)	3.3 (3.5)
Schist	Undivided	–	–	–	–	–	–	–	–	–	0.4 (0.2)	–	–	–	–	–	0.3 (0.5)	–	–
Others	Vein quartz	4.5 (4.6)	2.9 (3.0)	5.5 (5.7)	4.0 (2.5)	5.1 (6.2)	2.9 (2.2)	2.2 (2.9)	2.4 (2.2)	2.5 (2.7)	2.2 (1.7)	2.3 (2.5)	1.3 (1.2)	2.9 (3.6)	2.7 (4.1)	2.9 (3.2)	2.3 (2.3)	2.7 (2.6)	–
	Argillaceous sediment	3.7 (2.8)	4.3 (3.1)	3.8 (4.2)	3.2 (3.7)	5.1 (4.5)	3.8 (2.3)	5.6 (6.3)	3.8 (3.0)	7.9 (7.3)	3.9 (3.9)	6.6 (5.5)	2.0 (1.3)	2.3 (2.6)	1.1 (1.7)	5.0 (4.6)	2.6 (2.7)	37.7 (38.7)	43.1 (41.4)
	Coal	–	0.4 (0.1)	1.2 (0.6)	1.3 (0.8)	2.0 (0.8)	1.0 (0.3)	3.9 (2.1)	0.7 (0.2)	6.0 (2.7)	0.4 (0.1)	–	–	2.3 (1.2)	1.9 (0.4)	1.8 (0.8)	–	0.4 (0.1)	–
	Limonitic ironstone nodules	3.7 (4.9)	3.6 (3.4)	2.0 (2.5)	0.9 (0.5)	3.7 (3.2)	1.3 (1.1)	1.7 (1.4)	–	0.9 (0.8)	0.4 (0.6)	1.8 (1.7)	0.3 (0.2)	1.4 (1.1)	0.8 (0.5)	1.8 (1.4)	1.6 (1.7)	0.8 (1.1)	–

Table 3 continued

British Standard Trade Groups	Rock type (modified after BS 812)	J 10–14 mm	J 16–32 mm	K 10–14 mm	K 16–32 mm	L 10–14 mm	L 16–32 mm	M 10–14 mm	M 16–32 mm	N 10–14 mm	N 16–32 mm	O 10–14 mm	O 16–32 mm	P 10–14 mm	P 16–32 mm	Q 10–14 mm	Q 16–32 mm
Number of pebbles counted:		225	250	224	187	267	231	305	174	252	291	470	310	251	199	378	156
Basalt	Basalt	10.7 (12.0)	10.0 (9.8)	11.6 (12.4)	10.7 (11.6)	6.8 (7.7)	7.4 (8.9)	10.2 (12.0)	7.5 (7.8)	6.7 (7.6)	7.9 (9.2)	6.0 (6.2)	7.8 (10.2)	3.6 (3.2)	2.5 (1.7)	4.7 (5.0)	3.2 (3.9)
	Andesite	1.8 (1.7)	2.4 (2.7)	3.1 (3.0)	3.2 (2.7)	1.5 (0.9)	2.1 (1.5)	1.6 (1.8)	2.9 (2.3)	2.0 (1.8)	2.1 (2.4)	1.1 (0.9)	2.0 (2.6)	1.6 (1.6)	1.5 (1.3)	0.3 (0.2)	0.6 (0.6)
Flint	Chert	1.8 (1.9)	1.2 (0.7)	0.9 (0.8)	1.1 (0.8)	1.1 (1.1)	0.8 (0.6)	2.6 (3.1)	2.3 (2.3)	2.4 (2.5)	2.1 (2.5)	3.6 (3.7)	4.8 (4.0)	2.0 (1.8)	1.0 (0.8)	0.5 (0.6)	–
Gabbro	Undivided	0.4 (0.5)	0.8 (2.1)	0.9 (1.0)	–	–	0.4 (0.3)	–	–	–	–	0.2 (0.2)	0.6 (0.6)	1.6 (1.7)	0.5 (0.5)	0.3 (0.3)	0.6 (0.8)
Granite (inc. microgranite)	Undivided	–	0.4 (0.8)	–	1.1 (2.9)	0.4 (0.3)	–	–	0.6 (0.6)	0.4 (0.5)	0.3 (0.5)	1.3 (1.4)	0.6 (1.0)	0.8 (1.1)	–	0.3 (0.2)	0.6 (0.5)
Gritstone	Grit and greywacke (indurated)	27.1 (27.1)	23.6 (22.3)	27.7 (29.6)	28.9 (32.1)	30.0 (32.0)	26.0 (28.5)	19.0 (19.0)	21.3 (20.4)	22.6 (22.8)	21.0 (19.7)	21.4 (23.0)	17.7 (20.3)	24.7 (24.4)	25.6 (28.0)	19.3 (23.1)	18.1 (22.9)
	Sandstone (inc. quartzitic sandstone)	36.3 (34.1)	43.2 (44.5)	37.5 (35.5)	32.0 (26.6)	40.8 (39.3)	42.0 (37.5)	38.7 (38.0)	37.4 (33.9)	40.4 (38.7)	42.3 (41.1)	36.0 (35.5)	40.6 (36.4)	43.7 (43.6)	41.7 (36.6)	45.0 (45.1)	57.1 (54.4)
Limestone	Undivided	–	–	–	–	–	–	–	1.1 (1.7)	0.8 (0.6)	1.0 (1.6)	–	–	–	–	1.1 (0.9)	1.3 (0.7)
Porphyry	Felsite	4.0 (4.1)	3.6 (4.0)	2.2 (2.6)	2.7 (2.4)	3.0 (2.9)	3.5 (3.5)	4.6 (5.3)	4.0 (3.5)	4.8 (5.0)	4.5 (4.7)	5.1 (4.8)	4.2 (3.2)	4.0 (3.7)	5.1 (5.9)	5.6 (5.6)	6.5 (6.7)
	Others	3.6 (4.4)	2.8 (3.1)	3.6 (3.2)	6.4 (7.0)	4.1 (4.4)	5.2 (5.5)	4.6 (4.1)	12.6 (13.3)	3.6 (3.6)	4.5 (5.0)	5.5 (5.8)	4.0 (4.3)	4.8 (5.1)	6.0 (6.8)	4.5 (4.5)	1.3 (0.9)
Quartzite	Undivided	5.3 (4.8)	2.8 (2.9)	5.4 (5.6)	4.8 (5.3)	4.5 (4.4)	6.1 (6.8)	4.9 (6.0)	6.9 (12.2)	6.7 (6.3)	9.0 (8.6)	5.1 (5.1)	9.0 (9.0)	3.6 (3.6)	4.5 (6.4)	2.9 (3.0)	1.9 (1.9)
Schist	Undivided	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.3 (0.3)	–
Others	Vein quartz	3.6 (3.2)	0.8 (0.3)	1.8 (2.0)	2.7 (2.0)	2.2 (2.5)	3.5 (3.6)	3.3 (3.2)	–	4.8 (6.3)	2.1 (2.4)	5.3 (5.9)	2.9 (3.3)	3.6 (3.5)	3.5 (3.7)	3.4 (4.3)	3.8 (4.2)
	Argillaceous sediment	2.7 (3.0)	5.2 (4.2)	3.1 (2.6)	5.9 (6.4)	4.5 (4.1)	2.6 (2.9)	5.9 (4.9)	1.7 (1.6)	1.6 (1.6)	1.3 (1.2)	5.1 (4.0)	4.8 (3.2)	4.0 (4.7)	5.1 (6.9)	2.4 (2.3)	0.6 (0.3)
	Coal	–	–	0.9 (0.5)	0.5 (0.2)	1.1 (0.4)	0.4 (0.4)	3.3 (1.3)	1.7 (0.4)	1.6 (0.8)	0.6 (0.3)	–	–	1.6 (1.5)	–	9.4 (4.6)	3.8 (1.6)
	Limonitic ironstone nodules	2.7 (3.2)	3.2 (2.6)	1.3 (1.2)	–	–	–	1.3 (1.3)	–	1.6 (1.9)	1.3 (0.8)	4.3 (3.5)	1.0 (1.9)	0.4 (0.5)	3.0 (1.4)	–	0.6 (0.6)

Table 4 Results of mechanical and physical tests (BS 812: 1975)

Sample	Deposit type	Ratio of gritstone to basalt trade groups*	Ratio of sandstone to greywacke*	AIV	AIVR	ACV	ACVR	10% fines value (kN)	Relative density (oven-dried basis)
A	Fluvioglacial sand and gravel	4.2:1	1.9:1	21	42	–	–	160	2.40
B	Fluvioglacial sand and gravel	6.3:1	1.2:1	19	40	23	30	180	2.40
C	Fluvioglacial sand and gravel	6.3:1	1.8:1	19	38	22	30	–	2.39
D	Fluvioglacial sand and gravel	4.7:1	1.1:1	22	38	24	29	140	2.38
E	Fluvioglacial sand and gravel	12.6:1	2.1:1	25	40	–	–	130	2.34
F	Alluvium	9.4:1	2.2:1	23	37	–	–	–	2.41
G	Alluvium	3.0:1	1.9:1	26	37	–	–	–	2.35
H	Till	8.9:1	1.2:1	23	40	–	–	160	2.39
I	Fluvioglacial sand and gravel	10.9:1	1.5:1	28	25	–	–	–	2.36
J	Fluvioglacial sand and gravel	4.5:1	1.3:1	23	40	24	31	140	2.44
K	Fluvioglacial sand and gravel	4.2:1	1.2:1	20	41	21	34	180	2.39
L	Fluvioglacial sand and gravel	8.3:1	1.2:1	25	38	23	33	130	2.36
M	Fluvioglacial sand and gravel	4.1:1	2.0:1	24	39	23	35	130	2.45
N	Fluvioglacial sand and gravel	6.5:1	1.7:1	24	44	–	–	160	2.47
O	Fluvioglacial sand and gravel	8.2:1	1.5:1	23	41	–	–	150	2.43
P	Fluvioglacial sand and gravel (buried)	14.1:1	1.8:1	26	36	–	–	–	2.36
Q	Fluvioglacial sand and gravel (buried)	13.1:1	2.0:1	25	36	–	–	–	2.35

* Based on weight percentage of 10 to 14 mm sized range material.

The resistance of an aggregate to sudden shock and compressive load is a function of petrography and shape, the latter characteristic being in turn related to petrography and to conditions of deposition. In clastic sedimentary rocks failure is primarily a function of the strength of the intergranular cement. In igneous rocks it depends on the degree of crystal interlocking which decreases with increase in the surface area of crystals, and is therefore inversely proportional to grain size. Additionally, in coarse-grained igneous rocks, the strength of individual crystals, a function of twinning, cleavage and microfracture planes, becomes important (Ramsay 1965). Generally, therefore, fine grained igneous rocks are the strongest, followed by coarse grained igneous and sedimentary rocks of decreasing induration, although weathering will reduce the strength of any rock.

AIV and ACV, provide some indication of the toughness of intergranular bonding. In certain circumstances a misleading impression of aggregate performance may be gathered as the tests consider only the fine cataclastic products, that is, the amount of material after test passing a 2.36 mm sieve. Consequently, on completion of the impact and crushing determinations the amount of material retained on a 10 mm sieve was also determined, expressed as a percentage of the original total weight and labelled 'aggregate impact value residue' (AIVR) and 'aggregate crushing value residue' (ACVR) as appropriate (Ramsay 1965 and Dhir and others, 1971). The AIVR and ACVR provide additional data about the behaviour of aggregate and, according to Dhir and others, (1971), are more sensitive indicators of the aggregate quality, nature and performance.

The AIV results range from 19 to 28, have a mean of 23, and are higher than the average of 19 for gravels given by Edwards (1970). A similar trend is shown by the ACV results which range from 21 to 24 and have a mean of 23, again high in comparison to the average value of 17 for gravels given by Edwards (1970). The 10 per cent fines values show the expected general correlation with AIV and ACV, determinations having a range of 180 to 130 and a mean of 160. AIVR results range from 44 to 25 (mean

Relative density (surface-dried basis)	Apparent relative density	Water absorption (%)
2.51	2.70	4.6
2.50	2.68	4.4
2.50	2.70	4.9
2.49	2.67	4.6
2.45	2.65	5.1
2.51	2.69	4.3
2.45	2.60	4.0
2.49	2.67	4.4
2.47	2.66	4.9
2.54	2.71	4.1
2.49	2.67	4.5
2.47	2.66	4.8
2.54	2.70	3.9
2.55	2.69	3.3
2.53	2.69	3.9
2.47	2.66	4.8
2.44	2.58	3.8

38) and ACVR from 35 to 29 (mean 32). As a whole, the results reported here indicate that the material tested is highly susceptible to disaggregation when exposed to conditions of stress.

Although showing no simple relationship with petrography, the results generally reflect variations in the preponderance of sandstone and argillaceous sediments, especially in relation to basalt and porphyry trade group and greywacke constituents. The stronger material, for example, that derived from the exposed fluvioglacial deposits around Glespin (samples A to C) and Douglas (sample K), generally have lower gritstone to basalt trade group and sandstone to greywacke ratios than the weaker gravels from the buried fluvioglacial deposits (samples P and Q) and the mudstone-rich deposits of Auchlochan [809 375] (sample I). However, samples J to O which are in general petrographically similar to samples A to C are of intermediate strength. Low strength however, does not in itself adversely affect the use of the aggregate in concrete manufacture, as the strength of a mix is largely dependent on water absorption, surface texture, specific surface area, organic impurities and the chemistry (Edwards, 1970).

The relative density is quoted both on an oven-dry and a saturated, surface-dry basis. Values of the former range from 2.34 to 2.47 (the mean is 2.39), those of the latter range from 2.44 to 2.55 and have a mean of 2.49. Values for the apparent relative density vary between 2.58 and 2.71 and mirror the trend indicated by the relative densities.

The water absorption value is a measure of the amount of distilled water absorbed by an aggregate after 24 hours of immersion, expressed as a percentage of the oven-dry weight. The importance of this measure is its broad linear relationship with drying shrinkage, both of the aggregate itself and of any concrete manufactured from it. The drying shrinkage in turn is a key factor affecting the stress-carrying and weathering ability of concrete. Attempts have been made to relate water absorption to petrography (Edwards 1966, 1970). In very general terms quartz and flint give the lowest absorption, gritstone, mudstone and shale, the highest and the acid igneous rocks have a lower absorption than their more basic counterparts, although weathering is likely to increase the absorption of any rock. The values obtained from the aggregates tested in this survey range from 3.3 to 5.1 per cent and have a mean of 4.4 per cent. In comparison with the average of 1.48 per cent for other gravels, listed by Edwards (1970), these determinations are high and generally reflect the dominance of gritstone (Table 3). Using the graph drawn by Edwards (1970) linking water absorption with concrete drying shrinkage, aggregates from the superficial deposits in the Douglas area have inferred shrinkage values of between 0.095 and 0.135 per cent. Aggregates with values greater than 0.085 per cent lie in the category defined by the Building Research Station Digest 35 (1968), that requires the greatest

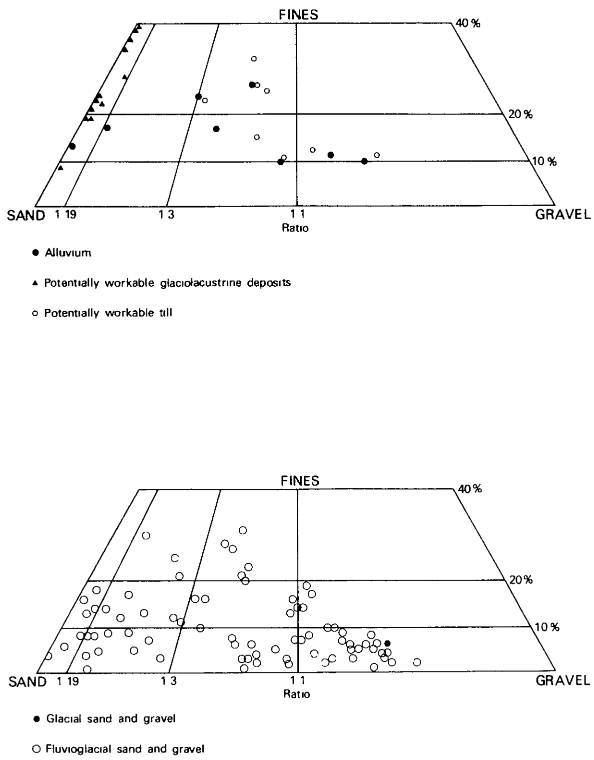


Figure 8 Comparison of the mean particle size of mineral deposits

care to be exercised when they are used in concrete manufacture. It must be emphasised that these inferred shrinkage values should be interpreted cautiously; for definitive values laboratory tests of concrete blocks made from the various aggregates, should be undertaken.

THE MAP

The sand and gravel resource map is folded into the pocket at the end of this report. The base map is the Ordnance Survey 1:25 000 Outline Edition in grey, on which the topography is shown by contours in green, and the geological lines, symbols and borehole data in black. Mineral assessment information including areas of potentially workable sand and gravel, resource notes and block boundaries is presented in shades of red.

Geological data: The geological boundary lines and symbols are taken from the geological maps of the area which was last surveyed on the scale of 1:10 560 by staff of the Institute's South Lowlands Unit during 1976. The boundaries are the best interpretation of information available at the time of the survey. However, it is inevitable, particularly with variable superficial deposits, that locally the accuracy of the map will be improved as new evidence from boreholes and excavations becomes available.

Mineral assessment information: The map is divided into resource blocks (see Appendix A), within which the extent of mineral is shown in red. A further subdivision of the mineral into areas where it is exposed (where the overburden averages less than 1.0 m in thickness) and areas where it is present in continuous or almost continuous spreads beneath overburden averaging more than 1.0 m in thickness are represented by progressivly lighter shading. Within these areas, however, there may be small patches where sand and gravel is absent or not potentially workable, as for example, around borehole 83 SE 30. Areas where sand and gravel is considered to be generally not potentially workable, where the superficial deposits do not contain mineral or where bedrock crops out, are uncoloured. Small patches of unassessed sand and gravel, although they may be potentially workable, are indicated by red stipple.

For the most part the distribution of resource categories is based on mapped geological boundaries. Where transitions between categories cannot be related to the geological map, inferred boundaries have been inserted. Such boundaries, drawn primarily for the purpose of volume estimation, are shown by a distinctive zigzag symbol, which is intended to convey an approximate location within a likely zone of occurrence rather than to represent the breadth of the zone; its width is dictated 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 5. Further particulars of grading are shown in Tables 6 and 7 and Figures 9 and 10.

Table 5 Summary of statistical assessments

Resource block	No. of sample points used in the assessment	Area (km²)		Mean thickness (m)		Volume of mineral			Mean grading percentage		
		Block	Mineral	Overburden	Mineral	million m³	Limits at the 95% probability level ±%	million m³	Fines $-\frac{1}{16}$ mm	Sand $+\frac{1}{16}$–4 mm	Gravel +4 mm
A Undifferentiated alluvium, fluvioglacial sand and gravel and glaciolacustrine deposits	29	5.4	5.1	1.2	12.2	31†	25	8	12	63	25
B Undifferentiated fluvioglacial, glacial and glaciolacustrine deposits	57	137.6	9.8	0.9	9.9	97	20	19	14	61	25
Total	86	143.0	14.9	1.0	10.6	128	–	–	13	62	25

†volume calculated as a triangular prism

Notes

a Limits at the 95 per cent probability level are a measure of the range of thicknesses about the mean. Because of differences in borehole density between blocks it is not justifiable to give limits when volumes of mineral for individual blocks are added.

b Whereas the best estimate of total volume is the sum of the components, the most accurate assessment of overall mineral thickness is the mean of all borehole data. Consequently total volumes are not the product of area and mean thickness.

c The term 'sample point' may include a number of closely spaced boreholes which, in the calculations, have been grouped and given a total weighing factor of one. Therefore, the number of sample points used in the assessment of resources may be less than the total number of borehole records available for the block.

Accuracy of results: For the two resource blocks statistically assessed the accuracy of the results at the 95 per cent probability level is 20 and 25 per cent (that is, it is probable that 19 times out of 20 the volumes present lie within these limits). However, the true values are more likely to be nearer the figure estimated than the limits. Moreover, it is probable that in each block roughly the same percentage limits would apply for the estimate of volume of 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 of part of a block, it can be expected that data from more than ten sample points will be required, even if the area is quite small.

However, it must be emphasised that the quoted volume of sand and gravel has no simple relationship to the amount that could be extracted in practise, as no allowance has been made in the calculations for any restraints (such as existing buildings and roads) on the use of land for mineral working.

NOTES ON THE RESOURCE BLOCKS

Potentially workable sand and gravel occurs in the alluvial, glacial, fluvioglacial and glaciolacustrine deposits. Till, in terms of the arbitrary criteria adopted for this survey, is locally potentially workable but because of its compositional variability and the sporadic distribution of sample points proving mineral it has not been considered in the estimation of volumes.

Potentially workable deposits are mainly confined to the floor and lower sides of the valleys of the Douglas Water and its tributaries, the Poniel Water and Glespin Burn. They extend from Glespin in the south-west corner of the resource sheet to the confluence of the Douglas Water with the River Clyde near Crookboat [8976 3943]. The resource blocks are defined geologically. Block A contains the alluvial deposits and underlying glacial meltwater deposits within the confines of the floor of the main valley system; most of the deposits lie beneath the permanent water table. Block B, which is divided by block A, comprises the remainder of the resource sheet, and contains glacial deposits of the valley sides and the drift lying outwith the major drainage system.

Block A

The block is defined by the extent of the alluvial tracts of the Douglas Water, the Poniel Water and the Glespin Burn and includes those alluvial cones formed where tributaries debouch onto the major valley floors. Much of the potentially workable material including alluvium, fluvioglacial sand and gravel and glaciolacustrine deposits lies below the permanent water table.

The north-easterly flowing Douglas Water occupies a broad alluvium-floored valley which falls from about 210 m (700 ft) to 175 m (575 ft) above Ordnance Datum across the length of the block. The Poniel Water and the Glespin Burn have narrow alluvium lined valleys though most of the tributaries to the Douglas Water are floored by bedrock. Within the main valley system older alluvial deposits form dissected terraces: on the present-day floodplain meanders and ox-bow lakes are common. At its confluence with the Douglas Water near Crookboat the River Clyde takes a marked change in direction to flow north-westwards. Downstream the Clyde flows over exposed bedrock and an inferred boundary delineates the area of mineral from drift too thin to the judged potentially workable. For the same reason inferred boundaries have been drawn to the east of Weston [82 29] and where the Glespin Burn, Raw Burn [86 36] and Burnhouse Burn [83 31] join the valley of the Douglas Water.

Coal waste which partly obscures alluvium in the vicinity of Glespin and Douglas Water has been ignored in the calculation of overburden mean thickness: in the valley bottom, flooded areas where ground has subsided due to undermining occur near Douglas Water and to the north of Douglas.

Sub-surface data reveal that the valleys of the Douglas Water and Poniel Water have been overdeepened to a depth of at least 47 m. Longitudinal and transverse profiles show the bedrock surface to be irregular but suggest the overdeepened valleys were graded towards the north-east. Because detailed logs supported by grading data are available for those boreholes specially drilled for this survey, within the material infilling the overdeepened valleys it is possible to distinguish alluvium from glacial meltwater deposits. Older records which, in the main, record only major lithological changes, do not allow such distinctions to be easily recognised. Although deficient in this respect and lacking detail of grading, these additional logs, which are more numerous than the IMAU boreholes, provide much data on the form of the bedrock surface and of variation in the thickness of sand and gravel. Because it is not always possible to differentiate on logs, with any degree of certainty, alluvial from meltwater deposits, the resources lying beneath the floodplain of the present-day Douglas Water and its tributaries have been assessed as a whole and termed valley floor deposits. Moreover, although the only grading data available are for IMAU boreholes, elsewhere where bore logs record sand and gravel it has been assumed to be potentially workable.

In the valleys of the Douglas Water and Poniel Water IMAU boreholes indicate that glacial meltwater deposits underlie alluvium and rest on bedrock. Other records indicate that locally till occurs beneath glacial meltwater deposits and overlying bedrock: additionally some boreholes prove till, probably lenses, usually less than 3.5 m thick, within sand and gravel. In the valley of the Glespin Burn alluvium overlies till which rests on bedrock. At Poniel Old Bridge [8530 3519] glacial deposits form an isolated mound known as Heron's Hill [852 352] which rises to about 6 m above the level of the floodplain of the Poniel Water and is completely surrounded by alluvium.

The drift shows rapid lateral variation. Between Glespin and Douglas the valley floor deposits have a maximum proved thickness of 12.6 m but between Douglas and Happendon, boreholes 83 SW 94 [8491 3268] penetrated 42.7 m overlying bedrock. Between Happendon [355 335] and Douglas Water the maximum proved thickness is 37.0 m (borehole 83 NE 60 [8657 3566]) and at Douglas Water 47.3 m (borehole 83 NE 33/1 [8715 3643]). Further north borehole data is sparse the thickest sequence being proved by borehole 83 NE 75 which, although not proving bedrock, penetrated 25.0 m of drift before being terminated. Generally, the drift in the valley of the Poniel Water is thinner: borehole 83 NE 69 proves 9.0 m of sand and gravel and east of Folkerton Mill [8572 3593] borehole 83 NE 62 [8589 3597] records 11.0 m of which the lower 6.6 m is composed of till.

On the basis of data from IMAU boreholes alluvium, which is 'clayey', ranges in thickness from 1.9 m in borehole 82 NW 158 to 6.5 m in borehole 83 NE 75. The deposit appears to show systematic lateral variation in grade, the gravel content decreasing downstream (further details are given in the composition section). Borehole 83 SE 31 sited on an alluvial cone proved 3.1 m of which the upper 1.1 m, comprising laminated silt and clay, is judged not potentially workable. The gravel content of the potentially workable alluvial cone deposit (fines 26, sand 45 and gravel 29 per cent) is similar to that for alluvium (fines 13, sand 57 and gravel 30 per cent). As it is thought that the alluvial cone deposit proved by borehole 83 SE 31 is representative of alluvial cones throughout the resource sheet area they are all considered potentially workable and shown as such on the resource map. For the purposes of assessment they have been included with the valley floor deposits.

The grading of the buried glacial meltwater deposits appears to be related to thickness. Between Glespin and Douglas, and in the valley of the Poniel Water where the deposits are thin, they have a mean grading of fines 4, sand 43 and gravel 53 per cent. Boreholes 82 NW 158, 82 NW 161 and 83 NE 69 prove 10.0, 3.7 and 5.7 m respectively of mineral which grades as gravel. Where boreholes suggest that the longitudinal profile of the buried valley of the Douglas Water has been locally steepened the fill is finer, grading as fines 16 and sand 84 per cent. Around Douglas, Happendon Quarry [857 335] and Douglas Water, pre-existing borehole data prove sand and gravel interbedded with fine sand and silt, probably glacial lake deposits. Similar sequences were proved by IMAU boreholes near Newtonhead [869 345] and Sandilands Station [892 386] where the deposit (fine sand and interbedded silt) in part grades as non-mineral. In these areas consideration of the cumulative drift thickness as proved by all known boreholes indicates that in the order of 70 per cent is potentially workable.

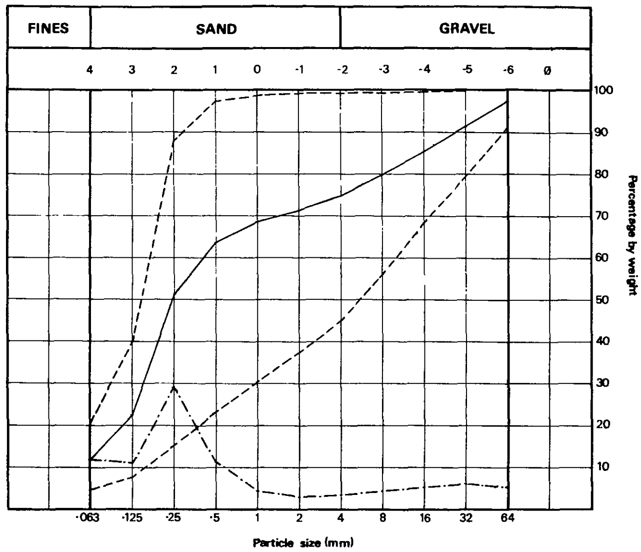


Figure 9 Grading characteristics of resources in block A: the continuous line is the cumulative weighted mean; the broken lines denote the envelope containing the cumulative mean grading of mineral proved in individual boreholes; the frequency distribution of the mean grading is shown by a dashed and dotted line

Throughout the block overburden which comprises soil on alluvial silts varies in thickness. Between Glespin and Douglas, Happendon and Douglas Water and in the valley of the Poniel Water overburden is generally less than 0.8 m. However, between Douglas and Happendon it has a mean thickness of 1.9 m and to the north of Douglas Water averages 1.5 m. For the block as a whole the mean thickness of overburden is 1.2 m and the mean thickness of mineral 12.2 m

Six IMAU boreholes, twenty-one other records, the results of twenty-four boreholes sunk mainly for coal exploration and two commerical logs form the basis of the assessment. In assessing the valley floor deposits it has been assumed that the shape of the resource approximates to a triangular prism and the area of alluvium times half the mean thickness is the basis of the calculation.

A volume of 31 million $m^3 \pm 25$ per cent is indicated: the mean grading is fines 12, sand 63 and gravel 25 per cent. Additional information is presented in Table 6 and Figure 9.

Table 6 Block A: data from assessment boreholes – all deposits

Borehole	Recorded thickness			Mean grading percentage						
	Total mineral (m)	Over-burden to first mineral (m)	Inter-vening waste (m)	Fines −$\frac{1}{16}$ mm	Fine sand +$\frac{1}{16}$–$\frac{1}{4}$ mm	Medium sand +$\frac{1}{4}$–1 mm	Coarse sand +1–4 mm	Fine gravel +4–16 mm	Coarse gravel +16–64 mm	Cobbles and boulders +64 mm
83 NE 69	9.0	0.4	–	9	17	23	9	15	24	3
83 NE 75	22.0+	1.5	1.5	19	67	12	1	1	0	0
83 SE 31	2.0	1.4	–	26	23	14	8	10	19	0
83 SE 36	13.5	0.8	–	8	54	23	4	5	5	1
82 NW 158	11.9	0.7	–	5	10	15	15	24	23	8
82 NW 161	7.7	0.2	–	8	15	15	11	19	26	6
Mean	11.0	0.8	–	12	40	17	6	10	12	3

Block B

The block comprises the area of the resource sheet outwith the confines of the major valley floors. Much of the potentially workable material, however, including fluvioglacial, glacial and glaciolacustrine deposits (referred to collectively as glacial meltwater deposits), covers the valley sides of the Douglas Water, which divides the block.

In the south-east of the block rounded hills attaining heights of about 400 m (1300 ft) above Ordnance Datum expose bedrock down to levels of about 275 m (900 ft), a thin cover of till, in places underlying small patches of peat, occurs over the lower ground. Numerous streams dissect the till and often reveal bedrock in the valley bottoms. In the valley of Mill Burn [90 27], in the extreme south-east of the resource sheet, fluvioglacial deposits are mapped, but as with those in the valleys of Ponfeigh Burn and Shields Burn, to the east of Rigside, they have not been assessed, due to lack of information. Over the north-western part of the block the country is undulating and generally lower than that to the south. The till cover is extensive, bedrock cropping out only on hill-tops, such as Broken Cross Muir [843 371], and in stream beds. Patches of peat are extensive around Coalburn and Greenstrands Farm [875 394]. Fluvioglacial deposits in the valley of the River Nethan and to the east of Lesmahagow have not been assessed due to the paucity of thickness and grading data.

Within the glacial meltwater deposits, material judged to be potentially workable drapes the lower valley sides of the Douglas Water and Poniel Water to an elevation of about 230 m (750 ft) above Ordnance Datum and generally overlies till. Fluvioglacial and glaciolacustrine deposits usually form terraces: glacial sand and gravel occurs in eskers which attain heights in excess of 5 m and lengths of up to 800 m. Glacial meltwater channels mark the valley sides in Long Plantation [83 32], at Cairnhouse [842 355], Sandilands [884 378], Glaickhead [811 364] and Wallace's Cave [821 337].

Drift deposits are obscured by waste from coal workings around Glespin, Douglas West [821 309], Douglas Water, Coalburn and Newtonfoot [869 353]. At the last two localities accumulations are sufficient to form potential sources of bulk fill. Collapse of coal workings to the north of Douglas [835 315] has created surface depressions, now flooded. Sand and gravel has been worked near Boncastle Hill [857 328]. The glacial meltwater deposits within the block proved to be very variable in thickness and composition and, as in block A, these two factors appear to be related. Fluvioglacial sediments comprise the bulk of the potentially workable material and commonly merge into glaciolacustrine deposits where sequences are thickly developed. Because fluvioglacial and glaciolacustrine deposits have been recognised at depth by grading data alone, such distinction is not possible in the older borehole records; nor is it possible to distinguish glacial (eskerine) sand and gravel at depth from fluvioglacial deposits. Therefore, all the glacial deposits on the valley sides of the Douglas Water and Poniel Water have been assessed as a whole.

Boreholes on the valley sides prove that the glacial meltwater deposits often overlie till which in turn rests on bedrock, and locally contain lenses of probably soliflucted till up to 13.5 m in thickness.

South-west of Happendon Bridge, glacial meltwater deposits cover both sides of the valley of the Douglas Water almost continuously: to the north-east they form extensive spreads which lie mainly on the west flank of the valley between Happendon and Barnhill [869 371], but farther north the deposits occur mainly on the eastern side.

On the valley sides around Glespin the glacial meltwater deposits are thin, borehole 82 NW 160 proving a maximum of 3.0 m of mineral. The gravel content in neighbouring boreholes and sections ranges from 42 to 72 per cent. Peat, thought to line a kettle hole and to be developed on the till, occurs north-east of Glespin West [811 280]. Downstream, subsurface data suggest that the glacial meltwater deposits thicken, borehole 82 NW 159 at Hazelside [814 287] recording 14.2 m, and become finer grained comprising interbedded sequences of silts and sands which locally are judged to be non-mineral. Between Hazelside and Douglas, boreholes prove seams of till within the glacial meltwater deposits. In borehole 82 NW 162, at Weston [824 290], intercalated till 7.0 m thick is potentially workable. Near Gateside [833 303] and Scrogton [826 304], however, the deposit is judged to be non-mineral.

In the vicinity of Douglas Castle the glacial meltwater deposits show marked thickening, borehole 83 SW 110 [8452 3241] sited on a terrace on the northern valley side, encountered 33.1 m comprising gravel grading downwards into fine sand and silts. At a nearby site, borehole 83 SW 200 terminated at 25 m without proving the full drift thickness: 35 per cent of the sequence grades as non-mineral. In contrast on the southern valley side the drift is hummocky, proves to be equally thick but is coarser grained. Borehole 83 SW 104 [8446 3183] records 32.8 m of meltwater deposits and in borehole 83 SW 201 sand and gravel exceeds 24.8 m. The mineral apparently thins towards Happendon, 7.1 and 6.7 m being proved by boreholes 83 SE 32 and 83 SE 33 respectively.

Glacial meltwater deposits cover the valley sides of the Poniel Water around Nether Fauldhouse [844 352] and Saddlerhead [833 354] and form large spreads around Poniel [840 343]. At the first two localities they prove to be thin, borehole 83 NW 110 [8451 3523] encountering sand and gravel to a depth of only 1.2 m and borehole 83 NW 149, 5.8 m of similar material. North-westerly-trending eskers overlie till at Birkhill [838 356]. Nearer Poniel, borehole 83 SW 198 proved 0.4 m of soil on 'clayey' sand and gravel in excess of 17.4 m thick, yet to the west and north boreholes 83 SW 180 [8423 3463] and 83 SW 181 [8415 3479] reveal respectively 3.4 and 1.2 m of sand and gravel beneath 2.3 and 3.7 m of overburden. Within the mapped area of sand and gravel boreholes show till to occur locally, borehole 83 SW 182 [8410 3489] proving 18.3 m of the deposit from the surface. Closer to Poniel, boreholes 83 SW 178 [8383 3426] and 83 SW 183 [8403 3444] record seams of till up to 3.5 m thick within sand and gravel.

The extensive spread of fluvioglacial sand and gravel between Happendon and Wolfcrooks [865 359], which lies on the interfluve between the valleys of the Douglas Water and the Poniel Water, is variable in thickness and composition. Borehole 83 SE 30 proved thinly bedded glacial meltwater deposits, judged to be not potentially workable, over-

Table 7 Block B: data from assessment boreholes, sections and pits – all deposits except potentially workable till

Borehole	Recorded thickness			Mean grading percentage						
	Total mineral (m)	Overburden to first mineral (m)	Intervening waste (m)	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}-1$ mm	Coarse sand +1–4 mm	Fine gravel +4–16 mm	Coarse gravel +16–64 mm	Cobbles and boulders +64 mm
93 NW 1	23.3	0.2	–	14	32	26	8	8	10	2
83 NW 149	5.8	0.6	–	16	31	22	7	10	11	3
83 NE 70	19.0+	3.0	3.0	8	35	41	7	5	4	0
83 NE 71	1.8	0.5	–	30	30	29	5	5	1	0
83 NE 73	4.6	0.1	–	23	26	14	8	12	16	1
83 NE 76	1.8	0.5	–	28	30	14	6	11	11	0
83 NE 77B	4.6	0.4	–	23	30	12	6	9	13	7
83 NE 78	12.6	0.2	–	12	37	38	7	4	2	0
83 NE 79	1.4	0.7	–	16	20	14	9	17	21	3
83 NE 80*	3.5+[1]	0.6	–	6	6	11	13	11	32	21
83 NE 81*	1.7+[1]	0.8	–	3	10	15	13	18	30	11
83 NE 82*	5.1+[1]	0.6	–	12	41	30	5	3	9	0
83 SW 195	14.8	0.7	3.8	15	16	15	13	18	19	4
83 SW 196B	12.4	0.4	2.1	7	16	32	11	18	14	2
83 SW 197	6.1	1.0	1.6	18	42	15	4	7	12	2
83 SW 198	17.4+	0.4	–	15	36	34	4	6	5	0
83 SW 200	15.2+	0.6	9.2	21	42	27	2	4	4	0
83 SW 201	24.8+	0.2	–	12	23	36	9	11	8	1
83 SW 202*	7.5+	0.5	–	2	17	28	12	14	20	7
83 SW 203*	9.1+[1]	0.6	1.0	5	21	40	9	10	14	1
83 SE 32	7.1	3.6	–	9	13	11	13	24	20	10
83 SE 33	6.7	0.3	–	24	41	22	6	3	4	0
82 NW 159	9.6	0.2	–	17	27	11	8	13	18	6
82 NW 160	3.0	0.2	–	5	7	19	11	18	29	11
82 NW 162	11.2[2]	0.6	–	10	15	29	13	16	16	1
82 NW163*	2.1	0.4	–	2	3	15	8	10	35	27
82 NW 164*	3.0	0.5	–	13	14	15	16	17	22	3
82 NW 165*	6.4	0.3	–	3	9	12	15	21	20	20
Mean	8.6	0.7	–	14	27	26	8	11	11	3

*Section sites
[1]Not used in calculations as full thickness of deposit not proved
[2]Not including 7.0 m of mineral till

lying till. In places till crops out and peat has formed where the former is close to the surface. In borehole 83 SE 8 [8507 3479], 13.5 m of till separates an upper 3.5 m from a lower 14.8 m of sand and gravel. At Tofts Gate, pit 83 SE P2 and to the east, borehole 83 SE 9 [8603 3418] discovered bedrock just beneath the surface. Close by, sand and gravel was proved by pits 83 SE P3 and 83 NE P3 to depths of 1.9+ and 1.8 m+ respectively. The deposit becomes finer northwards, borehole 83 NE 52 [8589 3563] sited on till proving sand to a depth of 24.2 m and borehole 83 NE 70, 9.2 m of interbedded silt and sand which grades downwards into sand and gravel. To the east of Folkerton Mill an esker composed mainly of gravel is surrounded by the finer grained deposits.

The large spread of glacial meltwater deposits around Barnhill, between the valleys of the Raw Burn and the Douglas Water, shows lateral variation in thickness, boreholes 83 NE 71 and 83 NE 31 [8722 3717] proving deposits to 2.3 and 27.4 m respectively. West of Barnhill the drift attains a thickness of 43.7 m (borehole 83 NE 11 [8683 3720]) and includes an 8.4 m waste seam of clay. Such data have been used to infer the presence of a buried channel to the west of the present course of the Douglas Water (schematic horizontal section B–B′).

North of Sandilands an extensive spread of glacial meltwater deposits includes a series of esker ridges around Sandilands Station [892 386]. Boreholes 83 NE 77 A and B (83 NE 77 A is not shown on the resource map) and 83 NE 76 near Sandilands demonstrate that the meltwater deposits are thin, composed of 'clayey' sand and gravel and overlie till which, in the last-named borehole, rests on laminated silts. The maximum drift thickness proved is 15.0 m. The glacial meltwater deposits thicken northwards and directly overlie bedrock, borehole 83 NE 78 near Crookboat proving 12.6 m of 'clayey' sand and gravel. To the west of Millmoor [904 393] deposits of a similar composition were encountered to a depth of 23.5 m in borehole 93 NW 1. Sections 83 NE 81 and 83 NE 82 are in intermittent workings of these deposits.

The glaciolacustrine deposits enclosed by and to the north of the River Clyde [897 399] were proved to a depth of 5.0 m by borehole 84 SE 30 [8970 4011] (Laxton and Nickless, 1980).

Data from boreholes drilled in exposed till generally prove it to be thin (the maximum recorded thickness in IMAU boreholes is 6.9 m) and to progressively thin up the valley sides. To the north and east of Broken Cross Muir the till cover is thicker than usual 10.9 m and 15.3 m being encountered in boreholes sunk to investigate coal-bearing strata. Locally, the till is judged to be potentially workable, 31 per cent of the total thickness drilled in this survey proving to be potentially workable. However, because of the scatter of sample points proving mineral till and the rapid lateral compositional variation it has not been considered in the estimation of resources.

The assessment of glacial meltwater deposits on the valley sides is based on twenty-one IMAU boreholes, three sections, one pit and thirty well records, the results of twelve boreholes sunk to investigate coal-bearing strata and ten commercial logs. Data from five sections which do not prove the full thickness of sand and gravel have not been used in the calculations although thickness and grading details are shown on the resource map and in Table 7.

Overburden is generally thin and composed of soil. The mean thickness for the block is 0.9 m: locally, however, boreholes recorded up to 3.0 m (borehole 83 NE 70) and borehole 83 SE 32 proves 3.6 m of made ground.

All the potentially workable meltwater deposits in the block have been assessed as a whole. The mean thickness is 9.9 m and the estimated volume 97 million $m^3 \pm 20$ per cent. The mean grading is 14 per cent fines, 61 per cent sand and 25 per cent gravel. For additional details refer to Table 7 and Figure 10.

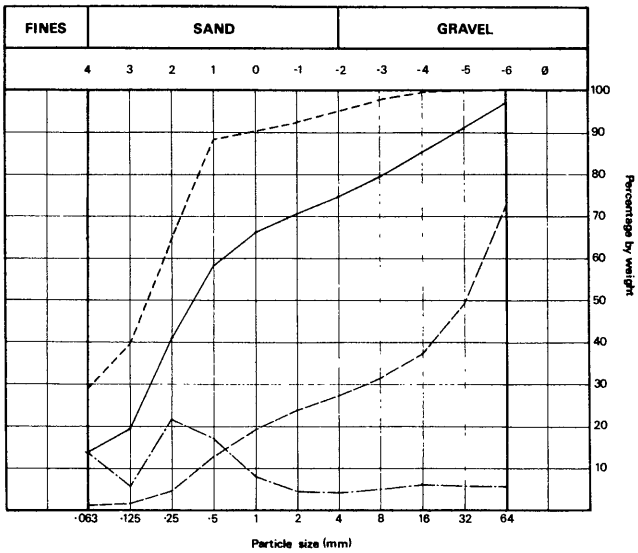


Figure 10 Grading characteristics of resources in block B (for explanation see Figure 9)

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 co-operation of sand and gravel operators ensures that boreholes are not drilled where reliable information is already available; although this may be used in the calculations, it is held confidentially by the Institute and cannot be disclosed.

The mineral shown on each 1:25 000 sheet is divided into resource blocks. The arbitrary size selected, 10 km², 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 deposit, or ideally at every 1 m (3.3 ft) depth. The samples, each weighing between 25 and 45 kg (55 and 100 lb), are despatched in heavy duty polythene bags to a laboratory for grading. The grading procedure is based on British Standard 1377 (1975). Random checks on the accuracy of the grading are made in the laboratories of the Industrial Minerals Assessment Unit.

All data, including mean grading analysis figures

Figure 11 Example of resource block assessment: calculation and results

Block calculation 1:25 000 Block } Fictitious

Area
Block: 11.08 km²
Mineral: 8.32 km²

Mean thickness
Overburden: 2.5 m
Mineral: 6.5 m

Volume
Overburden: 21 million m³
Mineral: 54 million m³

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

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

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

Calculation of confidence limits

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

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

L_V is calculated as

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

calculated for the total thickness of the mineral, are entered on standard record sheets, abbreviated copies of which are reproduced in Appendix F.

Detailed records may be consulted at the Institutes Edinburgh office, upon application to the Officer-in-Charge, Industrial Minerals Assessment Unit.

APPENDIX B

STATISTICAL PROCEDURE

Statistical Assessment

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

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

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

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

4 The above relationship may be transposed such that

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

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

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

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

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

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

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

6 The sampled area in each resource block is coloured pink on the map. Wherever possible, calculations relate to the mineral within mapped geological boundaries (which may not necessarily correspond to the limits of deposit). Where the area is not defined by a mapped boundary, that is, where the boundary is inferred, a distinctive symbol is used. Experience suggests that the errors in determining area are small relative to those in thickness. The relationship $S_A/S_{\bar{l}_m} \leq \frac{1}{3}$ is assumed in all cases. It follows from equation [2] that

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

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

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

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

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

9 In calculating confidence limits for volume, L_V, the following inequality corresponding to equation [3] is applied: $L_{\bar{l}_m} \leq L_V \leq 1.05 L_{\bar{l}_m}$

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

$[(1.05 \times t)/\bar{l}_m] \times [\sqrt{\Sigma(l_m - \bar{l}_m)^2/n(n-1)}] \times 100$ per cent, and when n is greater than 20, as

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

11 The application of this procedure to a fictitious area is illustrated in Figures 11 and 12.

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

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

14 No assessment is attempted for an isolated area of mineral less than 0.25 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 need be only approximately regular and in estimating the mean thickness only simple weighting is necessary. In practice, equal weighting can often be applied to thicknesses at all sample points. If, however, there is a distinctly unequal distribution of points, bias is avoided by dividing the sampled area into broad zones, to each of which a value roughly proportional to its area is assigned. This value is then shared between the data points within the zone as the weighting factor.

APPENDIX C

CLASSIFICATION AND DESCRIPTION OF SAND AND GRAVEL

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

The terminology commonly used by geologists when describing sedimentary rocks (Wentworth, 1922) is not entirely satisfactory for this purpose. For example, Wentworth proposed that a deposit should be described as a 'gravelly sand' when it contains more sand than gravel and there is at least 10 per cent of gravel, provided that there is less than 10 per cent of material finer than sand (less than $\frac{1}{4}$ mm) and coarser than pebbles (more than 64 mm in diameter). Because deposits containing more than 10 per cent fines are not embraced by this system a modified binary classification based on Willman (1942) has been adopted.

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

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

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

Thus it is possible to classify the mineral into one of twelve descriptive categories (see Figure 13). The procedure is as follows:

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

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

Many differing proposals exist for the classification of the grain size of sediments (Atterberg, 1905; Udden, 1914; Wentworth, 1922; Wentworth, 1935; Allen, 1936; Twenhofel, 1937; Lane and others, 1947). As Archer (1970a, b) has emphasised, there is a pressing need for a simple metric scale acceptable to both scientific and engineering interests, for which the class limit sizes correspond closely with certain marked changes in the natural properties of mineral particles. For example, there is an important change in the degree of cohesion between particles at about the $\frac{1}{16}$ mm size, which approximates to the generally accepted boundary between silt and sand. These and other requirements are met by a system based on Udden's geometric scale and a simplified form of Wentworth's terminology (Table 8), which is used in this Report.

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

The size distribution of borehole samples is determined by sieve analysis, which is presented by the laboratory as logarithmic cumulative curves (see, for example, British Standard 1377:1975). In this report the grading is tabulated on the borehole record sheets (Appendix F), the intercepts corresponding with the simple geometric scale $\frac{1}{16}$ mm, $\frac{1}{4}$ mm, 1 mm, 4 mm, 16 mm and so on as required. Original sample grading curves are available for reference at the appropriate office of the Institute.

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

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

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

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

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

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

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

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

Table 8 Classification of gravel, sand and fines

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

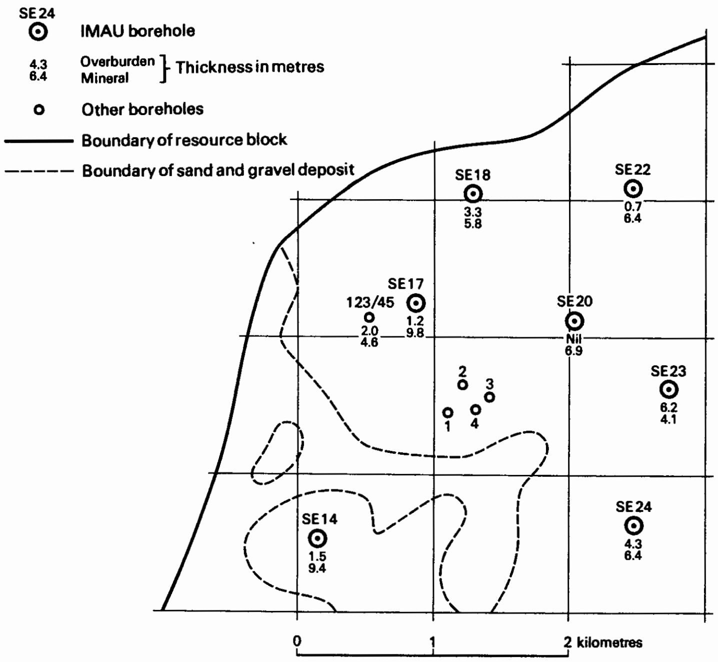


Figure 12 Example of resource block assessment: map of fictitious block

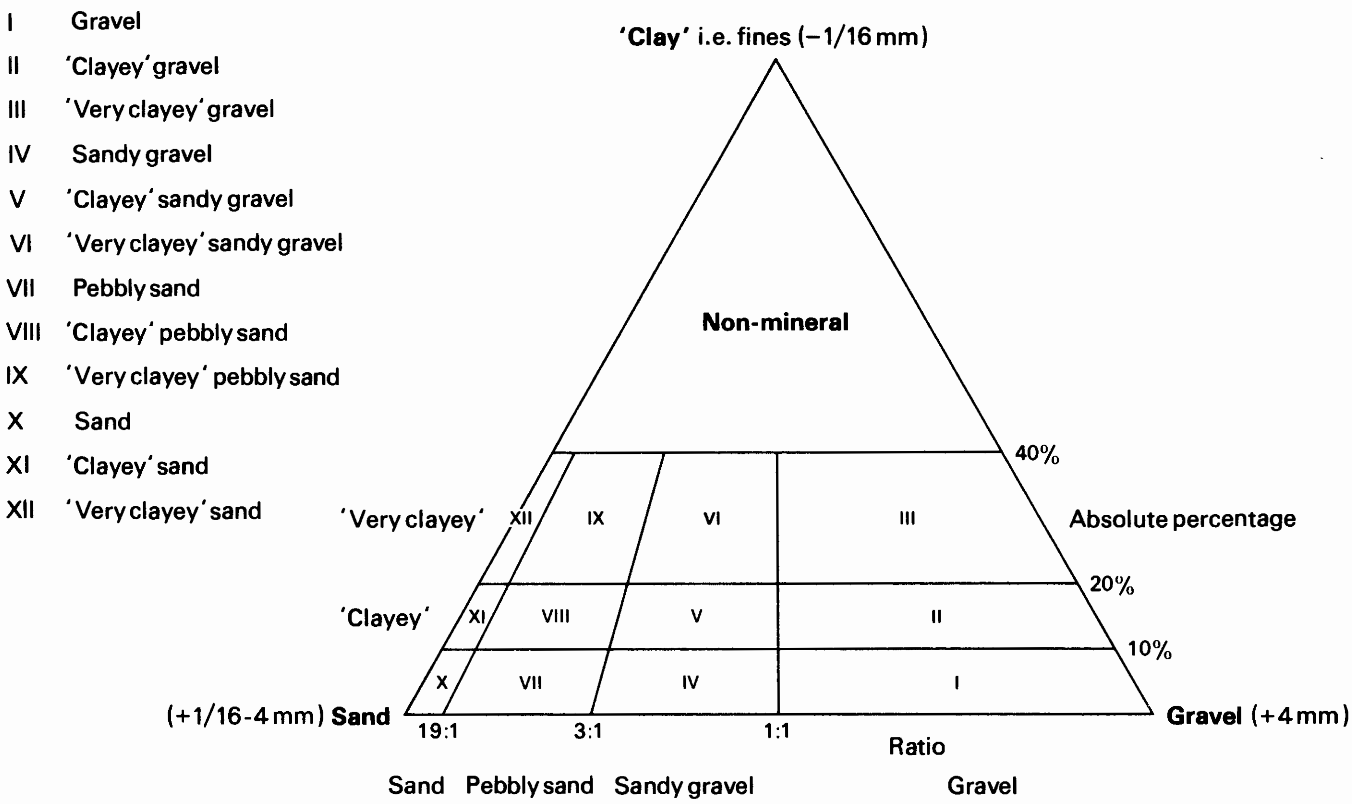


Figure 13 Diagram showing the descriptive categories used in the classification of sand and gravel

APPENDIX D

EXPLANATION OF THE BOREHOLE RECORDS

ANNOTATED EXAMPLE

NS 83 SW 195[1] 8286 3070[2] Scrogton, Douglas[3] **Block B**

Surface level +212.5 m (+697 ft)[4]
Water struck at +195.0 m[5]
254 and 203 mm percussion[6]
January 1978

Overburden 0.7 m[7]
Mineral 13.0 m
Waste 3.8 m
Mineral 1.8 m
Bedrock 1.0 m+

LOG

Geological classification[10]	Lithology[11]	Thickness m	Depth[8] m
	Soil	0.5	0.5
Head	Sandy slightly pebbly clay, firm medium brown	0.2	0.7
Fluvioglacial sand and gravel	**a** 'Clayey' gravel Gravel: coarse and fine with cobbles, subrounded to rounded, red, red-brown, yellow and white sandstones and basalt Sand: coarse to fine, subrounded, quartz with rare sandstone and felsite. Sandy lenses between 11.6 and 11.9 m Fines: disseminated clay	13.0	13.7
Till	Pebbly sandy clay, firm, brown-grey	3.8	17.5
Fluvioglacial sand and gravel	**b** 'Very clayey' sandy gravel Gravel: fine and coarse, subrounded, basalt and orange and white sandstones Sand: fine with medium and some coarse, subrounded to rounded, quartz, yellow-brown Fines: disseminated silt and clay	1.8	19.3
Carboniferous (Coal Measures)	Siltstone, light grey with silty seams	1.0+[9]	20.3

GRADING

	Mean for deposit[15] *percentages*			Depth below surface (m)[12]	*percentages*[13]							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$	
a	14	42	44	0.7–1.7	11	10	15	15	21	18	10	
				1.7–2.6	12	13	12	12	23	28	0	
				2.6–3.6	22	14	14	15	18	14	3	
				3.6–4.6	18	12	12	12	16	18	12	
				4.6–5.6	15	13	16	15	20	21	0	
				5.6–6.0	14	15	15	16	17	17	6	
				6.0–7.0	9	16	13	8	13	13	28	
				7.0–8.0	12	16	18	11	17	26	0	
				8.0–9.0	15	15	16	16	24	14	0	
				9.0–10.0	13	12	19	16	23	17	0	
				10.0–11.0	13	11	17	15	24	20	0	
				11.0–11.6	12	12	15	12	17	32	0	
				11.6–12.6	15	29	11	13	15	17	0	
				12.6–13.7	16	14	11	11	17	27	4	
				Mean	14	14	15	13	19	20	5	
b	22	58	20	17.5–18.5	29	31	21	6	7	6	0	†[14]
				18.5–19.3	14	27	21	9	19	10	0	†
				Mean	22	29	21	8	12	8	0	
a & b	15	44	41	Mean	15	16	15	13	18	19	4	

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

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

1 The number of the 1:25 000 sheet on which the borehole lies, for example NS 83.

2 The quarter of the 1:25 000 sheet on which the borehole lies and its number in a series for that quarter, for example SW 195.

Thus the full registration number is NS 83 SW 195. Usually this is abbreviated to 83 SW 195 in the text.

Natural sections used in the assessment have been registered under the same series. They are distinguished by an asterisk following the registration number. Shallow pits are numbered in a similar way but form part of a separate series: they are distinguished by the letter P placed before the serial number.

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

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

4 Surface level
The surface level at the borehole site is given in metres and feet above Ordnance Datum. 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 either encountered or statically measured is normally given (in metres above Ordnance Datum).

6 Type of drill and date of drilling
Modified shell and auger rigs were used in this survey. The drilling method, the external diameter of the casing used, and the month and year of completion of the borehole are stated.

7 Overburden, mineral, waste and bedrock
Mineral is aggregate which, as part of a deposit, falls within the arbitrary definition of potentially workable material (see p. 1). Mineral thicknesses may include waste partings up to 1.0 m thick which are excluded in the assessment of resources. Consequently mineral thicknesses given in Tables 6 and 7 may not correspond precisely with the logs. Bedrock is the 'formation', 'country rock' or 'rock head' below which potentially workable material will not be found. Waste is any material other than bedrock or mineral. Where waste occurs between the surface and mineral it is classified as overburden.

8 Thickness and depth
All measurements were made in metres.

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

10 Geological classification
The geological classification is given whenever possible.

11 Lithological description
When potentially workable material is recorded a general description based on the mean grading characteristics (for details see Appendix C) is followed by more detailed particulars. The descriptions of non-mineral deposits and bedrock are based on visual examination, in the field.

12 Sampling
A continuous series of bulk samples is taken through the thickness of potentially workable aggregate. A new sample is commenced whenever there is an appreciable lithological change within the deposit or ideally at every 1 m of depth.

13 Grading results
The results are expressed as per cent by weight retained on British Standard sieves whose aperture sizes are given in millimetres or fractions thereof.

14 Bailed samples
Fully representative sampling of sand and gravel is difficult to achieve particularly where groundwater levels are high. Comparison between boreholes and adjacent exposures suggests that in borehole samples the proportion of sand may be higher and the proportions of fines and coarse gravel (+16 mm) may be lower. Samples obtained by the bailing technique (that is, from deposits below the water table) are indicated thus: †.

15 Mean grading
The grading of the full thickness of the mineral deposit identified in the log is the mean of the individual sample gradings weighted by the thicknesses represented. The classification used is shown in Table 8. Where two or more distinct mineral units form continuous sequences, the mean gradings of these are also given under each unit. Where two or more distinct mineral units form a continuous sequence separated from another sequence by waste the combined mean grading of units appears on the left hand side of the log in addition to the mean grading for the full thickness of mineral identified. Each mineral unit is designated by a letter, for example (a), (b), etc. Samples with less than 40 per cent by weight passing $\frac{1}{16}$ mm, but not considered in the calculation of mean grading are indicated thus: ‡. These samples are either considered to be non-mineral due to the amount of overburden or form small parts of sequences regarded as generally not potentially workable.

APPENDIX E
LIST OF BOREHOLES, SECTIONS AND SHALLOW PITS USED IN THE ASSESSMENT OF RESOURCES

Borehole number*	Grid reference
1 INDUSTRIAL MINERALS ASSESSMENT UNIT BOREHOLES	
NS 93 NW 1	9016 3950
NS 83 NW 149	8363 3536
NS 83 NE 69	8528 3520
70	8641 3595
71	8712 3699
72	8784 3691
73	8731 3579
74	8898 3929
75	8899 3883
76	8870 3806
77A	8861 3800
77B	8861 3801
78	8991 3921
79	8930 3822
NS 83 SW 195	8286 3070
196A	8334 3143
196B	8335 3142
197	8334 3018
198	8434 3463
199	8472 3281
200	8414 3215
201	8429 3158
NS 83 SE 30	8555 3374
31	8523 3305
32	8588 3262
33	8536 3252
34	8519 3202
35	8675 3486
36	8637 3428
37	8643 3337
NS 82 NW 158	8094 2822
159	8146 2874
160	8129 2814
161	8286 2960
162	8247 2920

Pit number*	Grid reference
3 INDUSTRIAL MINERALS ASSESSMENT UNIT PITS (shallow pits dug by excavator)	
NS 93 NW P1	9043 3940
NS 83 NW P1	8066 3720
P2	8236 3915
NS 83 NE P1	8572 3609
P2	8662 3643
P3	8604 3522
P4	8813 3874
P5	8871 3807
P6	8916 3979
P7	8927 3827
NS 83 SW P1	8288 3072
P2	8286 3072
P3	8326 3153
P4	8430 3459
P5	8423 3419
P6	8446 3138
NS 83 SE P1	8588 3491
P2	8565 3440
P3	8558 3419
P4	8556 3374
P5	8587 3270
P6	8536 3250
P7	8636 3431
NS 82 NW P1	8100 2853
P2	8093 2823
P3	8014 2786
P4	8174 2912
P5	8255 2899
P6	8238 2872
P7	8319 2994

Section number*	Grid reference	Type of section	Locality
2 INDUSTRIAL MINERALS ASSESSMENT UNIT SECTIONS			
NS 83 NE 80	8605 3591	river-cliff	Folkerton Mill
81	8881 3824	pit	Sandilands
82	8977 3946	pit	Crookboat
NS 83 SW 202	8345 3057	river-cliff	Cransley
203	8330 3057	cutting	Douglas Monument
NS 82 NW 163	8107 2842	river-cliff	Glespin
164	8137 2838	river-cliff	Glespin
165	8213 2931	river-cliff	Windrow Wood

*By sheet quadrant

Borehole number*	Grid reference†	Thicknesses in metres			
		Overburden	Mineral	Waste	Bedrock
4 OTHER BOREHOLE RECORDS					
BLOCK A					
82 NW 97	8242 2940	1.9	7.3	3.4	1.5+
151	8204 2888	1.4	7.7		0.4+
154	8053 2791	0	2.1		1.9+
83 NW 95	8450 3503	0.3	2.5		1.5+
83 NE 4	8643 3639	0.6	5.2	13.1+	
33/1	8715 3643	1.5	23.5+ inc. 10.0 waste		
51	8657 3554	0	25.0+		
59	8531 3528	0.3	3.7		1.5+
60	8657 3566	1.2	23.8+		
62	8589 3597	0.2	4.2	6.6	0.4+
83 SW 63	8344 3136	0.9	18.3 inc. 3.1 waste		1.2+
65	8358 3124	0.5	18.3		0.4+
68	8371 3162	1.5	23.5+		
92	8485 3231	0.9	6.8 inc. 0.9 waste	12.2	0.6+
94	8491 3268	8.2 inc. 1.2 mineral	3.4	13.0	
108	8471 3216	1.9	17.2 inc. 4.4 waste		0.6+
109	8457 3230	0.7	22.5 inc. 5.2 waste		0.5+
134	8343 3467	2.2	1.7	3.3	4.7+
192	8462 3495	1.8	9.5		0.2+
83 SE 1	8616 3491	0.7	24.3+		
BLOCK B					
82 NW 152	8180 2915	0.6	19.1 inc. 3.8 waste	12.2	0.6+
155	8139 2818	0	1.8		0.5+
83 NW 110[1]	8451 3523	0.3	0.9		10.9+
83 NE 11	8683 3720	0.3	20.3	4.5+	
31[1]	8722 3717	not recorded	25.0+		
33/13	8720 3653	2.5	22.5+ inc. 2.7 waste		
52	8589 3563	not recorded	24.1		0.6+
83 SW 45	8277 3094	1.8	8.6 inc. 2.5 waste		6.1+
60	8244 3041	1.2	15.0		1.5+
64	8335 3148	0.3	13.6		0.7+
67	8341 3163	0.3	7.7	1.7	1.8+
72	8371 3135	0.3	15.8		0.3+
73	8384 3150	0.6	7.9	6.9	0.9+
74	8352 3176	0.6	16.6		1.7+
80	8309 3106	0.3	9.7 inc. 0.9 waste		0.4+
83 SW 103	8444 3165	0.4	21.0		2.6+
104	8446 3183	0.2	24.8+		
105	8464 3198	0.2	13.3 inc. 4.2 waste	6.1	0.6+
110	8452 3241	4.6	20.4+		
111	8432 3245	0.9	13.8		0.3+
115	8406 3227	0.4	15.7 inc. 0.6 waste		0.4+
140	8473 3451	0	2.5	17.9	
164	8414 3424	0	1.9	0.8	1.7+
170	8458 3469	2.9	2.3	10.0	0.6+
178	8383 3426	0	15.1 inc. 3.7 waste		0.1+
179	8424 3453	6.1	4.6	5.6	0.4+
180	8423 3463	2.3	3.4		8.5+
181[1]	8415 3479	3.7	1.2		0.2+
182	8410 3489			18.3	0.9+
183	8403 3444	0	17.1 inc. 3.1 waste		5.8+
83 SE 2	8553 3340	0	8.1		0.9+
8	8507 3479	0.3	24.7+ inc. 13.5 waste		
9	8603 3418			0.3	5.5+
21	8588 3270	2.3	4.0		0.4+

[1]Borehole not used in the calculations but referred to in the text. *By sheet quadrant.

APPENDIX F

INDUSTRIAL MINERALS ASSESSMENT UNIT BOREHOLE, SECTION PIT RECORDS

NS 82 NW 158 8094 2822 Tablestane, Glespin **Block A**

Surface level +206.3 m (+677 ft)
Water struck at +204.3 m
254 and 203 mm percussion
January 1978

Overburden 0.7 m
Mineral 11.9 m
Bedrock 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.7	0.7
Alluvium	**a** 'Clayey' gravel Gravel: coarse with fine and cobbles, subrounded, red and yellow sandstones, greywacke, basalt, felsite and quartzite Sand: coarse to fine, subangular to subrounded, quartz with some coal, yellow-brown Fines: disseminated silt and clay	1.9	2.6
Fluvioglacial sand and gravel	**b** Gravel Gravel: fine and coarse with cobbles, subrounded, red and yellow sandstones, greywacke, basalt and felsite Sand: medium and coarse with fine, subrounded with rare subangular clasts, quartz with rare coal which increases with depth Fines: disseminated silt and clay	10.0	12.6
Carboniferous (Coal Measures)	Silt, soft, dark grey	0.3	12.9
	Sandstone, fine grained, indurated, light grey	0.4	13.3
	Siltstone, light grey	0.4+	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	
a	10	33	57	0.7–1.6	11	14	11	12	17	22	13	
				1.6–2.6	9	10	8	11	15	24	23	†
				Mean	10	12	9	12	16	23	18	
b	3	42	55	2.6–3.6	4	10	14	11	25	31	5	†
				3.6–4.5	4	13	14	6	16	28	19	†
				4.5–5.6	4	16	20	12	26	22	0	†
				5.6–6.6	5	7	19	23	32	14	0	†
				6.6–7.6	3	5	14	19	30	24	5	†
				7.6–8.6	1	10	15	13	25	23	13	†
				8.6–9.7	3	9	16	15	25	26	6	†
				9.7–10.6	3	7	17	13	28	28	4	†
				10.6–11.6	4	9	23	20	24	20	0	†
				11.6–12.6	2	12	13	20	28	20	5	†
				Mean	3	10	17	15	26	23	6	
a & b	5	40	55	Mean	5	10	15	15	24	23	8	

NS 82 NW 159 8146 2874 Hazelside, Glespin **Block B**

Surface level +211.5 m (+694 ft)
Water struck at +206.2 m
254 and 203 mm percussion
January 1978

Overburden 0.2 m
Mineral 9.6 m
Waste 4.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	**a** Gravel Gravel: coarse and fine with cobbles – coarse mainly well rounded, fine angular to subrounded. Yellow and red sandstones, greywacke, felsite, basalt and vein quartz Sand: coarse to fine, angular to subrounded, medium brown Fines: disseminated silt	3.6	3.8
Glaciolacustrine deposit	**b** 'Very clayey' sand Gravel: fine with coarse, well rounded, basalt Sand: fine with traces of medium and coarse, subrounded, medium brown Fines: silt, disseminated and in seams	1.5	5.3
Fluvioglacial sand and gravel	**c** 'Very clayey' sandy gravel Gravel: coarse and fine with rare cobbles, subrounded to well rounded, red and yellow sandstones, greywacke, felsite, basalt, and vein quartz with quartzite and chert Sand: fine with medium and coarse, subrounded to rounded, quartz with rare coal, reddish brown Fines: disseminated silt and clay	4.5	9.8
Glaciolacustrine deposit	Silty clay, pale to medium grey, laminated	4.2	14.0
Fluvioglacial sand and gravel	'Clayey' sandy gravel Gravel: coarse and fine with cobbles and boulders, rounded to well rounded, red and yellow sandstones, greywacke, basalt, quartzite, vein quartz and felsite Sand: medium with coarse and fine, subrounded, medium to dark brown Fines: disseminated silt	0.4+	14.4
	Borehole terminated on boulder obstruction		

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64	
a	8	32	60	0.2–1.2	10	15	9	7	18	35	6	
				1.2–2.2	5	8	9	9	14	21	34	
				2.2–3.2	7	9	11	14	25	34	0	
				3.2–3.8	9	13	12	15	22	17	12	
				Mean	8	11	10	11	19	28	13	
b	28	69	3	3.8–5.3	28	64	3	2	2	1	0	
c	21	50	29	5.3–6.3	25	20	10	7	9	20	9	†
				6.3–7.3	17	15	16	10	14	28	0	†
				7.3–8.0	23	18	17	11	19	12	0	†
				8.0–9.0	16	26	19	10	15	14	0	†
				9.0–9.8	27	58	13	1	1	0	0	†
				Mean	21	27	15	8	11	16	2	
a to c	17	46	37	Mean	17	27	11	8	13	18	6	

NS 82 NW 160 **8129 2814** **Glespin West, Glespin** **Block B**

Surface level +216.6 m (+711 ft)
Water not struck
254 mm percussion
January 1978

Overburden 0.2 m
Mineral 3.0 m
Waste 5.4 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	Gravel Gravel: coarse with fine and cobbles (generally to 110 mm) – coarse mainly well rounded, fine subangular to well rounded. Red and yellow sandstones, greywacke, quartzite, vein quartz, felsite and coal Sand: medium with coarse and fine, subangular to rounded, quartz with some coal, reddish brown Fines: disseminated silt	3.0	3.2
Till	Gravelly clay, yellowy grey-brown with rounded pebbles of yellow sandstone and fragments of grey shale, mudstone and coal, cohesive. Becoming darker and containing more coal and shale	0.9	4.1
	Gravelly clay, dark grey with fragments of coal, shale and mudstone and rare rounded pebbles of yellow and red sandstone, cohesive	4.5	8.6
Carboniferous (Coal Measures)	Mudstone, reddish grey with plant remains and containing ironstone nodules between 9.1 and 9.3 m	1.0+	9.6

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
5	37	58	0.2–1.2	4	9	27	11	18	23	8
			1.2–2.2	5	6	14	14	21	36	4
			2.2–3.2	6	7	15	8	15	27	22
			Mean	5	7	19	11	18	29	11

NS 82 NW 161 8286 2960 Arnesalloch Bridge, Douglas **Block A**

Surface level +194.9 m (+639 ft)
Water struck at +192.3 m
254 mm percussion
February 1978

Overburden 0.2 m
Mineral 7.7 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	**a** 'Clayey' gravel Gravel: coarse and fine with cobbles (up to 200 mm) – coarse mainly well rounded, fine subrounded to well rounded. Yellow and white sandstones, greywacke, basalt, felsite, vein quartz and red mudstone Sand: coarse to fine, subangular to subrounded, quartz with some coal, medium brown becoming grey-brown below 1.2 m Fines: disseminated silt with thin seams of dark reddish grey tenacious silty clay between 2.4 and 2.7 m	4.0	4.2
Fluvioglacial sand and gravel	**b** Gravel Gravel: coarse and fine with cobbles (up to 160 mm) – coarse mainly well rounded, fine subangular to subrounded. Yellow and white sandstones, greywacke, basalt, felsite, andesite, vein quartz and black shale Sand: medium and coarse with some fine, subangular to subrounded, quartz, medium to dark brown Fines: disseminated silt	2.0	6.2
	c Sandy gravel Gravel: coarse and fine with cobbles, subangular to rounded, red, yellow and white sandstones with greywacke, basalt, felsite and vein quartz Sand: fine with medium and some coarse, rounded, yellow-brown Fines: disseminated silt	1.7	7.9
Carboniferous (Coal Measures)	Sandstone, medium grained, red becoming grey-brown	1.0+	8.9

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	
a	11	38	51	0.2–1.2	7	8	11	13	22	39	0	
				1.2–2.2	14	16	12	9	19	30	0	
				2.2–3.2	15	11	12	10	21	18	13	†
				3.2–4.2	7	13	21	18	19	22	0	†
				Mean	11	12	14	12	21	27	3	
b	3	32	65	4.2–5.2	2	2	14	13	22	30	17	†
				5.2–6.2	3	5	16	15	24	37	0	†
				Mean	3	3	15	14	23	34	8	
c	6	59	35	6.2–7.2	6	30	17	7	12	8	20	†
				7.2–7.9	5	43	20	3	10	19	0	†
				Mean	6	35	18	6	11	12	12	
b & c	4	45	51	Mean	4	18	17	10	17	24	10	
a to c	8	41	51	Mean	8	15	15	11	19	26	6	

NS 82 NW 162 **8247 2920** **Weston, Douglas** **Block B**

Surface level +210.9 m (+692 ft)
Water struck at +198.6 m
254 and 203 mm percussion
January 1978

Overburden 0.6 m
Mineral 18.2 m
Waste 2.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Fluvioglacial sand and gravel	**a** Sandy gravel Gravel: coarse and fine with rare cobbles, mainly well rounded, yellow, white and red sandstones, greywacke, basalt, quartzite and vein quartz Sand: medium with coarse and some fine, rounded, quartz with some coal, medium to dark brown Fines: disseminated silt	6.0	6.6
	b 'Very clayey' sandy gravel. Gravel occurs as stringers Gravel: coarse and fine, mainly well rounded, sandstone, greywacke, basalt, quartzite, vein quartz and coal Sand: fine with medium and coarse, rounded, medium brown Fines: silt, disseminated and in thin, laminated seams	2.6	9.2
Till	**c** 'Very clayey' sandy gravel Gravel: coarse and fine with cobbles, angular to well rounded, red, yellow and green sandstones, greywacke, mudstone, basalt and coal Sand: fine with medium and coarse, grey brown becoming medium brown Fines: clay, stiff No representative samples available below 12.3 m	7.0	16.2
Fluvioglacial sand and gravel	**d** Sandy gravel Gravel: coarse and fine with cobbles-coarse mainly well rounded, fine subangular to rounded. Quartzite, red and yellow sandstones, greywacke, red mudstone, basalt, vein quartz, felsite, porphyry and coal Sand: medium with fine and coarse, subangular to subrounded, quartz with coal, medium brown Fines: disseminated silt	2.6	18.8
Till	Sandy gravelly clay, dark grey, tough with angular to rounded pebbles of felsite, quartzite, vein quartz, sandstone, shale and coal	2.2+	21.0

Borehole terminated at 21.0 m on boulder obstruction

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$	
a	7	59	34	0.6–1.6	6	7	21	16	23	27	0	
				1.6–2.6	4	4	17	15	26	34	0	
				2.6–3.6	8	8	31	12	21	16	4	
				3.6–4.6	8	8	47	15	14	8	0	
				4.6–5.6	8	6	59	11	7	9	0	
				5.6–6.6	10	7	54	15	10	4	0	
				Mean	7	7	38	14	17	16	1	
b	27	49	24	6.6–7.6	27	23	14	8	13	15	0	
				7.6–8.6	30	33	7	5	9	16	0	
				8.6–9.2	25	40	15	7	9	4	0	
				Mean	27	31	11	7	11	13	0	
c	32	42	26	9.2–10.2	33	29	11	5	8	4	10	
				10.2–12.3	31	24	10	7	11	17	0	
				Mean	32	26	10	6	10	13	3	
d	1	60	39	16.2–17.2	1	20	32	17	19	11	0	†
				17.2–18.2	1	14	25	15	20	25	0	†
				18.2–18.8	2	20	23	13	12	23	7	†
				Mean	1	18	27	15	18	19	2	
a & b	13	56	31	Mean	13	14	30	12	15	15	1	
a+b+d	10	57	33	Mean	10	15	29	13	16	16	1	
a to d	15	53	32	Mean	15	17	25	11	15	16	1	

NS 82 NW 163* **8107 2842** **Glespin, north bank of Douglas Water** **Block B**

Surface level +210.7 m (+691 ft)
Water seepage at +208.2 m
Sampling by hand
May 1978

Overburden 0.4 m
Mineral 2.1 m
Waste 3.2 m
Bedrock 0.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	Gravel Gravel: coarse with fine and numerous cobbles, rounded to well rounded, sandstone with greywacke, basalt, porphyry and felsite Sand: medium with coarse and some fine, rounded, quartz, medium brown, unsorted Fines: disseminated silt	2.1	2.5
Till	Gravelly clay, tough with sandy patches, medium to dark grey	3.2	5.7
Carboniferous (Coal Measures)	Siltstone, weathered, maroon	0.6+	6.3

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
2	26	72	0.4–1.4	1	3	11	5	7	24	49
			1.4–2.5	2	4	18	11	13	45	7
			Mean	2	3	15	8	10	35	27

NS 82 NW 164* **8137 2838** **Glespin, south bank of Douglas Water** **Block B**

Surface level +210.5 m (+691 ft)
Section dry
Sampling by hand
June 1978

Overburden 0.5 m
Mineral 3.0 m
Waste 5.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Fluvioglacial sand and gravel	'Clayey' sandy gravel Gravel: coarse and fine with cobbles, rounded to well rounded, mainly sandstone and greywacke Sand: coarse to fine, subrounded, quartz, orange-brown Fines: disseminated silt and clay	3.0	3.5
Till	Pebbly sand, clay, soft with pebbles mainly of sandystone, medium brown	3.2	6.7
	Pebbly clay, stiff with fine fragments of coal, shale and sandstone, dark grey	2.5+	9.2

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
13	45	42	0.5–1.7	11	13	15	16	19	26	0
			1.7–2.7	15	13	15	19	14	15	9
			2.7–3.5	15	18	13	13	17	24	0
			Mean	13	14	15	16	17	22	3

NS 82 NW165* **8213 2931** **Weston, Douglas** **Block B**

Surface level +202.0 m (+663 ft)
Section dry
Sampling by hand
June 1978

Overburden 0.3 m
Mineral 6.4 m
Bedrock 0.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	**a** Gravel Gravel: coarse and fine with numerous cobbles, well rounded, sandstone, greywacke, basalt, felsite, porphyry, vein quartz and coal Sand: coarse to fine, rounded, quartz, medium brown, unsorted Fines: disseminated silt	4.4	4.7
	b Sandy gravel, clasts showing imbrication Gravel: fine with coarse, up to 30 mm, well rounded, sandstone, greywacke, basalt, felsite, porphyry, vein quartz and coal Sand: coarse to fine, rounded, quartz, medium brown, well sorted Fines: disseminated silt	2.0	6.7
Carboniferous (Coal Measures)	Mudstone, with shaly partings, weathered, maroon	0.4+	7.1

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
a	2	31	67	0.3–1.8	2	10	15	12	21	25	15
				1.8–3.2	1	6	5	6	7	19	56
				3.2–4.7	2	10	12	15	21	24	16
				Mean	2	9	11	11	16	23	28
b	7	47	46	4.7–6.7	7	10	15	22	31	15	0
a & b	3	36	61	Mean	3	9	12	15	21	20	20

NS 83 NW 149 8363 3536 Saddlerhead, Coalburn **Block B**

Surface level +209.5 m (+687 ft)
Water struck at +203.1 m
254 mm percussion
February 1978

Overburden 0.6 m
Mineral 5.8 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Fluvioglacial sand and gravel	'Clayey' sandy gravel Gravel: coarse and fine with rare cobbles, subrounded to rounded, yellow and white sandstones, greywacke, weathered basalt and quartzite, with some felsite and coal Sand: fine and medium with coarse, fining with depth, subrounded, quartz, medium brown Fines: disseminated clay	5.8	6.4
Carboniferous (Passage Group)	Sandstone, medium grained, yellow	0.2+	6.6

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
16	60	24	0.6–1.6	14	16	30	11	16	13	0
			1.6–2.6	16	28	29	7	9	11	0
			2.6–3.6	18	38	20	4	5	15	0
			3.6–4.6	18	32	18	7	12	13	0
			4.6–5.7	16	33	12	6	12	5	16
			5.7–6.4	15	42	24	3	6	10	0
			Mean	16	31	22	7	10	11	3

NS 83 NE 69 8528 3520 Poniel Old Bridge, Douglas Water **Block A**

Surface level +187.1 m (+614 ft)
Water struck at +186.3 m
254 mm percussion
March 1978

Overburden 0.4 m
Mineral 9.0 m
Bedrock 0.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Alluvium	**a** 'Clayey' sandy gravel Gravel: coarse and fine, subrounded to rounded, yellow sandstone, greywacke, basalt and coal Sand: fine and medium with coarse, subrounded, quartz with rock fragments, medium brown to grey-brown Fines: silt, disseminated and in seams	3.3	3.7
Fluvioglacial sand and gravel	**b** Gravel Gravel: coarse and fine with numerous cobbles, coarsening with depth, mainly well rounded, red, yellow-brown and white sandstones, greywacke, basalt, felsite, porphyry, vein quartz, shale and coal Sand: medium with fine and coarse, subrounded to rounded, quartz with rock fragments, medium to dark grey-brown Fines: disseminated silt with rare, thin silty laminae	5.7	9.4
Carboniferous (Passage Group)	Sandstone, medium to coarse grained, white with carbonaceous debris	0.7+	10.1

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	
a	17	57	26	0.4–0.7	17	22	12	7	7	35	0	
				0.7–1.7	9	26	38	10	10	7	0	†
				1.7–2.7	23	27	18	7	12	13	0	†
				2.7–3.7	20	24	15	8	10	23	0	†
				Mean	17	26	23	8	10	16	0	
b	4	45	51	3.7–4.7	5	11	36	18	18	12	0	†
				4.7–5.7	3	25	48	7	10	7	0	†
				5.7–6.7	5	12	27	8	9	28	11	†
				6.7–7.7	3	7	12	10	29	39	0	†
				7.7–8.7	3	8	10	9	22	41	7	†
				8.7–9.4	3	4	6	3	21	49	14	†
				Mean	4	11	24	10	18	28	5	
a & b	9	49	42	Mean	9	17	23	9	15	24	3	

NS 83 NE 70 **8641 3595** **Wolfcrook's, Douglas Water** **Block B**

Surface level +195.3 m (+641 ft)
Water struck at +175.5 m
254 and 203 mm percussion
March 1978

Overburden 3.0 m
Mineral 1.0 m
Waste 3.0 m
Mineral 18.0+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.8	0.8
Glaciolacustrine deposits	Silt, medium brown with traces of fine sand	2.2	3.0
	a 'Very clayey' sand Sand: fine with some medium and traces of coarse, subrounded, quartz, medium brown Fines: silt, disseminated and in seams	1.0	4.0
	Sandy silt, medium brown with some fine sand	3.0	7.0
	b 'Very clayey' sand Sand: fine with some medium, subrounded, quartz, medium brown Fines: silt, disseminated and in seams	3.0	10.0
Fluvioglacial sand and gravel	**c** Sand Sand: medium and fine with traces of coarse, subrounded, quartz with some coal, medium brown Fines: disseminated silt	2.0	12.0
	d Pebbly sand Gravel: fine with coarse, subangular to rounded, red, yellow and white sandstones, greywacke, coal, felsite, basalt, vein quartz and quartzite Sand: medium with fine and some coarse, subangular to subrounded, quartz, medium brown Fines: disseminated silt	10.8	22.8
	e Sandy gravel Gravel: fine and coarse with rare cobbles, subrounded to rounded, yellow, red and white sandstones, greywacke, felsite, basalt, vein quartz and coal Sand: medium and coarse with fine, subrounded, quartz, medium grey-brown Fines: disseminated silt	2.2+	25.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
					−$\frac{1}{16}$	+$\frac{1}{16}$–$\frac{1}{4}$	+$\frac{1}{4}$–1	+1–4	+4–16	+16–64	+64	
a	21	79	0	3.0–4.0	21	62	16	1	0	0	0	
				4.0–5.1	41	52	6	1	0	0	0	‡
				5.1–6.0	39	59	2	0	0	0	0	‡
				6.0–7.0	44	55	1	0	0	0	0	‡
b	23	77	0	7.0–8.1	20	68	11	1	0	0	0	
				8.1–9.0	17	69	14	0	0	0	0	
				9.0–10.0	33	55	12	0	0	0	0	
				Mean	23	64	12	1	0	0	0	
c	4	96	0	10.0–11.0	3	48	49	0	0	0	0	
				11.0–12.0	4	45	50	1	0	0	0	
				Mean	4	46	49	1	0	0	0	
d	4	89	7	12.0–13.0	3	17	69	6	3	2	0	
				13.0–14.0	2	33	57	5	2	1	0	
				14.0–15.0	2	31	60	6	1	0	0	
				15.0–16.0	3	15	62	12	6	2	0	
				16.0–16.8	4	14	61	13	7	1	0	
				16.8–17.7	2	13	53	15	13	4	0	
				17.7–18.7	2	35	49	9	5	0	0	
				18.7–19.7	6	48	41	4	1	0	0	
				19.7–20.7	3	34	59	3	1	0	0	†
				20.7–21.7	9	33	40	7	6	5	0	†
				21.7–22.5	4	22	42	12	12	8	0	†
				22.5–22.8	7	36	43	6	5	3	0	†
				Mean	4	27	54	8	5	2	0	
e	3	51	46	22.8–23.8	4	11	20	19	27	15	4	†
				23.8–24.8	3	12	21	17	19	28	0	†
				24.8–25.0	3	16	29	21	18	13	0	†
				Mean	3	12	21	18	23	21	2	
a & b	23	77	0	Mean	23	63	13	1	0	0	0	
c to e	4	84	12	Mean	4	27	48	9	7	5	0	
a to e	8	83	9	Mean	8	35	41	7	5	4	0	

‡non-mineral: not considered in calculation of mean grading

NS 83 NE 71 8712 3699 Barnhill, Douglas Water **Block B**

Surface level +189.8 m (+623 ft)
Water struck at +187.9 m
254 mm percussion
February 1978

Overburden 0.5 m
Mineral 1.8 m
Bedrock 0.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glaciolacusterine deposit	Silt: light to medium grey with some iron staining	0.1	0.5
Fluvioglacial sand and gravel	'Very clayey' pebbly sand Gravel: fine with coarse, rounded, sandstone, greywacke, felsite, vein quartz and coal Sand: fine and medium with some coarse, subangular to subrounded, quartz with some felsite and coal, grey-brown Fines: silt and clay, disseminated with some silty seams	1.8	2.3
Carboniferous (Upper Limestone Group)	Sandstone, fine grained, medium grey passing downwards into siltstone	0.6+	2.9

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	
30	64	6	0.5–1.5	24	31	36	5	4	0	0	
			1.5–2.3	37	30	20	5	6	2	0	†
			Mean	30	30	29	5	5	1	0	

NS 83 NE 72 8784 3691 Dyke, Douglas Water **Block B**

Surface level +207.4 m (+680 ft)
Water struck at +204.8 m
254 mm percussion
February 1978

Overburden 0.1 m
Mineral 4.4 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	**a** 'Very clayey' sandy gravel Gravel: coarse and fine with cobbles, angular to rounded, yellow sandstone with basalt, felsite, greywacke and coal Sand: fine with medium and coarse, subrounded with coarse angular rock fragments, grey-brown becoming medium brown below 0.5 m Fines: disseminated silt and clay, stiff below 1.5 m	2.0	2.1
	b 'Clayey' gravel Gravel: coarse with fine and rare cobbles, angular to rounded, yellow sandstone with greywacke, basalt, felsite and coal Sand: fine with medium and coarse, angular to subrounded, medium brown Fines: disseminated silt and clay, stiff	2.4	4.5
Carboniferous (Limestone Coal Group)	Sandstone, fine to medium grained, yellow, with plant remains	0.3+	4.8

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	
a	26	44	30	0.1–1.1	27	24	11	6	7	11	14	
				1.1–2.1	24	25	13	9	16	13	0	
				Mean	26	24	12	8	11	12	7	
b	11	29	60	2.1–3.2	8	12	7	6	26	41	0	†
				3.2–4.5	13	18	8	7	13	41	0	†
				Mean	11	15	8	6	19	41	0	
a & b	17	36	47	Mean	17	19	10	7	16	28	3	

NS 83 NE 73 8731 3579 Holmhead, Douglas Water **Block B**

Surface level +203.4 m (+667 ft)
Water struck at +201.2 m
254 mm percussion
February 1978

Overburden 0.1 m
Mineral 4.6 m
Bedrock 0.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Fluvioglacial sand and gravel	'Very clayey' sandy gravel Gravel: coarse and fine with rare cobbles, subangular to well rounded, yellow and red sandstones, greywacke and basalt with felsite and coal Sand: fine with medium and some coarse, subrounded, quartz with coal, medium brown Fines: disseminated silt and clay	4.6	4.7
Carboniferous (Upper Limestone Group)	Mudstone, weathered, dark grey to black, shaly in parts	0.8+	5.5

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines	Sand			Gravel			
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64	
23	48	29	0.1–1.1	32	29	14	7	11	7	0	
			1.1–2.1	25	28	14	9	11	13	0	
			2.1–3.1	14	25	16	8	14	16	7	†
			3.1–4.1	16	21	11	8	13	31	0	†
			4.1–4.7	28	26	14	10	12	10	0	†
			Mean	23	26	14	8	12	16	1	

NS 83 NE 74 **8898 3929** **Harperfield, Lanark** **Block B**

Surface level +207.2 m (+680 ft)
Water not struck
254 mm percussion
March 1978

Overburden 0.3 m
Mineral 3.6 m
Bedrock 0.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	'Very clayey' sandy gravel Gravel: coarse with fine, coarse gravel content reducing with depth, subangular to rounded, brown sandstone, quartzite, vein quartz and felsite. Sand: fine with some medium and coarse, subrounded, quartz, orange-brown Fines: disseminated silt and clay	3.6	3.9
Lower Old Red Sandstone	Sandstone, medium grained, yellow-brown to red, mottled	0.4+	4.3

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
23	56	21	0.3–1.3	21	34	10	4	7	24	0
			1.3–2.3	20	42	12	4	8	14	0
			2.3–3.0	26	38	12	5	9	10	0
			3.0–3.9	25	46	15	4	7	3	0
			Mean	23	40	12	4	8	13	0

NS 83 NE 75 8899 3883 Douglasmouth Bridge, Sandilands Station **Block A**

Surface level +176.1 m (+578 ft)
Water struck at +174.1 m
254 and 203 mm percussion
February 1978

Overburden 1.5 m
Mineral 14.0 m
Waste 1.5 m
Mineral 8.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, with interbedded overbank deposits	1.0	1.0
Alluvium	Clayey silt, medium brown	0.5	1.5
	a 'Very clayey' sandy gravel Gravel: fine and coarse, rounded, basalt, diorite, vein quartz, greywacke, brown and white sandstones with rare coal Sand: fine with medium and some coarse, subrounded, quartz with some coal, medium brown Fines: silt and clay, disseminated and in seams	1.0	2.5
	b 'Clayey' sand Gravel: traces of fine, becoming rarer with depth Sand: fine with rare medium and traces of coarse, subrounded, quartz with coal, medium brown Fines: silt and clay, disseminated and in seams	5.0	7.5
Glaciolacustrine deposits	**c** 'Very clayey' sand Sand: fine with traces of medium, subrounded, quartz with coal, grey-brown Fines: silt, disseminated and in seams	8.0	15.5
	Silt, sandy to 16.3 m, laminated, grey	1.5	17.0
	d 'Clayey' sand Sand: fine with medium, subrounded, quartz with coal, grey-brown Fines: silt, disseminated and in seams	8.0+	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	
a	24	57	19	1.5–2.5	24	36	16	5	11	8	0	†
b	13	86	1	2.5–3.5	15	72	8	3	1	1	0	†
				3.5–4.5	13	78	5	2	2	0	0	†
				4.5–5.5	12	84	3	1	trace	0	0	†
				5.5–6.5	12	81	6	1	trace	0	0	†
				6.5–7.5	12	85	3	trace	0	0	0	†
				Mean	13	80	5	1	1	0	0	
c	23	77	0	7.5–8.5	23	76	1	0	0	0	0	†
				8.5–9.5	18	80	2	0	0	0	0	†
				9.5–10.5	19	80	1	0	0	0	0	†
				10.5–11.5	15	83	2	0	0	0	0	†
				11.5–12.5	23	76	1	0	0	0	0	†
				12.5–13.5	35	64	1	0	0	0	0	†
				13.5–14.5	36	63	1	0	0	0	0	†
				14.5–15.5	18	80	2	0	0	0	0	†
				Mean	23	75	2	0	0	0	0	
d	19	81	0	17.0–18.0	33	54	13	0	0	0	0	†
				18.0–19.0	21	47	32	0	0	0	0	†
				19.0–20.0	14	47	39	0	0	0	0	†
				20.0–21.0	18	54	28	0	0	0	0	†
				21.0–22.0	15	55	30	0	0	0	0	†
				22.0–23.0	25	49	26	0	0	0	0	†
				23.0–24.0	19	55	26	0	0	0	0	†
				24.0–25.0	7	66	27	0	0	0	0	†
				Mean	19	53	28	0	0	0	0	
a & b	15	81	4	Mean	15	73	7	1	3	1	0	
c & d	21	79	0	Mean	21	64	15	0	0	0	0	
a to d	19	80	1	Mean	19	67	12	1	1	0	0	

NS 83 NE 76 **8870 3806** **Sandilands, Carmichael** **Block B**

Surface level +193.9 m (+636 ft)
Water struck at +178.9 m
254 and 203 mm percussion
February 1978

Overburden 0.5 m
Mineral 1.8 m
Waste 12.7 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Fluvioglacial sand and gravel	'Very clayey' sandy gravel Gravel: coarse and fine with cobbles (up to 150 mm), subrounded to rounded, basalt, porphyritic basalt, greywacke and yellow and brown sandstones Sand: fine with medium and some coarse, subrounded, quartz, light brown Fines: disseminated clay	1.8	2.3
Till	Pebbly sandy clay, stiff to hard, with clasts of sandstone, basalt, rare felsite and vein quartz, dark brown	8.1	10.4
Glaciolacustrine deposit	Clayey silt, laminated, with light and dark bands, firm to stiff, green-grey	4.6	15.0
Upper Old Red Sandstone	Sandstone, medium grained, grey-red	0.3+	15.3

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
28	50	22	0.5–1.5	29	33	16	4	6	12	0
			1.5–2.3	27	27	12	8	17	9	0
			Mean	28	30	14	6	11	11	0

NS 83 NE 77 A 8861 3800 Sandilands, Carmichael Block B

Surface level +196.8 m (+646 ft)
Water struck at +193.8 m and at +191.4 m
254 mm percussion
February 1978

Overburden 0.4 m
Mineral 4.0 m
Waste 1.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	'Very clayey' pebbly sand Gravel: fine and coarse, coarsening with depth, subrounded, basalt, red and yellow sandstones, greywacke, quartzite and coal Sand: fine with medium and some coarse, quartz, light brown Fines: disseminated silt and clay with silty seams	4.0	4.4
Till	Pebbly sandy clay, hard, dark brown	1.6+	6.0
	Borehole abandoned on boulder obstruction		

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
21	62	17	0.4–1.5	16	20	25	14	20	5	0
			1.5–2.5	30	40	10	6	6	8	0
			2.5–3.6	23	64	11	1	1	0	0
			3.6–4.4	17	18	22	10	16	17	0
			Mean	21	37	17	8	10	7	0

NS 83 NE 77 B **8861 3801** **Sandilands, Carmichael** **Block B**

Surface level +196.8 m (+646 ft)
Water struck at +193.8 m and at +191.5 m
254 mm percussion
February 1978

Overburden 0.4 m
Mineral 4.6 m
Waste 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	'Very clayey' sandy gravel Gravel: coarse and fine with cobbles, subrounded to rounded, red and yellow sandstones, greywacke, weathered basalt, quartzite and coal Sand: fine with medium and some coarse, subrounded, quartz, light brown Fines: clay and silt, disseminated and in seams	4.6	5.0
Till	Pebbly sandy clay, stiff, dark brown	0.3+	5.3
	Borehole abandoned on boulder obstruction		

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
23	48	29	0.4–1.4	32	19	6	3	4	12	24
			1.4–2.4	16	17	18	11	17	21	0
			2.4–3.4	18	44	14	6	8	10	0
			3.4–4.6	25	34	11	4	8	13	5
			4.6–5.0	23	40	14	7	8	8	0
			Mean	23	30	12	6	9	13	7

NS 83 NE 78 8991 3921 Crookboat, Carmichael **Block B**

Surface level +201.7 m (+662 ft)
Water struck at +190.7 m and at +188.9 m
254 and 203 mm percussion
February 1978

Overburden 0.2 m
Mineral 12.6 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	**a** 'Clayey' pebbly sand Gravel: fine and coarse with rare cobbles, mainly rounded with subrounded, yellow sandstone, greywacke, basalt, felsite and vein quartz Sand: medium and fine with coarse, subrounded to rounded, quartz, medium brown Fines: disseminated silt	2.0	2.2
	b 'Clayey' sand Gravel: fine with coarse, mainly rounded with subrounded, yellow sandstone, greywacke, basalt, felsite, vein quartz and coal Sand: fine and medium with some coarse, subrounded to rounded, quartz with some coal, light to medium brown Fines: silt, disseminated and in seams	8.8	11.0
	c Pebbly sand Gravel: fine and coarse, white sandstone, greywacke, basalt and felsite Sand: medium with fine and some coarse – fine and medium, subrounded to rounded and of quartz; coarse, of angular rock fragments. Grey-brown Fines: disseminated silt	1.8	12.8
Upper Old Red Sandstone	Sandstone, medium grained, yellow	0.5+	13.3

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	
a	13	73	14	0.2–1.2	14	31	37	7	7	4	0	
				1.2–2.2	12	28	31	12	11	6	0	
				Mean	13	29	34	10	9	5	0	
b	13	84	3	2.2–3.2	12	42	41	3	1	1	0	
				3.2–4.0	10	62	24	2	1	1	0	
				4.0–5.0	19	27	33	10	7	4	0	
				5.0–6.0	15	49	24	9	3	0	0	
				6.0–7.0	13	50	34	3	0	0	0	
				7.0–8.0	10	36	53	1	0	0	0	
				8.0–9.0	13	47	35	4	1	0	0	
				9.0–10.0	14	26	52	6	2	0	0	
				10.0–11.0	16	35	40	7	2	0	0	
				Mean	13	41	38	5	2	1	0	
c	5	79	16	11.0–12.0	4	24	45	9	9	9	0	†
				12.0–12.8	6	33	37	12	8	4	0	†
				Mean	5	28	41	10	9	7	0	
a to c	12	82	6	Mean	12	37	38	7	4	2	0	

NS 83 NE 79 **8930 3822** **Burnhousemill, Carmichael** **Block B**

Surface level +204.0 m (+669 ft)
Water not struck
254 mm percussion
February 1978

Overburden 0.7 m
Mineral 1.4 m
Waste 1.3 m
Bedrock 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Head	Sandy pebbly clay, plastic, medium brown	0.2	0.7
Fluvioglacial sand and gravel	'Clayey' sandy gravel Gravel: coarse and fine with rare cobbles, subrounded, greywacke, basalt and yellow, orange and grey sandstones Sand: fine and medium with coarse, subrounded, quartz, light brown Fines: disseminated silt and clay with rare clay seams	1.4	2.1
Till	Pebbly sandy clay, firm, medium brown	1.3	3.4
Upper Old Red Sandstone	Sandstone, medium grained, indurated, reddish grey	1.1+	4.5

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
16	43	41	0.7–1.7	15	23	15	9	17	21	0
			1.7–2.1	18	13	13	9	16	20	11
			Mean	16	20	14	9	17	21	3

NS 83 NE 80* **8605 3591** **Poniel Water, Folkerton Mill** **Block B**

Surface level +185.7 m (+609 ft)
Section dry
Sampling by hand
June 1978

Overburden 0.6 m
Mineral 3.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Glacial sand and gravel	Gravel Gravel: coarse with fine and cobbles, rounded to well rounded, sandstone, greywacke, basalt, porphyry, ironstone, chert and vein quartz Sand: coarse and medium with fine, subrounded, quartz, medium brown, unsorted Fines: disseminated silt	3.5+	4.1

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
6	30	64	0.6–1.6	6	9	23	26	8	23	5
			1.6–2.6	4	4	6	6	10	38	32
			2.6–4.1	7	5	6	9	13	35	25
			Mean	6	6	11	13	11	32	21

NS 83 NE 81* **8881 3824** **Sandilands, Carmichael** **Block B**

Surface level +193.4 m (+635 ft)
Section dry
Sampling by hand
May 1978

Overburden 0.8 m
Mineral 1.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.8	0.8
Fluvioglacial sand and gravel	Gravel Gravel: coarse and fine with cobbles, subrounded to well rounded, red, yellow and white sandstones, greywacke, basalt, felsite, vein quartz and coal Sand: coarse to fine, subrounded, quartz, medium brown, poorly sorted Fines: disseminated silt	1.7+	2.5

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
3	38	59	0.8–1.8	2	7	15	8	13	36	19
			1.8–2.5	5	14	16	19	24	22	0
			Mean	3	10	15	13	18	30	11

NS 83 NE 82* **8977 3946** **Crookboat, Carmichael** **Block B**

Surface level +193.4 m (+635 ft)
Section dry
Sampling by hand
May 1978

Overburden 0.6 m
Mineral 5.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Fluvioglacial sand and gravel	**a** Sandy gravel showing cross bedding and imbrication of gravel Gravel: coarse with some fine, mainly well rounded, sandstone with greywacke, felsite, basalt, coal and vein quartz Sand: fine and medium with some coarse, rounded, quartz, medium brown Fines: disseminated silt	1.0	1.6
	b 'Clayey' sand Gravel: coarse and fine, well rounded, red and yellow sandstones, greywacke, basalt, felsite, vein quartz and coal, occurring as stringers Sand: fine and medium with some coarse, rounded quartz with some coal, yellow-brown, cross-bedded Fines: silt, disseminated and in seams	4.1+	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
a	5	52	43	0.6–1.6	5	24	23	5	7	36	0
b	14	82	4	1.6–2.6	14	42	30	9	3	2	0
				2.6–3.6	14	37	33	7	3	6	0
				3.6–4.6	18	47	34	1	0	0	0
				4.6–5.7	10	55	31	2	1	1	0
				Mean	14	45	32	5	2	2	0
a & b	12	76	12	Mean	12	41	30	5	3	9	0

NS 83 SW 195 8286 3070 Scrogton, Douglas **Block B**

Surface level +212.5 m (+697 ft)
Water struck at +195.0 m
254 and 203 mm percussion
January 1978

Overburden 0.7 m
Mineral 13.0 m
Waste 3.8 m
Mineral 1.8 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Head	Sandy slightly pebbly clay, firm, medium brown	0.2	0.7
Fluvioglacial sand and gravel	**a** 'Clayey' gravel Gravel: coarse and fine with cobbles, subrounded to rounded, red, red-brown, yellow and white sandstones, greywacke and basalt Sand: coarse to fine, subrounded, quartz with rare sandstone and felsite. Sandy lenses between 11.6 and 11.9 m Fines: disseminated clay	13.0	13.7
Till	Pebbly sandy clay, firm, brown-grey	3.8	17.5
Fluvioglacial sand and gravel	**b** 'Very clayey' sandy gravel Gravel: fine and coarse, subrounded, greywacke, basalt and orange and white sandstones Sand: fine with medium and some coarse, subrounded to rounded, quartz, yellow-brown Fines: disseminated silt and clay	1.8	19.3
Carboniferous (Coal Measures)	Siltstone, light grey with silty seams	1.0+	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	
a	14	42	44	0.7–1.7	11	10	15	15	21	18	10	
				1.7–2.6	12	13	12	12	23	28	0	
				2.6–3.6	22	14	14	15	18	14	3	
				3.6–4.6	18	12	12	12	16	18	12	
				4.6–5.6	15	13	16	15	20	21	0	
				5.6–6.0	14	15	15	16	17	17	6	
				6.0–7.0	9	16	13	8	13	13	28	
				7.0–8.0	12	16	18	11	17	26	0	
				8.0–9.0	15	15	16	16	24	14	0	
				9.0–10.0	13	12	19	16	23	17	0	
				10.0–11.0	13	11	17	15	24	20	0	
				11.0–11.6	12	12	15	12	17	32	0	
				11.6–12.6	15	29	11	13	15	17	0	
				12.6–13.7	16	14	11	11	17	27	4	
				Mean	14	14	15	13	19	20	5	
b	22	58	20	17.5–18.5	29	31	21	6	7	6	0	†
				18.5–19.3	14	27	21	9	19	10	0	†
				Mean	22	29	21	8	12	8	0	
a & b	15	44	41	Mean	15	16	15	13	18	19	4	

NS 83 SW 196 A **8334 3143** **Broadlea Cottage, Douglas** **Block B**

Surface level +193.4 m (+634 ft)
Water not struck
254 mm percussion
February 1978

Overburden 0.3 m
Mineral 3.0 m
Waste 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	**a** 'Clayey' gravel Gravel: coarse and fine with rare cobbles, rounded to well rounded, yellow, red and green sandstones, greywacke, basalt, porphyry and vein quartz Sand: medium, fine and coarse, subrounded, medium brown Fines: disseminated silt and clay	2.0	2.3
	b Gravel Gravel: coarse and fine with cobbles, rounded to well rounded, yellow and red sandstones, greywacke, basalt, porphyry and vein quartz Sand: coarse to fine, subrounded, medium brown Fines: disseminated silt	1.0	3.3
Glaciolacustrine deposit	Silt, laminated, maroon with orange-brown and black partings	1.1	4.4
Fluvioglacial sand and gravel	'Clayey' gravel Gravel: coarse and fine with rare cobbles, mainly well rounded, red and yellow sandstones, basalt, greywacke and vein quartz Sand: coarse to fine, rounded, medium brown Fines: disseminated silt	0.4+	4.8
	Borehole terminated on boulder obstruction		

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64	
a	19	39	42	0.3–1.3	20	17	13	10	17	23	0	
				1.3–2.3	18	12	19	7	19	25	0	
				Mean	19	14	16	9	18	24	0	
b	6	32	62	2.3–3.3	6	8	12	12	24	25	13	
	18	38	44	4.4–4.8	18	13	12	13	21	23	0	‡
a & b	15	37	48	Mean	15	12	15	10	20	24	4	

‡non-mineral: not considered in calculation of mean grading

NS 83 SW 196 B **8335 3142** **Broadlea Cottage, Douglas** **Block B**

Surface level +193.4 m (+634 ft)
Water struck at +187.9 m
254 and 203 mm percussion
March 1978

Overburden 0.4 m
Mineral 1.8 m
Waste 2.1 m
Mineral 10.6 m
Bedrock 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	**a** 'Clayey' gravel Gravel: coarse and fine with cobbles, mainly well rounded, yellow, red and green sandstones, greywacke, basalt, felsite, porphyry, vein quartz and coal Sand: medium with coarse and fine, subrounded to rounded, quartz with some rock fragments, medium brown Fines: disseminated silt and clay	1.8	2.2
Glaciolacustrine deposit	Silt, laminated, with thin seams of sand and rare fine pebbles, orange-brown, maroon and medium grey	2.1	4.3
Fluvioglacial sand and gravel	**b** 'Clayey' gravel Gravel: coarse and fine with cobbles, mainly well rounded, basalt, red, green and white sandstones, greywacke, felsite, vein quartz and coal Sand: medium, fine and coarse, rounded, quartz, medium brown Fines: disseminated silt and clay	1.4	5.7
	c Pebbly sand Gravel: fine and coarse, mainly well rounded, red sandstone, greywacke, coal, basalt, felsite and vein quartz Sand: medium with fine and some coarse, rounded, quartz with some coal, medium brown Fines: disseminated silt	3.0	8.7
	d Sandy gravel Gravel: fine with coarse and some cobbles – coarse mainly well rounded, fine subangular to well rounded. Red, yellow and white sandstones, greywacke, basalt, felsite vein quartz and coal Sand: medium with coarse and fine, mainly subrounded, quartz with rock fragments, medium brown Fines: disseminated silt	6.2	14.9
Carboniferous (Coal Measures)	Siltstone, weathered becoming hard, pale grey	1.1+	16.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$	
a	10	39	51	0.4–1.4	9	12	18	7	18	32	4	
				1.4–2.2	10	8	20	14	23	19	6	
				Mean	10	10	19	10	20	26	5	
b	17	39	44	4.3–5.3	18	11	19	9	21	20	2	
				5.3–5.7	16	15	13	10	21	25	0	
				Mean	17	12	17	10	21	22	1	
c	8	87	5	5.7–6.7	10	28	51	8	3	0	0	†
				6.7–7.7	8	27	58	5	2	0	0	†
				7.7–8.7	7	21	51	7	6	8	0	†
				Mean	8	26	54	7	3	2	0	
d	4	56	40	8.7–9.9	3	17	38	8	15	13	6	†
				9.9–10.9	2	12	37	9	19	17	4	†
				10.9–11.9	3	14	35	10	22	14	2	†
				11.9–12.9	2	8	27	17	31	13	2	†
				12.9–13.9	3	12	22	15	30	15	3	†
				13.9–14.9	11	14	17	21	29	8	0	†
				Mean	4	13	30	13	24	13	3	
b to d	7	62	31	Mean	7	16	35	11	18	11	2	
a to d	7	59	34	Mean	7	16	32	11	18	14	2	

NS 83 SW 197 8334 3018 Gateside, Douglas **Block B**

Surface level +205.8 m (+675 ft)
Water struck at +198.0 m
254 and 203 mm percussion
February 1978

Overburden 1.0 m
Mineral 1.2 m
Waste 1.6 m
Mineral 4.9 m
Waste 0.6 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	1.0	1.0
Fluvioglacial sand and gravel	**a** Sandy gravel Gravel: coarse and fine with rare cobbles (up to 160 mm), mainly well rounded, yellow and red sandstones, greywacke, basalt, felsite and vein quartz Sand: medium with coarse and some fine, rounded, quartz, medium brown Fines: disseminated silt	1.2	2.2
Till	Pebbly clay, tenacious, maroon with fragments of maroon mudstone and some decomposed sandstone, coal, andesite and quartzite	0.3	2.5
Glaciolacustrine deposit	Silt, laminated, medium brown with rare small pebbles, coal fragments and white mica	1.3	3.8
Fluvioglacial sand and gravel	**b** 'Very clayey' pebbly sand becoming less pebbly with depth Gravel: coarse and fine with rare cobbles (up to 110 mm), mainly of red sandstone, content decreasing with depth Sand: fine with some medium and traces of coarse, subrounded, quartz, reddish brown Fines: silt, disseminated and in seams	4.9	8.7
Till	Pebbly silty clay: stiff, reddish brown with decomposed green siltstone fragments	0.6	9.3
Carboniferous (Coal Measures)	Sandstone, fine to medium grained, micaceous, yellow-grey	0.3+	9.6

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64	
a	6	56	38	1.0–2.2	6	5	39	12	14	24	0	
b	21	62	17	3.8–4.8	19	43	4	3	8	9	14	
				4.8–7.4	21	51	11	2	5	10	0	
				7.4–7.8	21	58	9	2	5	5	0	
				7.8–8.7	23	53	12	3	4	5	0	†
				Mean	21	50	10	2	5	9	3	
a & b	18	61	21	Mean	18	42	15	4	7	12	2	

NS 83 SW 198 8434 3463 Poniel, Coalburn **Block B**

Surface level +210.8 m (+692 ft)
Water struck at +198.1 m
254 and 203 mm percussion
February 1978

Overburden 0.4 m
Mineral 17.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	**a** 'Clayey' gravel Gravel: coarse and fine, subrounded, yellow and red sandstones, greywacke, weathered basalt and rare quartzite Sand: medium with coarse and fine, subangular to subrounded, quartz with some basalt, light brown Fines: disseminated clay	2.3	2.7
	b 'Clayey' sand Gravel: traces of fine and coarse with rare cobbles and boulders, sandstone, greywacke, basalt and coal Sand: fine and medium with traces of coarse, subrounded, quartz with coaly seams, light brown to dark grey-brown Fines: silt, disseminated and in seams	13.0	15.7
	c 'Clayey' sandy gravel Gravel: coarse and fine with rare cobbles and boulders, subrounded, greywacke, basalt and yellow and red sandstones Sand: medium and fine with coarse, quartz, light grey-brown Fines: disseminated clay	2.1	17.8
	Borehole terminated due to boulder obstruction		

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64	
a	10	38	52	0.4–1.4	9	10	13	13	24	31	0	
				1.4–2.4	11	11	17	10	23	28	0	
				2.4–2.7	12	12	20	11	27	18	0	
				Mean	10	11	16	11	24	28	0	
b	16	83	1	2.7–3.7	34	52	11	1	1	1	0	
				3.7–4.7	19	54	26	1	trace	0	0	
				4.7–5.9	8	47	45	trace	0	0	0	
				5.9–7.7	20	66	13	1	0	0	0	
				7.7–8.6	16	45	35	1	2	1	0	
				8.6–9.6	29	50	17	2	2	trace	0	
				9.6–10.6	16	18	58	6	2	trace	0	
				10.6–11.6	14	28	54	3	1	0	0	
				11.6–12.6	14	32	51	2	1	0	0	
				12.6–13.7	12	48	39	1	trace	0	0	†
				13.7–14.7	8	20	62	5	3	2	0	†
				14.7–15.7	5	34	59	2	trace	0	0	†
				Mean	16	43	38	2	1	trace	0	
c	10	64	26	15.7–16.5	10	24	28	12	14	12	0	†
				16.5–17.8	No grading data available							†
a to c	15	74	11	Mean	15	36	34	4	6	5	0	

NS 83 SW 199 8472 3281 Long Plantation, Douglas **Block B**

Surface level +192.6 m (+632 ft)
Water struck at +190.4 m
254 mm percussion
March 1978

Overburden 1.1 m
Mineral 3.6 m
Bedrock 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.7	0.7
Till	Pebbly clay, pale to medium brown with white sandstone fragments	0.4	1.1
	'Clayey' gravel Gravel: fine and coarse, subrounded to rounded, red and yellow sandstones, greywacke, basalt, felsite, quartzite and coal Sand: medium, coarse and fine, subangular to subrounded, quartz with rock fragments, medium brown Fines: clay and silt, becoming stiffer with depth	3.6	4.7
Carboniferous (Coal Measures)	Siltstone, weathered, pale grey	1.1+	5.8

GRADING

Mean for deposit *percentages* Fines	Sand	Gravel	Depth below surface (m)	*percentages* Fines $-\frac{1}{16}$	Sand $+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	Gravel $+4-16$	$+16-64$	$+64$	
12	41	47	1.1–2.1	7	6	19	14	32	22	0	
			2.1–3.1	10	9	24	15	26	16	0	†
			3.1–4.2	12	9	11	12	29	27	0	†
			4.2–4.7	23	24	13	12	17	11	0	†
			Mean	12	10	17	14	27	20	0	

NS 83 SW 200 8414 3215 Gardens House, Douglas **Block B**

Surface level +199.9 m (+656 ft)
Water struck at +187.9 m
254 and 203 mm percussion
February 1978

Overburden 0.6 m
Mineral 5.1 m
Waste 5.2 m
Mineral 3.0 m
Waste 2.0 m
Mineral 1.0 m
Waste 2.0 m
Mineral 6.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Fluvioglacial sand and gravel	**a** Gravel Gravel: coarse and fine with rare cobbles, mainly well rounded, yellow, white and red sandstones, greywacke, basalt and felsite Sand: medium and coarse with fine, subrounded, quartz, medium to dark brown Fines: disseminated silt	2.1	2.7
Glaciolacustrine deposits	**b** 'Very clayey' sand Gravel: coarse and fine, coal Sand: fine with medium and traces of coarse, rounded, quartz with grains of white mica and coal, medium brown Fines: silt, disseminated and in numerous thin seams	3.0	5.7
	Silt, laminated with fine sandy seams, medium brown, very silty sand between 8.9 and 9.9 m	5.2	10.9
	c 'Very clayey' sand Sand: fine with medium and traces of coarse, rounded, quartz with rare coal and some white mica, medium brown Fines: silt, disseminated and in seams	3.0	13.9
	Silt, laminated with fine sandy seams, medium brown	2.0	15.9
	d 'Very clayey' sand Sand: fine with medium, rounded, quartz with rare coal, medium brown Fines: silt, disseminated and in seams	1.0	16.9
	Silt, laminated with fine sandy seams, medium brown	2.0	18.9
	e 'Very clayey' sand Sand: fine with medium and traces of coarse, rounded, quartz with some coal, medium brown Fines: silt, disseminated and in seams	6.1+	25.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
					−1/16	+1/16–1/4	+1/4–1	+1–4	+4–16	+16–64	+64	
a	6	34	60	0.6–1.6	6	10	17	10	28	29	0	
				1.6–2.7	5	5	15	12	30	29	4	
				Mean	6	7	16	11	29	29	2	
b	22	76	2	2.7–3.7	26	27	41	2	2	2	0	
				3.7–4.7	16	51	32	1	0	0	0	
				4.7–5.7	24	69	7	trace	0	0	0	
				Mean	22	49	26	1	1	1	0	
	38	62	0	8.9–9.9	38	56	6	0	0	0	0	‡
c	24	76	0	10.9–11.9	32	63	3	2	0	0	0	
				11.9–12.9	18	46	35	1	0	0	0	†
				12.9–13.9	21	40	38	1	0	0	0	†
				Mean	24	49	26	1	0	0	0	
d	34	66	0	15.9–16.9	34	46	20	0	0	0	0	†
e	23	77	trace	18.9–19.9	18	56	23	1	1	1	0	†
				19.9–20.9	27	44	28	1	0	0	0	†
				20.9–21.9	23	37	39	1	0	0	0	†
				21.9–22.9	34	48	17	1	0	0	0	†
				22.9–23.9	19	38	41	2	0	0	0	†
				23.9–25.0	17	46	37	trace	0	0	0	†
				Mean	23	45	31	1	trace	trace	0	
b to e	24	76	trace	Mean	24	47	28	1	trace	trace	0	
a to e	21	71	8	Mean	21	42	27	2	4	4	trace	

‡non-mineral: not considered in calculation of mean grading

NS 83 SW 201 **8429 3158** **Douglas Castle, Douglas** **Block B**

Surface level +209.5 m (+687 ft)
Water struck at +190.6 m
254 and 203 mm percussion
February 1978

Overburden 0.2 m
Mineral 24.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	**a** Gravel Gravel: coarse and fine with cobbles, subrounded, yellow, red and grey sandstones, greywacke, weathered basalt, quartzite and coal Sand: medium with coarse and fine, subangular to subrounded, quartz with some coal, medium grey-brown Fines: silt, disseminated and in seams	6.5	6.7
	b Pebbly sand Gravel: fine with some coarse, subangular to subrounded, white and yellow sandstones and coal Sand: medium with some fine and rare coarse, subrounded, quartz with some coal, light to medium brown Fines: disseminated silt and clay	1.4	8.1
	c Gravel Gravel: fine with coarse, subrounded to well rounded, yellow and red sandstones, greywacke, weathered basalt, felsite and coal Sand: medium and coarse with fine, subrounded, quartz with coal and rock fragments, dark grey-brown Fines: disseminated silt and clay	1.7	9.8
	d Pebby sand. Gravel occurs as stringers Gravel: coarse and fine, mainly well rounded, sandstone, greywacke and basalt with felsite Sand: medium with fine and traces of coarse, rounded, quartz, medium brown Fines: disseminated silt	1.0	10.8
	e Pebbly sand Gravel: fine with some coarse, mainly well rounded, yellow sandstone, greywacke, basalt, felsite and coal Sand: medium with coarse and fine, subangular to subrounded, quartz with coal, medium to dark grey-brown Fines: disseminated silt	2.7	13.5
	f 'Clayey' sand Gravel: rare, coarse and fine to 18.7 m, well rounded, white sandstone and coal Sand: medium and fine with traces of coarse, rounded, quartz with coal and some white mica, dark grey to medium grey-brown Fines: silt, disseminated and in thin seams with a laminated, medium brown seam from 13.5 to 13.7 m	11.5+	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
a	8	44	48	0.2–1.2	12	7	30	11	16	22	2
				1.2–2.2	6	7	22	14	21	21	9
				2.2–3.5	10	9	14	9	30	23	5
				3.5–3.9	8	19	29	5	15	24	0
				3.9–4.8	6	11	24	14	27	18	0
				4.8–5.9	6	6	21	15	21	25	6
				5.9–6.7	6	11	27	13	26	17	0
				Mean	8	9	23	12	23	21	4
b	8	86	6	6.7–7.7	8	18	59	9	5	1	0
				7.7–8.1	8	18	67	2	5	trace	0
				Mean	8	18	61	7	5	1	0
c	7	46	47	8.1–9.0	8	9	23	17	26	17	0
				9.0–9.8	5	5	19	20	31	20	0
				Mean	7	7	21	18	29	18	0
d	9	78	13	9.8–10.8	9	22	53	3	6	7	0
e	7	75	18	10.8–11.8	6	12	32	26	20	4	0
				11.8–12.8	6	14	32	28	16	4	0
				12.8–13.5	8	14	64	9	4	1	0
				Mean	7	13	40	22	15	3	0
f	18	80	2	13.7–14.7	21	56	21	2	0	0	0
				14.7–15.7	20	29	44	4	3	0	0
				15.7–16.7	13	14	57	9	5	2	0
				16.7–17.7	18	39	33	3	3	4	0
				17.7–18.7	16	33	43	3	2	3	0
				18.7–19.7	15	44	35	6	0	0	0
				19.7–20.7	21	29	45	5	0	0	0
				20.7–21.7	20	36	42	2	0	0	0
				21.7–22.7	9	31	59	1	0	0	0 †
				22.7–23.7	10	58	31	1	0	0	0 †
				23.7–25.0	31	44	24	1	0	0	0 †
				Mean	18	38	39	3	1	1	0
a to e	7	58	35	Mean	7	11	33	14	19	14	2
a to f	12	68	20	Mean	12	23	36	9	11	8	1

NS 83 SW 202* **8345 3095** **Douglas Monument, Douglas** **Block B**

Surface level +198.4 m (+651 ft)
Section dry
Sampling by hand
May 1978

Overburden 0.5 m
Mineral 7.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Fluvioglacial sand and gravel	Sandy gravel; thinly bedded sequence showing upward fining with erosive bases, sometimes trough shaped and imbrication of pebbles Gravel: coarse and fine with cobbles, rounded to well rounded, yellow, red and white sandstones, greywacke, basalt and vein quartz with coal Sand: medium with fine and coarse, subrounded, quartz with rock fragments, yellow-brown Fines: silt, disseminated and in rare thin seams	7.5+	8.0

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
2	57	41	0.5–1.6	0	2	12	7	9	37	33
			1.6–2.6	2	6	31	26	26	9	0
			2.6–3.6	2	24	27	16	12	19	0
			3.6–4.6	1	33	35	5	5	21	0
			4.6–5.7	2	14	14	11	26	20	13
			5.7–6.7	3	33	23	9	13	19	0
			6.7–8.0	2	14	51	13	6	14	0
			Mean	2	17	28	12	14	20	7

NS 83 SW 203* **8330 3057** **Cransley, Douglas** **Block B**

Surface level +201.3 m (+660 ft)	Overburden 0.6 m
Section dry	Mineral 2.9 m
Sampling by hand	Waste 1.0 m
May 1978	Mineral 6.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Fluvioglacial sand and gravel	**a** Sandy gravel. Cross-bedded sand with gravel stringers Gravel: coarse and fine, rounded to well rounded, sandstone with felsite, vein quartz and coal Sand: medium with coarse and fine, rounded, quartz, medium brown Fines: disseminated silt	2.9	3.5
Glasciolacustrine deposit	Sandy silt, laminated, with medium brown fine sand containing coal fragments from 3.8 to 4.0 m	1.0	4.5
Fluvioglacial sand and gravel	**b** Sand Gravel: fine with coarse, well rounded, sandstone and coal Sand: medium with fine and traces of coarse, rounded, quartz, yellow-brown Fines: disseminated silt	1.3	5.8
	c Gravel, with sands, exhibiting cross-bedding and slump structures Gravel: coarse with fine with rare cobbles, rounded to well rounded, sandstone, greywacke, basalt, felsite, vein quartz and coal Sand: medium with coarse and fine, rounded, quartz, yellow-brown Fines: disseminated silt	1.1	6.9
	d Sand, cross-bedded Gravel: rare, coarse and fine coal fragments Sand: medium and fine with traces of coarse, rounded, quartz, yellow-brown Fines: silt, disseminated and in rare thin seams with silty lenses between 8.7 and 8.9 m	3.0	9.9
	e Sandy gravel, with cross-bedded sands Gravel: coarse with fine and some cobbles, rounded to well rounded, sandstone, greywacke, basalt, felsite, vein quartz and coal Sand: medium with coarse and fine, subrounded, quartz, yellow-brown Fines: disseminated silt	0.8+	10.7

Section continues to 12.5 m but face obscured by much slumped material

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
a	3	58	39	0.6–1.6	2	11	29	18	24	16	0
				1.6–2.6	3	10	43	17	12	15	0
				2.6–3.5	4	10	22	13	22	29	0
				Mean	3	10	32	16	19	20	0
b	8	88	4	4.5–5.8	8	22	64	2	3	1	0
c	1	35	64	5.8–6.9	1	8	18	9	20	44	0
d	6	92	2	6.9–7.9	6	37	52	4	1	0	0
				7.9–8.9	8	54	31	3	2	2	0
				8.9–9.9	4	29	62	4	1	0	0
				Mean	6	40	48	4	1	1	0
e	4	51	45	9.9–10.7	4	10	30	11	10	26	9
b to e	5	76	19	Mean	5	27	44	5	6	12	1
a to e	5	70	25	Mean	5	21	40	9	10	14	1

NS 83 SE 30 **8555 3374** **Happendon, Douglas** **Block B**

Surface level +203.8 m (+669 ft)
Water struck at +201.1 m
254 mm percussion
February 1978

Waste 11.6 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Fluvioglacial sand and gravel	'Clayey' sandy gravel Gravel: coarse and fine, subrounded, white and brown sandstones, greywacke, basalt and felsite Sand: fine with medium and some coarse, subrounded, quartz, yellow-brown Fines: disseminated silt and clay	0.6	1.2
Glaciolacustrine deposit	Pebbly sandy silt, laminated, variegated brown and grey	0.5	1.7
Fluvioglacial sand and gravel	Sandy gravel Gravel: fine and coarse with rare cobbles, subrounded to rounded, greywacke, basalt and white and red sandstones Sand: coarse with fine and medium, subrounded, quartz, light brown Fines: disseminated silt and clay	0.9	2.6
Till	Pebbly sandy clay, stiff to hard, with cobble beds, grey	9.0	11.6
Carboniferous (Passage Group)	Siltstone, light grey	0.9+	12.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*							
Fines	Sand	Gravel		Fines	Sand			Gravel			
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64	
16	62	22	0.6–1.2	16	37	19	6	11	11	0	‡
4	61	34	1.7–2.6	5	17	16	28	19	12	3	‡

‡non-mineral: deposits less than 1 metre thick

NS 83 SE 31 8523 3305 Happendon Camp, Douglas **Block A**

Surface level +182.2 m (+598 ft)
Water struck at +180.2 m
254 and 203 mm percussion
February 1978

Overburden 1.4 m
Mineral 2.0 m
Waste 16.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvial Cone	Silt, light to medium brown, laminated, with rare pebbles to 0.65 m, a layer of ashy made ground between 0.65 and 0.70 m, becoming sandy below 0.7 m	1.1	1.4
	'Very clayey' sandy gravel Gravel: coarse with fine, rounded to well rounded, sandstone, greywacke, basalt and vein quartz with some coal Sand: fine with medium and coarse, rounded, medium to light brown. Fines: silt, disseminated and in thin seams	2.0	3.4
Glaciolacustrine deposit	Silt, medium to dark grey, laminated with some fine sandy partings	16.1+	19.5

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines	Sand			Gravel			
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64	
26	45	29	1.4–2.4	19	29	17	8	9	18	0	
			2.4–3.4	33	16	11	9	12	19	0	†
			Mean	26	23	14	8	10	19	0	

NS 83 SE 32 **8588 3262** **Castle Mains, Douglas** **Block B**

Surface level +204.2 m (+670 ft)
Water struck at +199.5 m
254 mm percussion
February 1978

Overburden 3.6 m
Mineral 7.1 m
Waste 0.3 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Made ground	Fill, grey sandy till	3.0	3.6
Fluvioglacial sand and gravel	Gravel Gravel: fine and coarse with cobbles, subrounded to well rounded, red and yellow sandstones, greywacke, basalt and felsite Sand: coarse to fine, subangular, quartz and rock fragments, medium brown, unsorted Fines: disseminated silt and clay, content very variable, tenacious in parts	7.1	10.7
Till	Gravelly clay, tenacious, brown with sandstone clasts	0.3	11.0
Carboniferous (Upper Limestone Group)	Siltstone, weathered, medium grey	0.3+	11.3

GRADING

Mean for deposit *percentages* Fines	Sand	Gravel	Depth below surface (m)	*percentages* Fines $-\frac{1}{16}$	Sand $+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	Gravel $+4-16$	$+16-64$	$+64$	
9	37	54	3.6–4.6	24	20	14	9	16	17	0	
			4.6–5.6	9	14	13	13	20	31	0	†
			5.6–6.6	15	13	10	14	11	19	18	†
			6.6–7.6	4	5	6	9	33	21	22	†
			7.6–8.6	2	11	12	13	26	24	12	†
			8.6–9.6	4	11	6	16	28	18	17	†
			9.6–10.7	8	15	12	19	33	13	0	†
			Mean	9	13	11	13	24	20	10	

NS 83 SE 33 8536 3252 Boncastle, Douglas **Block B**

Surface level +194.5 m (+638 ft)
Water not struck
254 mm percussion
February 1978

Overburden 0.3 m
Mineral 6.7 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.3	0.3
Fluvioglacial sand and gravel	**a** 'Clayey' pebbly sand Gravel: fine with rare coarse, subrounded with rare subangular, coal, basalt and rare felsite Sand: medium with fine and some coarse, subrounded, quartz Fines: disseminated silt, with a clayey seam from 1.8 to 1.9 m	2.6	2.9
Glaciolacustrine deposit	**b** 'Very clayey' sand with rare pebbles Sand: fine, subrounded, quartz, orange-brown Fines: disseminated silt	2.0	4.9
Fluvioglacial sand and gravel	**c** 'Very clayey' pebbly sand Gravel: coarse with fine, subrounded, basalt with coal. Basalt boulder between 6.3 and 7.0 m Sand: fine with coarse and medium, subrounded, quartz Fines: disseminated silt	2.1	7.0
Carboniferous (Passage Group)	Mudstone, black, massive	0.3	7.3
	Sandstone, fine grained, grey speckled black and a yellow weathering corona	0.5	7.8
	Siltstone, light grey	0.2+	8.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
a	14	80	6	0.3–1.3	15	25	51	4	2	3	0
				1.3–1.9	11	9	52	18	9	1	0
				1.9–2.9	14	35	41	5	4	1	0
				Mean	14	26	47	7	4	2	0
b	36	64	trace	2.9–3.9	39	57	3	1	trace	0	0
				3.9–4.9	33	61	6	trace	0	0	0
				Mean	36	59	4	1	trace	0	0
c	25	61	14	4.9–5.9	25	39	8	13	6	9	0
				5.9–6.3	25	45	10	6	4	10	0
				Mean	25	41	9	11	5	9	0
a to c	24	69	7	Mean	24	41	22	6	3	8	0

no representative sample from 6.3 to 7.0 m

NS 83 SE 34 8519 3202 Mainshill Wood, Douglas **Block B**

Surface level +224.0 m (+735 ft)
Water struck at +220.9 m
254 mm percussion
January 1978

Overburden 0.4 m
Mineral 1.6 m
Waste 5.3 m
Bedrock 1.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	'Very clayey' sandy gravel Gravel: coarse and fine with cobbles, angular to well rounded, sandstone, greywacke, basalt, felsite, vein quartz and quartzite Sand: fine with medium and coarse, subangular, medium brown Fines: clay, stiff	1.6	2.0
	Gravelly clay, dark grey, very stiff with fine gravel to boulder size clasts of sandstone, greywacke, basalt, shale, coal, vein quartz and quartzite	5.3	7.3
Carboniferous (Passage Group)	Siltstone, medium grey, soft becoming hard	1.2+	8.5

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
25	43	32	0.4–2.0	25	25	10	8	15	17	0

NS 83 SE 35 8675 3486 Newtonfoot, Rigside **Block B**

Surface level +223.1 m (+732 ft)
Water not struck
254 mm percussion
February 1978

Waste 5.2 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Pebbly sandy clay, orangey brown to grey, mottled, stiff with fragments of coal and subrounded to rounded pebbles of yellow-white sandstone	1.1	1.4
	Gravelly sandy clay, medium to dark grey, stiff, with cobbles and boulders of yellow sandstone and coal fragments	3.8	5.2
Carboniferous (Upper Limestone Group)	Shale: dark grey to black with thin coal partings	0.9+	6.1

NS 83 SE 36 8637 3428 Newtonhead, Rigside **Block A**

Surface level +180.7 m (+593 ft)
Water struck at +178.5m
254 and 203 mm percussion
February 1978

Overburden 0.8 m
Mineral 13.5 m
Waste 10.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.8	0.8
Alluvium	**a** 'Clayey' sandy gravel Gravel: coarse and fine with rare cobbles, subrounded to rounded, basalt, tuff, white, red-brown and grey-brown sandstones, greywacke, quartzite and vein quartz Sand: fine with medium and some coarse, subrounded with rare subangular quartz Fines: disseminated silt and clay	3.5	4.3
Glaciolacustrine deposits	**b** Sand Gravel: traces of fine, subrounded, basalt and sandstone Sand: fine with medium and traces of coarse, subrounded, quartz with rare coal, light brown Fines: silt, disseminated and in seams	10.0	14.3
	Silt, sandy, soft with dark grey and brown-grey laminae	10.7+	25.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$	
a	10	48	42	0.8–1.2	28	51	17	2	2	trace	0	
				1.2–2.2	9	25	20	7	17	22	0	
				2.2–3.3	1	7	7	11	38	27	9	†
				3.3–4.3	15	44	11	6	6	13	5	†
				Mean	10	28	13	7	19	19	4	
b	8	91	1	4.3–5.3	8	67	18	3	3	1	0	†
				5.3–6.3	1	59	36	4	trace	0	0	†
				6.3–7.3	2	73	23	2	trace	0	0	†
				7.3–8.3	9	67	23	1	0	0	0	†
				8.3–9.2	7	61	31	1	trace	0	0	†
				9.2–10.2	8	66	25	1	trace	0	0	†
				10.2–11.2	6	49	36	7	2	0	0	†
				11.2–12.2	9	71	17	2	1	0	0	†
				12.2–13.5	7	54	34	3	2	0	0	†
				13.5–14.3	21	63	15	1	trace	0	0	†
				Mean	8	63	26	2	1	trace	0	
a & b	8	81	11	Mean	8	54	23	4	5	5	1	

NS 83 SE 37 8643 3337 Uddington **Block B**

Surface level +208.5 m (+684 ft)
Water not struck
254 mm percussion
February 1978

Overburden 0.5 m
Mineral 3.6 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Till	'Clayey' sandy gravel Gravel: coarse and fine with cobbles, subrounded to rounded, red, yellow and white sandstones, greywacke and basalt Sand: fine and medium with coarse, subrounded, quartz, brown Fines: disseminated clay and silt	3.6	4.1
Carboniferous (Upper Limestone Group)	Sandstone, medium grained, yellow, soft	1.0+	5.1

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
15	50	35	0.5–1.5	12	15	12	14	22	18	7
			1.5–2.5	16	40	10	5	8	7	14
			2.5–3.5	17	14	13	11	21	20	4
			3.5–4.1	12	31	42	5	2	8	0
			Mean	15	24	17	9	14	14	7

NS 93 NW 1 **9016 3950** **Millmoor, Carmichael** **Block B**

Surface level +196.8 m (+646 ft)
Water struck at +175.4 m
254 and 203 mm percussion
March 1978

Overburden 0.2 m
Mineral 23.3 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	**a** 'Clayey' pebbly sand Gravel: fine and coarse, subrounded to rounded, basalt, yellow, white and brown sandstones and greywacke with rare quartzite and coal Sand: fine with medium and some coarse, subrounded, quartz, light brown Fines: silt, disseminated and in seams	5.0	5.2
Glaciolacustrine deposit	**b** 'Clayey' sand Gravel: rare, fine with some coarse, subrounded to rounded, basalt and yellow, white and brown sandstones Sand: fine with medium and rare coarse, subrounded, quartz, light brown Fines: silt, disseminated and in seams	3.0	8.2
Fluvioglacial sand and gravel	**c** 'Clayey' pebbly sand Gravel: fine and coarse with rare cobbles, subrounded, basalt, greywacke, yellow, white and brown sandstones with rare coal Sand: medium with fine and coarse, subrounded, quartz with some basalt and sandstone, medium brown Fines: disseminated silt	6.8	15.0
	d 'Clayey' pebbly sand Gravel: coarse and fine, subrounded, yellow, white and brown sandstones with some greywacke, basalt and coal Sand: medium with fine and coarse, subrounded, quartz Fines: disseminated silt	2.9	17.9
	e 'Clayey' sandy gravel Gravel: coarse and fine with cobbles, subrounded to well rounded, basalt, greywacke, brown, red-brown and white sandstones with quartzite and vein quartz Sand: fine and medium with coarse, subangular to subrounded, quartz with some basalt and sandstone, medium brown Fines: disseminated silt	5.6	23.5
Upper Old Red Sandstone	Sandstone, yellow, hard	0.1+	23.6

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64	
a	12	78	10	0.2–1.2	21	47	19	5	4	4	0	
				1.2–2.2	10	43	24	12	8	3	0	
				2.2–3.2	10	41	30	10	8	1	0	
				3.2–4.2	8	46	27	6	6	7	0	
				4.2–5.2	13	54	21	4	3	5	0	
				Mean	12	46	24	8	6	4	0	
b	19	80	1	5.2–6.2	26	67	6	1	0	0	0	
				6.2–7.2	13	74	13	0	0	0	0	
				7.2–8.2	17	65	11	3	3	1	0	
				Mean	19	69	10	1	1	trace	0	
c	11	67	22	8.2–9.1	12	30	28	12	9	9	0	
				9.1–10.2	10	21	33	15	11	10	0	
				10.2–11.1	12	22	45	19	1	1	0	
				11.1–12.2	12	17	44	16	7	4	0	
				12.2–13.2	10	16	24	12	24	14	0	
				13.2–14.2	11	14	26	11	11	16	11	
				14.2–15.0	11	13	37	10	9	11	9	
				Mean	11	19	34	14	10	9	3	
d	17	74	9	15.0–16.0	17	16	50	10	4	3	0	
				16.0–17.0	16	18	53	7	3	3	0	
				17.0–17.9	18	18	45	4	6	9	0	
				Mean	17	17	50	7	4	5	0	
e	14	43	43	17.9–19.1	19	34	17	6	11	13	0	
				19.1–20.0	16	25	13	8	16	18	4	
				20.0–21.0	16	24	14	8	14	24	0	
				21.0–22.0	10	14	10	7	17	42	0	†
				22.0–23.0	9	14	12	11	16	20	18	†
				23.0–23.5	11	17	13	12	19	19	9	†
				Mean	14	22	13	8	15	23	5	
a to e	14	66	20	Mean	14	32	26	8	8	10	2	

NS 82 NW P1 8100 2853 Stablestone, Glespin **Block B**

Surface level +220.1 m (+722 ft)
Water not struck
Smalley excavator
May 1978

Waste 1.0 m
Bedrock 0.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.1	0.1
Till	Sandy, slightly pebbly clay, plastic, red-brown	0.1	0.2
	Clay, laminated, with seams of coal fragments at 0.40 and 0.65 m. Plastic to firm, yellow-brown, very rare pebbles	0.8	1.0
Carboniferous (Coal Measures)	Sandstone, fragments in a clay matrix	0.6+	1.6

NS 82 NW P2 8093 2823 Tablestane, Glespin **Block A**

Surface level +206.4 m (+677 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.3 m
Mineral 1.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Gravel Gravel: coarse with fine and numerous cobbles and boulders, mainly well rounded, greywacke, basalt, felsite and red and white sandstones Sand: medium with coarse, rounded to subangular, quartz, medium brown Fines: disseminated silt	1.2+	1.5

NS 82 NW P3 8014 2786 Glespin school, Glespin **Block B**

Surface level +217.4 m (+713 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.3 m
Mineral 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	Gravel, imbricated Gravel: coarse and fine with numerous cobbles and boulders, up to 350 mm, mainly well rounded, basalt, greywacke, yellow, white, grey and red sandstones with rare vein quartz Sand: coarse and medium with fine, rounded, quartz, medium brown Fines: disseminated silt and clay	1.1+	1.4

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
6	37	57	0.3–1.4	6	7	13	17	21	26	10

NS 82 NW P4 **8174 2912** **Windrow Wood, Glespin** **Block B**

Surface level +219.1 m (+719 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.2 m
Mineral 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	'Very clayey' sandy gravel Gravel: fine and coarse with rare cobbles, rounded to well rounded, sandstone, greywacke, basalt, vein quartz and coal Sand: fine and medium with coarse, rounded, medium brown Fines: disseminated clay and silt	1.5+	1.7

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
23	56	21	0.2–1.7	23	25	19	12	13	8	0

NS 82 NW P5 **8255 2899** **Weston, Douglas** **Block B**

Surface level +217.1 m (+712 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.2 m
Mineral 1.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	**a** Gravel Gravel: coarse and fine with cobbles, well rounded, yellow and grey sandstones, greywacke, basalt and coal Sand: coarse and medium with fine, rounded, quartz, medium brown Fines: disseminated silt	1.2	1.4
	b 'Very clayey' sandy gravel Gravel: fine with coarse, well rounded, yellow and grey sandstones, greywacke, basalt and coal Sand: fine with medium and some coarse, quartz, light brown Fines: silt, disseminated and in seams	0.4+	1.8

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
a	5	36	59	0.2–1.4	5	8	14	14	27	32	0
b	31	45	24	1.4–1.8	31	29	11	5	16	8	0
a & b	12	38	50	Mean	12	13	13	12	24	26	0

NS 82 NW P6 8238 2872 Weston, Douglas **Block B**

Surface level +224 m (+735 ft) approx.
Water not struck
Smalley excavator
May 1978

Waste 1.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Sandy pebbly clay, yellow-brown with some sand lenses. Iron staining from 0.8 m	0.7	0.9
	Clay, stiff, blue-grey with iron staining and very rare pebbles	0.8+	1.7

NS 82 NW P7 8319 2994 Midtown, Douglas **Block B**

Surface level +201.9 m (+662 ft)
Water struck at +200.2 m
Smalley excavator
May 1978

Overburden 0.3 m
Mineral 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	Gravel Gravel: coarse and fine with some cobbles, well rounded, red, yellow and white sandstones, greywacke, vein quartz, porphyry, ironstone, felsite and coal Sand: medium with coarse and some fine, subrounded to rounded, quartz with coal and felsite, medium brown Fines: disseminated silt	1.5+	1.8

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
2	44	54	0.3–1.8	2	4	26	14	23	29	2

NS 83 NW P1 8066 3720 Auchlochan, Lesmahagow **Block B**

Surface level +221.0 m (+725 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.6 m
Mineral 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Fluvioglacial sand and gravel	Gravel Gravel: coarse and fine with cobbles, subangular to rounded, basalt, greywacke, yellow, white and red sandstones, green mudstone and rare felsite Sand: coarse and medium with fine, subrounded, quartz, medium brown Fines: disseminated silt and clay	0.9+	1.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
5	33	62	0.6–1.5	5	6	12	15	23	30	9

NS 83 NW P2 8236 3915 Auldtoun, Lesmahagow **Block B**

Surface level +210.7 m (+691 ft)
Water not struck
Smalley excavator
May 1978

Overburden 1.0 m
Mineral 0.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and subsoil	1.0	1.0
Fluvioglacial sand and gravel	Pebbly sand Gravel: coarse and fine, rare, rounded, felsite and vein quartz Sand: fine with some medium and traces of coarse, rounded, quartz, yellow-brown Fines: disseminated silt	0.8+	1.8

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
8	87	5	1.0–1.8	8	70	15	2	2	3	0

NS 83 NE P1 8572 3609 Millhouse Cottage, Douglas Water **Block B**

Surface level +208.8 m (+685 ft) approx.
Water not struck
Smalley excavator
May 1978

Waste 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, with rare pebbles, stiff to hard, orange-brown becoming grey with depth	0.8+	1.1

NS 83 NE P2 8662 3643 Tower, Douglas Water **Block B**

Surface level +194.7 m (+639 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.4 m
Mineral 1.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.2	0.2
	Soil	0.2	0.4
Fluvioglacial sand and gravel	Pebbly sand Gravel: coarse with fine, well rounded, greywacke, sandstone, basalt, felsite, vein quartz and coal Sand: fine with medium and some coarse, rounded, quartz, medium brown Fines: silt, disseminated and in seams	1.3+	1.7

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
9	82	9	0.4–1.2	5	53	24	6	3	9	0
			1.2–1.7	14	63	14	3	4	2	0
			Mean	9	57	20	5	3	6	0

NS 83 NE P3 8604 3522 Laigh Tofts, Douglas Water **Block B**

Surface level +190.2 m (+624 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.3 m
Mineral 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	**a** Sandy gravel, bedded showing coarse and fine seams Gravel: coarse with fine, well rounded, sandstone, greywacke, basalt, felsite and vein quartz Sand: medium and coarse with some fine, subrounded, quartz, medium to dark brown Fines: disseminated silt	1.2	1.5
	b Pebbly sand Gravel: fine with coarse, as above Sand: medium and fine with some coarse, quartz, yellow-brown Fines: disseminated silt	0.3+	1.8

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
a	2	51	47	0.3–1.5	2	5	23	23	32	15	0
b	3	75	22	1.5–1.8	3	33	33	9	14	8	0
a & b	2	56	42	Mean	2	11	25	20	28	14	0

NS 83 NE P4 8813 3874 Netherhall, Douglas Water **Block B**

Surface level +203.0 m (666 ft) approx. Waste 2.1 m+
Water not struck
Smalley excavator
May 1978

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.8	0.8
Till	Silty sandy pebbly clay, containing seams of hard silt. Sandy band from 1.90 to 2.05 m	1.3+	2.1

NS 83 NE P5 8871 3807 Sandilands, Carmichael **Block B**

Surface level +194.0 m (+637 ft) Waste 1.9 m+
Seepage at +192.2 m
Smalley excavator
May 1978

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	Sandy gravelly clay, subrounded, coarse and fine gravel of yellow sandstone, greywacke and basalt with coarse to fine sand and much silt and clay, unsorted	1.5+	1.9

NS 83 NE P6 8916 3979 Harperfield, Lanark **Block B**

Surface level +202.1 m (+663 ft) Waste 1.8 m+
Water not struck
Smalley excavator
May 1978

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	1.0	1.0
Till	Sandy pebbly clay, plastic, coarse and fine, rounded to well rounded pebbles of felsite, vein quartz, sandstone and coal, pinky-red	0.6	1.6
	Pebbly clay, with clasts of weathered red sandstone, blue-grey	0.2+	1.8

NS 83 NE P7 **8927 3827** **Burnhousemill, Carmichael** **Block B**

Surface level +200.5 m (+658 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.5 m
Mineral 0.5m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Fluvioglacial sand and gravel	Gravel, unsorted Gravel: coarse and fine with cobbles and boulders, sandstone with felsite and vein quartz Sand: medium with coarse and fine, subrounded to rounded, quartz, medium brown Fines: a little disseminated silt and clay	0.5+	1.0
	Pit terminated on boulder obstruction		

NS 83 SW P1 **8288 3072** **Scrogton, Douglas** **Block B**

Surface level +211.0 m (+692 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.4 m
Mineral 0.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	Sand Gravel: rare stringers, coarse and fine, well rounded, boulder horizon at base Sand: fine to medium, quartz, orange-brown Fines: disseminated clay	0.4+	0.8
	Pit terminated on boulder obstruction		

NS 83 SW P2 8286 3072 Scrogton, Douglas **Block B**

Surface level +214.2 m (+703 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.2 m
Mineral 1.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	Gravel Gravel: coarse and fine with numerous cobbles and boulders (up to 400 mm), mainly well rounded, sandstone, greywacke, vein quartz, felsite, basalt and weathered mudstone. Fewer boulders from 0.9 m Sand: coarse and medium with fine, subrounded to rounded, quartz, medium brown Fines: disseminated silt	1.6+	1.8

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
4	32	64	0.2–1.8	4	6	12	14	31	33	0

NS 83 SW P3 8326 3153 Broadlea Cottage, Douglas **Block B**

Surface level +211.3 m (+693 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.6 m
Mineral 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Head	Gravel Gravel: coarse and fine with cobbles, well rounded, felsite, basalt, vein quartz, greywacke, red, yellow, white and green sandstones and andesite Sand: fine to coarse, rounded, quartz, orange-brown Fines: disseminated silt and clay, content decreasing slightly with depth	1.0+	1.6

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
11	47	42	0.6–1.6	11	21	16	10	14	17	11

NS 83 SW P4 **8430 3459** **Poniel, Coalburn** **Block B**

Surface level +210.9 m (+692 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.4 m
Mineral 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	Gravel Gravel: coarse and fine with cobbles, subrounded to rounded, red and white sandstones, greywacke and basalt with coal Sand: medium and coarse with fine, subrounded, quartz, brown Fines: disseminated silt and clay	1.5+	1.9

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
4	31	65	0.4–1.9	4	5	16	10	26	36	3

NS 83 SW P5 **8423 3419** **Poniel, Coalburn** **Block B**

Surface level +208.0 m (+638 ft)
Water struck at +206.8 m
Smalley excavator
May 1978

Overburden 0.3 m
Mineral 1.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	Gravel Gravel: fine and coarse with cobbles, rounded, red and white sandstones, greywacke, quartzite, felsite and basalt Sand: coarse and medium with fine, subrounded, quartz, medium brown Fines: silt and clay, disseminated and in seams	1.4+	1.7

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
7	38	55	0.3–1.7	7	7	13	18	26	22	7

NS 83 SW P6 **8446 3138** **New Mains, Douglas** **Block B**

Surface level +220.0 m (+722 ft)
Water not struck
Smalley excavator
May 1978

Waste 1.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, plastic to stiff with angular to rounded yellow sandstone, coal and felsite clasts, orange-brown	1.5+	1.8

NS 83 SE P1 **8588 3491** **High Tofts, Douglas Water** **Block B**

Surface level +198.3 m (+651 ft)
Water not struck
Smalley excavator
May 1978

Overburden 1.1 m
Mineral 0.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and subsoil	1.1	1.1
Glaciolacustrine deposit	'Very clayey' sand Gravel: very rare, coarse and fine, rounded, vein quartz and coal Sand: fine with some medium and traces of coarse, rounded, quartz with some coal, medium brown Fines: disseminated silt	0.6+	1.7

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
21	79	0	1.1–1.7	21	73	6	trace	0	0	0

NS 83 SE P2 **8565 3440** **Tofts Gate, Happendon** **Block B**

Surface level +208.1 m (+683 ft)
Water not struck
Smalley excavator
May 1978

Waste 0.5 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	Sand Sand: fine, quartz, orange-brown Fines: disseminated silt	0.3	0.5
Carboniferous (Passage Group)	Sandstone, fine grained, white	0.3+	0.8

NS 83 SE P3 **8558 3419** **Happendon Wood** **Block B**

Surface level +208.3 m (+683 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.5 m
Mineral 1.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Fluvioglacial sand and gravel	Pebbly sand Gravel: fine with rare coarse, subrounded, coal and sandstone Sand: medium with coarse and fine, rounded, quartz with some coal and sandstone, medium brown Fines: disseminated silt	1.4+	1.9

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
5	86	9	0.5–1.9	5	14	55	17	9	0	0

NS 83 SE P4 **8556 3374** **Happendon** **Block B**

Surface level +203.8 m (+688 ft)
Water not struck
Smalley excavator
May 1978

Waste 1.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel Fines: disseminated silt	'Clayey' sand Sand: medium, subrounded, quartz with coaly seams from 0.6 m, light brown	0.8	1.1
	Sandy gravel Gravel: coarse and fine, subangular to subrounded, white and brown sandstones, greywacke, felsite and basalt Sand: coarse and medium with fine, subrounded, quartz, medium brown Fines: disseminated silt and clay	0.1	1.2
	Silt, soft, grey-brown	0.2	1.4
	Sandy gravel Gravel: coarse and fine with cobbles, subangular to subrounded, basalt, greywacke and sandstone with some siltstone Sand: coarse to fine, subrounded, quartz, medium brown Fines: disseminated silt and clay	0.2	1.6
Till	Pebbly clay, dark grey, coarse and fine gravel with some cobbles of coal, sandstone and basalt	0.2+	1.8

NS 83 SE P5 **8587 3270** **Castle Mains, Douglas** **Block B**

Surface level +200.0 m (+656 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.3 m
Mineral 1.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	Gravel Gravel: coarse and fine with cobbles, subrounded to well rounded, basalt, sandstone, greywacke, coal and felsite Sand: coarse to fine, quartz, medium brown Fines: disseminated silt and clay	1.4+	1.7

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
3	38	59	0.3–1.7	3	9	16	13	23	36	0

NS 83 SE P6 **8536 3250** **Boncastle, Douglas** **Block B**

Surface level +194.6 m (+639 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.7 m
Mineral 1.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.4	0.4
Glaciolacustrine deposit	Interbedded fine sand and silt	0.3	0.7
Fluvioglacial sand and gravel	'Very clayey' sandy gravel Gravel: coarse and fine with cobbles, subangular to subrounded, yellow and white sandstones, greywacke and basalt Sand: fine with some medium and coarse, quartz, medium brown Fines: disseminated silt and clay	1.2+	1.9

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
20	50	30	0.7–1.9	20	35	9	6	13	17	0

NS 83 SE P7 **8636 3431** **Newtonhead, Rigside** **Block A**

Surface level +180.7 m (+593 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.3 m
Mineral 1.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	'Clayey' pebbly sand, gravel stringers at 0.9, 1.3, 1.5 and 2.0 m Gravel: fine, subrounded, sandstone with coal Sand: medium with coarse and some fine, quartz, light brown Fines: disseminated silt	1.7+	2.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
17	78	5	0.3–2.0	17	3	65	10	5	0	0

NS 93 NW P1 **9043 3940** **Millmoor, Carmichael** **Block B**

Surface level +212.1 m (+696 ft)
Water not struck
Smalley excavator
May 1978

Overburden 0.7m
Mineral 1.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.7	0.7
Fluvioglacial sand and gravel	Sandy gravel Gravel: coarse and fine, mainly well rounded, sandstone, greywacke, basalt, felsite and vein quartz Sand: medium to fine, subrounded, quartz, orange-brown Fines: disseminated silt and clay	0.3	1.0
	Pebbly sand with thin coaly seams at 0.95 and 1.1 m Gravel: fine with some coarse, well rounded Sand: medium with coarse and fine, subrounded, quartz with rare coal, medium brown Fines: disseminated silt	0.9+	1.9

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
1	90	9	1.0–1.9	1	10	69	11	8	1	0

APPENDIX G

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

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

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INSTITUTE OF GEOLOGICAL SCIENCES

INDUSTRIAL MINERALS ASSESSMENT UNIT

THE SAND AND GRAVEL RESOURCES OF THE VALLEY OF THE DOUGLAS WATER, STRATHCLYDE REGION

THE SAND AND GRAVEL RESOURCES OF THE VALLEY OF THE DOUGLAS WATER, STRATHCLYDE REGION

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

ORDNANCE SURVEY

SHEET NS 83 & Pts NS 82,92 & 93

PROVISIONAL EDITION

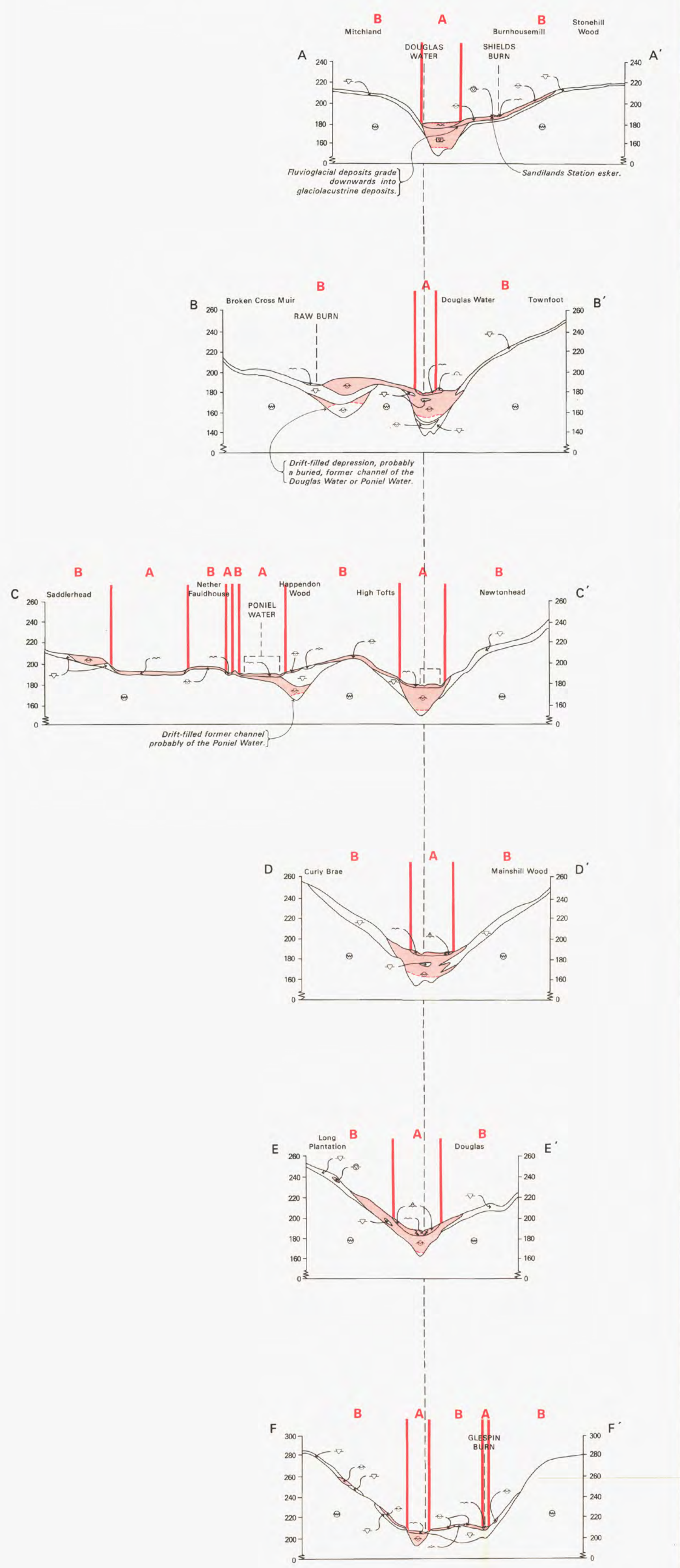
63

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

SCHEMATIC HORIZONTAL SECTIONS SHOWING RELATIONSHIPS OF DRIFT DEPOSITS

HORIZONTAL SCALE 1:25 000 VERTICAL EXAGGERATION APPROXIMATELY ×8

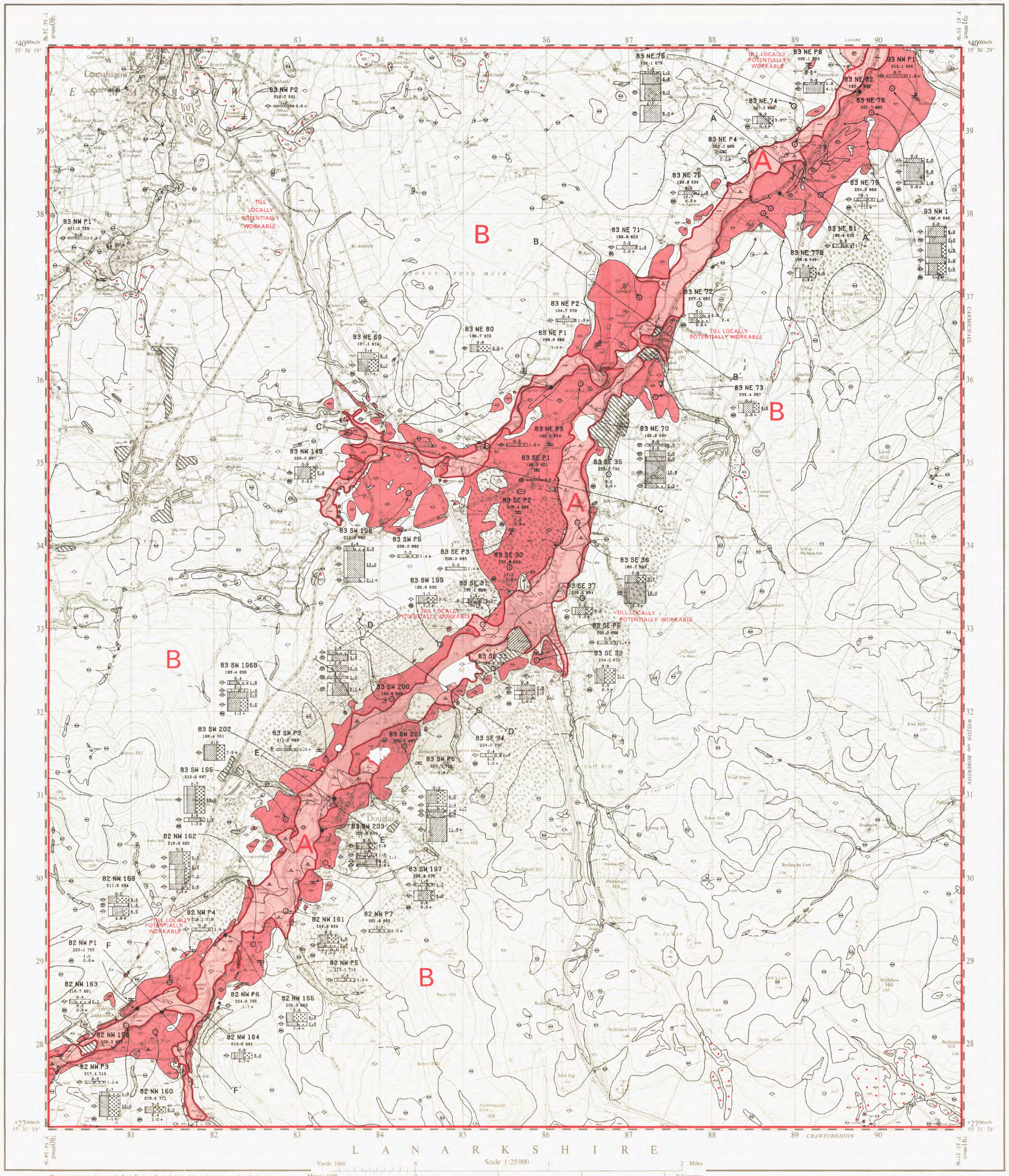
HEIGHTS IN METRES ABOVE ORDNANCE DATUM



KEY TO SECTIONS

- Potentially workable sand and gravel
- Made ground
- Geological boundary
- Boundary limiting the extent of potentially workable sand and gravel

Otherwise symbols and abbreviations as map legend.



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

The GRID lines on this sheet are at 1 Kilometre interval. Heights are in feet above Mean Sea Level at Newlyn.

1 square inch on this map represents 99·639 acres on the ground.

Made and published by the Ordnance Survey, Southampton.

Compiled from 6" sheets last fully revised 1898-1909
Other partial systematic revision 1941-54 has been incorporated
Major roads revised 1964-69

Original geological survey on the Six-inch scale by B.N.Peach and A.Geikie, 1870-72. Revised by L.W.Hinxman, G.Ross, H.H.Read, J.Phemister and E.M.Anderson between 1924 and 1932. Partial re-survey by I.B.Cameron in 1976. G.I.Lumsden, District Geologist.

Sand and Gravel Survey by A.J.Shaw and M.D.Issaias in 1978, under the supervision of E.F.P.Nickless. R.G.Thurrell, Head, Industrial Minerals Assessment Unit.

Borehole graphics drawn by computer programs written by J.L.McInnes, Computer Unit, I.G.S. Edinburgh.

1 : 25 000 Sand and Gravel Resource Sheet published 1981.
G.M. Brown, D.Sc., F.R.S., *Director, Institute of Geological Sciences, incorporating the Geological Survey of Great Britain, the Museum of Practical Geology and Overseas Geological Surveys.*

Data quoted for an individual borehole refer strictly to that site: reliable conclusions cannot be drawn about the thickness and grading elsewhere in the deposit, particularly in material as variable as sand and gravel. However, estimates of the volume and mean grading of the mineral as a whole in each Resource Block are given in the Report.

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

1100/81

EXPLANATION OF SYMBOLS AND ABBREVIATIONS

DRIFT

RECENT AND PLEISTOCENE

- **Peat** P-1
- **Alluvium** —clay, silt, sand and gravel A-17
- **Alluvial Cone** —fan composed of alluvium AC-2
- **Fluvioglacial sand and gravel (sometimes terraced at surface)** —sand with gravel FL-4
- **Glacial sand and gravel (deposited in eskers)** —gravel with sand GS-44
- **Glaciolacustrine deposits** —mainly clay, silt and fine sand, often laminated G-3
- **Till** —stony clay of variable stiffness, locally silty or sandy and containing deposits of head (ⓗ) TL-4

SOLID

Bedrock, at or near surface (undifferentiated)
In the valley of the Douglas Water and much of the northern part of the resource sheet, bedrock comprises sediments of Carboniferous age. The remaining parts are covered by Devonian sediments, lavas and intrusions which in the south-west and north-east flank inliers of Silurian sediments.

- **Made ground** —waste and/or natural earth materials deposited on original ground surface. MG-3
- **Worked ground** WG-1

BOUNDARY LINES

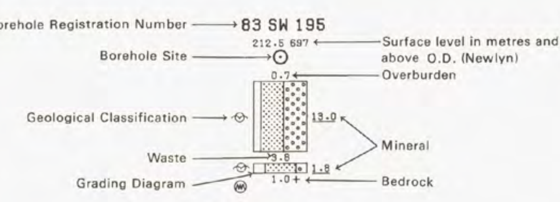
- Geological boundary
- Inferred boundary between recognised categories of deposits
- Resource Block boundary
- Back-feature of river terrace, downward slope in direction of arrowhead.
- Glacial drainage channel, arrow shows direction of water flow

BOREHOLE AND OTHER DATA

SITE LOCATIONS

- Industrial Minerals Assessment Unit (I.M.A.U.) Boreholes
- Recorded exposures
- Shallow pits

I.M.A.U. BOREHOLES



Thicknesses in metres

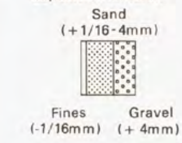
Note:
(i) Figures underlined denote thicknesses used in the assessment of resources.
(ii) The + sign indicates that the base of the deposit was not reached.
(iii) The Geological Classification is given only for mineral and bedrock.

Borehole Registration Number

Each I.M.A.U. borehole is identified by a Registration Number e.g. 83 SW 195. The first numbers and letters refer to the quarter sheet and the final figures to the I.G.S. serial numbers for that quarter. The unique designation for 83 SW 195 is NS 83 SW 195.

Grading Diagrams

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



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

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

EXPOSURE RECORDS

Information from the inspection of exposures is shown in the same way as for I.M.A.U. boreholes but they are located by an asterisk, thus ✱. The exposures are registered in the same series as the boreholes, for example, 83 SW 203.

SHALLOW PITS

Where space permits, the locations of shallow pits providing ancillary assessment data are shown. Each pit is identified by a serial registration number prefixed by P and indexed by the numbers and letters of the appropriate standard quarter sheet, for example, 82 NW P3.

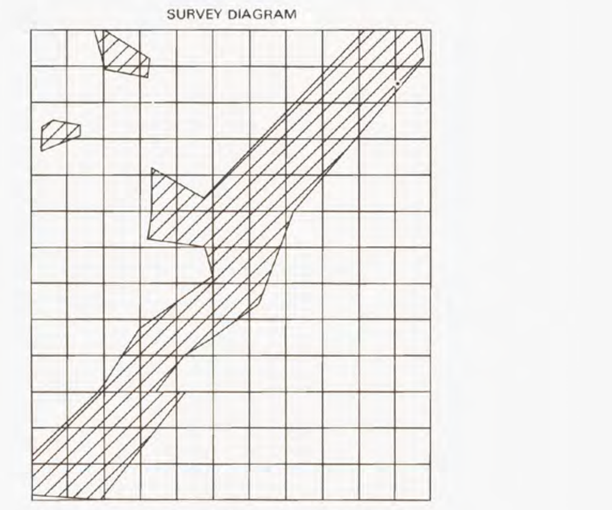
CATEGORIES OF DEPOSITS

- **Exposed mineral** CAT-E6
- **Continuous, or almost continuous spreads of mineral beneath overburden** CAT-C1
- **Sand and gravel not assessed (exposed and/or beneath cover)** CAT-N1
- **Sand and gravel absent or not potentially workable** CAT-A2

RESOURCE BLOCKS

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

SURVEY DIAGRAM



The area shown hatched was re-surveyed at Six-Inch scale by I.B.Cameron in 1976. The remainder of the sheet is compiled from older geological surveys.

Diagram showing the relation of the National Grid 1 : 25 000 sheets with the One-Inch sheets 15, 16, 23, and 24.

Detailed records may be consulted on application to the Officer-in-Charge, Industrial Minerals Assessment Unit, Institute of Geological Sciences, Murchison House, West Mains Road, Edinburgh EH9 3LA.