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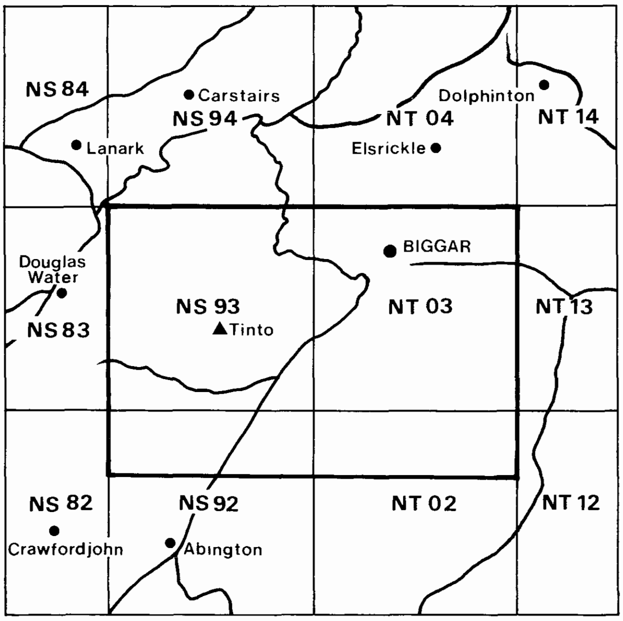

The sand and gravel resources of the country around Biggar, Strathclyde Region

Description of 1:25 000 sheets NS 93 and NT 03, and parts of NS 92 and NT 02

A. J. Shaw and J. W. Merritt

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

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

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

PREFACE

National resources of many industrial minerals may seem so large that stocktaking appears unnecessary, but the demand for minerals and for land for all purposes is intensifying and it has become increasingly clear in recent years that regional assessments of these mineral resources should be undertaken. 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 is being financed by the Department of the Environment, acting through the Scottish Development Department, and is being undertaken with the cooperation of the Sand and Gravel Association of Great Britain.

This report describes the resources of sand and gravel of 260 km^2 of country around Biggar, Strathclyde Region, shown on the accompanying resource sheet. The survey was conducted by A. J. Shaw and J. W. Merritt, and the work was controlled from the sub-unit in Edinburgh (E. F. P. Nickless, Officer-in-Charge). The work is based on Sheets 15, 16, 23 and 24 of the one-inch Geological Map of Scotland first published in 1870, 1889, 1872 and 1868 respectively, and re-published in a revised edition in 1937, 1924, 1929 and 1932 respectively. The geological lines, now presented at the 1 : 25 000 scale, include a re-appraisal of the drift geology by J. W. Merritt, A. M. Bell and I. B. Cameron based on field surveys between 1976 and 1979.

G. I. Coleman, ARICS, and J. D. Burnell, ISO, FRICS, (Land Agents) have been responsible for negotiating access to land for drilling. The ready cooperation of land owners, and tenants and the assistance of officials of Lanark and Tweeddale districts is gratefully acknowledged.

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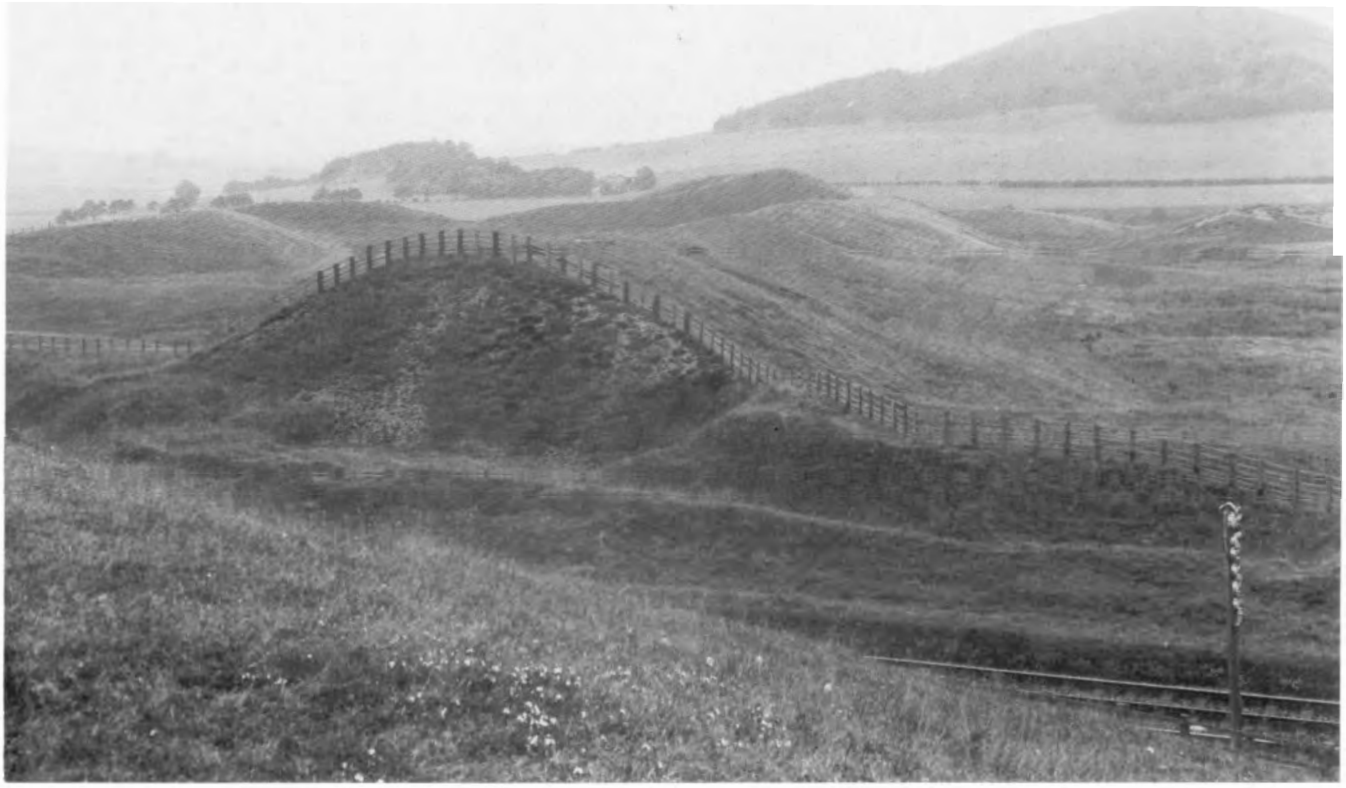

Plate 1 An old print showing part of a classic area of kame-and-kettle terrain known as the 'Thankerton Kames', which is now extensively dug away and landscaped. The view is to the north-north-east from the former golf course at Holm Braes [980 372] with Quothquan Law [988 384] in the distance. (C 2980)

Plate 2 The valley of the River Clyde looking from Quothquan Law south-westwards towards the Tinto Hills. The river is bordered by a well-defined floodplain beneath which a deep drift-filled channel is concealed. The land in the middle distance, once the site of the 'Thankerton Kames', has been extensively dug for sand and gravel, but is now largely reinstated. (D 3250)

Plate 3 The valley of the River Clyde looking from Quothquan Law westwards towards Thankerton village. The flattish land beyond the village was probably occupied by a lake in late-Glacial times. A tree-covered esker which probably once connected with the 'Thankerton Kames' lies in the middle distance. It stands up to 10 metres high, and is listed as a Site of Special Scientific Interest. (D 3251)

Plate 4 The valley of the River Clyde near Wandel. View north-eastwards from [940 270] near Moat Farm showing the floodplain bordered by laterally discontinuous terraced deposits of fluvioglacial sand and gravel and gently undulating spreads of glacial meltwater gravels. The river cliff to the left of the photograph is cut into till resting on bedrock. (D 3255)

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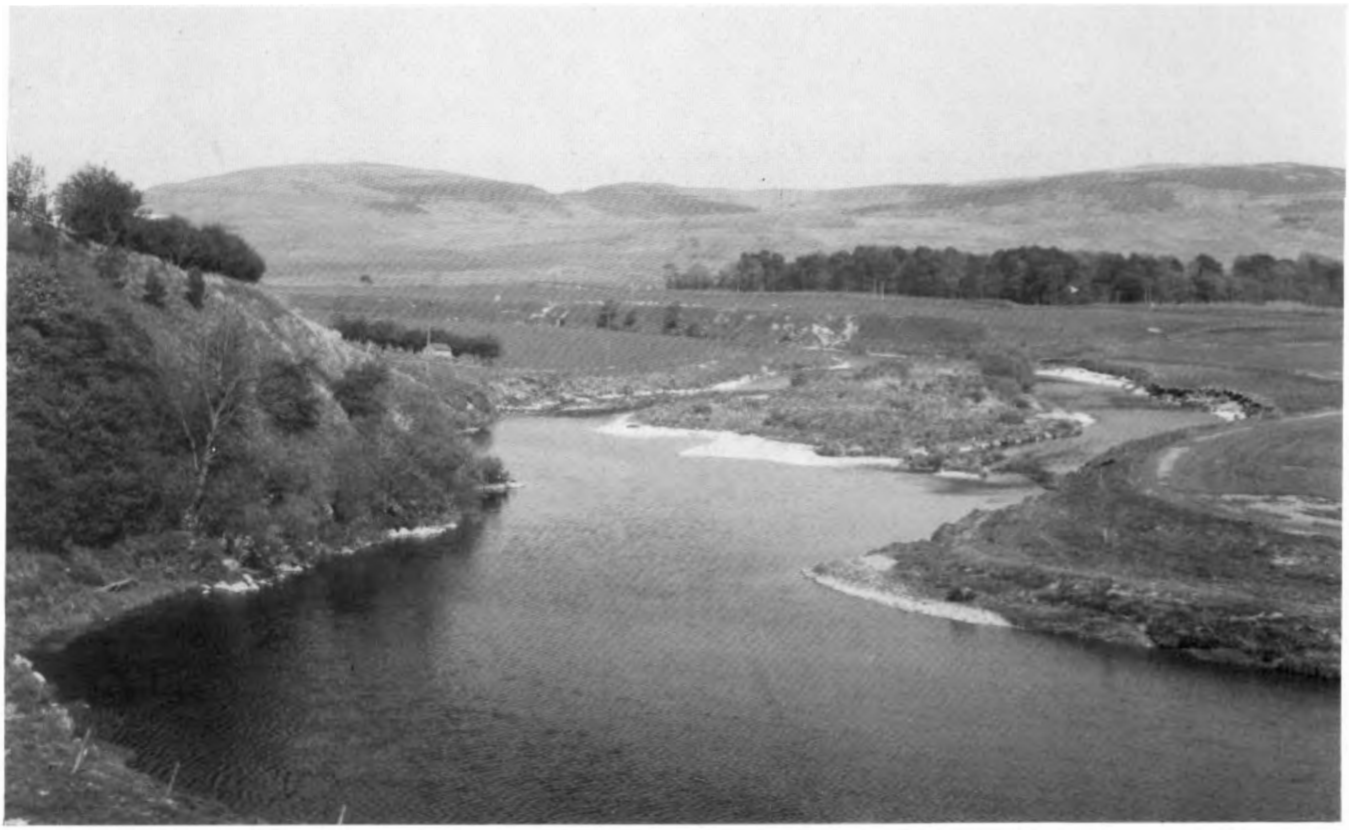

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The sand and gravel resources of the country around Biggar, Strathclyde Region

Description of 1:25 000 sheets NS 93 and NT 03, and parts of NS 92 and NT 02

A. J. SHAW and J. W. MERRITT

SUMMARY

The geological maps of the Institute of Geological Sciences, thirty-eight boreholes and forty-four shallow pits sunk for the Industrial Minerals Assessment Unit, together with pre-existing borehole information, form the basis of the assessment of sand and gravel resources in the Biggar area which straddles the boundary between Strathclyde and Borders regions.

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

The 1:25 000 map is divided into four resource blocks containing between 4.5 and 7.3 km^2 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 sample point data are given. The geology and the outlines of the resource blocks, the position of boreholes and shallow pits used in the assessment are shown on the accompanying resource map.

Bibliographical reference

SHAW, A. J. and MERRITT, J. W. 1981. The sand and gravel resources of the country around Biggar, Strathclyde Region: Description of 1:25 000 sheets NS 93 and NT 03 and parts of NS 92 and NT 02. *Miner. Assess. Rep. Inst. Geol. Sci.*, No. 95

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Note

National Grid References are given in the form [999 353] throughout. Figures with eastings between 9000 and 9999 relate to places in 100-km square NS, those with eastings between 0000 and 1000 to places in 100-km square NT.

INTRODUCTION

The survey is concerned with the estimation of resources, which include deposits that are not currently exploitable but have a foreseeable use, rather than reserves, which can only be assessed in the light of current, locally prevailing, economic considerations. Clearly, both the economic and the social factors used to decide whether a deposit may be workable in the future cannot be predicted; they are likely to change with time. Deposits not currently economically workable may be exploited as demand increases, as higher grade or alternative materials become scarce, or as improved processing techniques are applied to them. The improved knowledge of the main physical properties of the resource and their variability which this survey seeks to provide will add significantly to the factual background against which planning policies can be decided (Archer, 1969; Thurrell, 1971, 1981; 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 geological evidence. The sites available for inspection, measurement, and sampling are too widely 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 one metre 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 that broadly meets these criteria is regarded as 'potentially workable' and is described and assessed as 'mineral' in this report. As the assessment is at the indicated level, parts of such a deposit may not satisfy all the criteria.

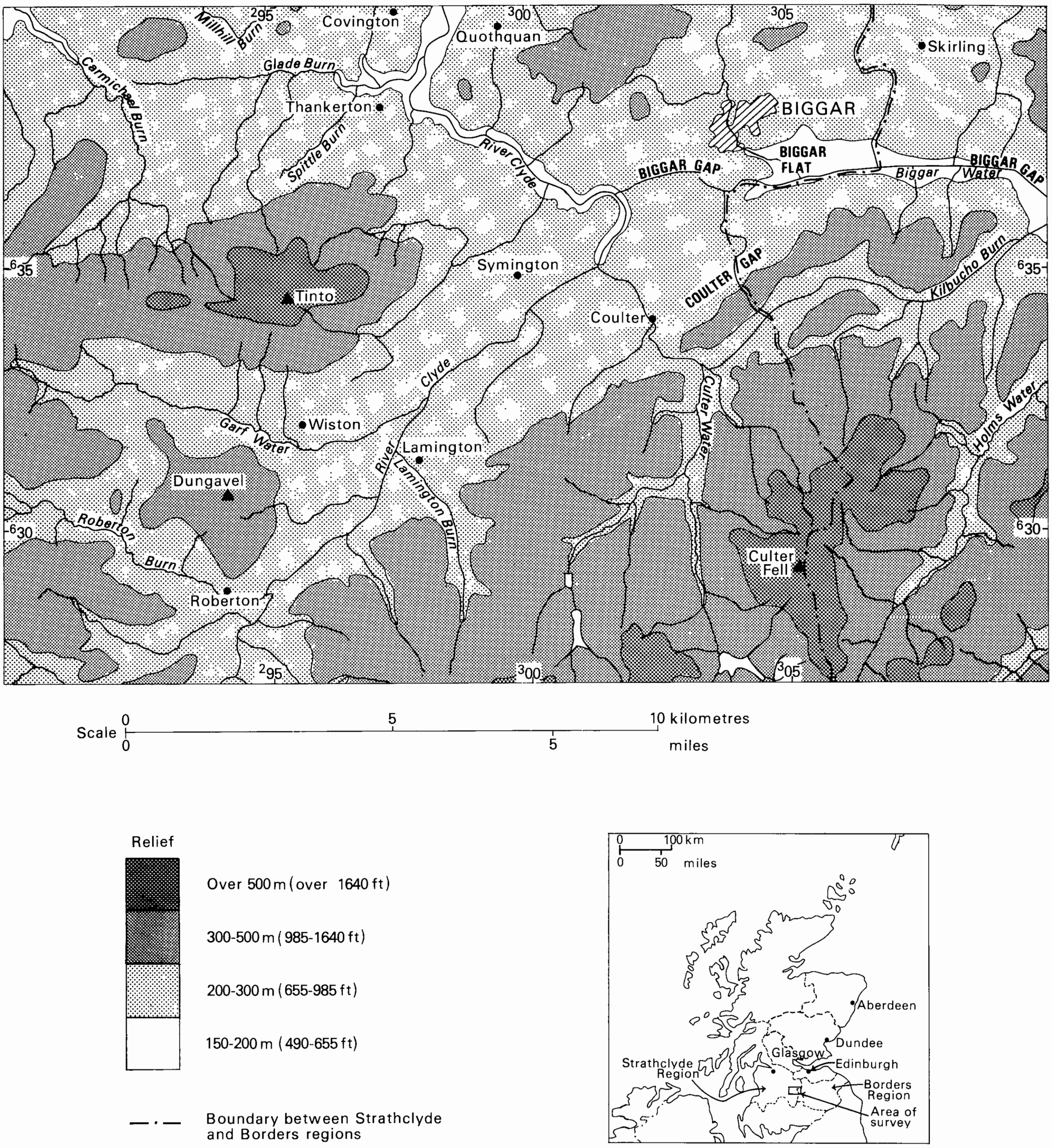


Figure 1 Sketch-map showing physiography and locality.

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

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

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

DESCRIPTION OF THE RESOURCE SHEET

GENERAL

The resource sheet area includes 260 km^2 of country around the small agricultural market town of Biggar, of which 22.2 km^2 or 8.5% are judged to be mineral-bearing. Fertile land is mainly restricted to the valley of the River Clyde and to the broad valley leading off to the east at Wolfclyde [0195 3624], much of the remainder of the area being upland and given over to sheep farming. By road Biggar is about 45 km south-west of Edinburgh and 53 km south-east of Glasgow. The main west-coast railway line linking Scotland with England passes through the area, following the valley of the River Clyde. A simplified physiographic map of the area also showing the larger settlements is given in Figure 1.

Previous literature on the sand and gravel resources of the region includes three systematic, brief accounts of the principal known sand and gravel deposits and workings (Anderson, 1946; Haldane, 1948; and Goodlet, 1970). More recently McAdam (1977) and Cameron and others (1977) have summarised published and unpublished data for Borders and Strathclyde regions respectively. Mineral Assessment Reports are available for three adjacent areas, namely, the valley of the Douglas Water (Shaw and Nickless, 1981), the Lanark area (Laxton and Nickless, 1980) and the Dolphinton area (McMillan, Laxton and Shaw, 1981).

The area has supported several large gravel pits (Appendix G), and although at the time of survey no material was being worked commercially, sand and gravel was being imported for processing and stockpiling at the pit [98 37] near Thankerton.

GEOLOGY

The geology of the resource sheet area is portrayed mainly on two sheets of the 1:50 000 Geological Map of Scotland, Lanark (23 East) and Biggar (24 West): a narrow strip of ground along the southern margin of the resource map falls on the Leadhills (15 East) and Tweedsmuir (16 West) sheets. Maps at 1:50 000 both solid and drift are in process of publication.

The area was originally surveyed at the scale of six inches to one mile by A. Geikie, J. Geikie and B. N. Peach, the maps being published in the early 1870s. A partial revision survey was undertaken by H. H. Read and J. Phemister in 1924 to 1925, the lines being incorporated in one-inch sheets 15, 16, 23 and 24, which were first published in 1937, 1924, 1929 and 1932 respectively. The drift was partially resurveyed with particular attention to the distribution of sand and gravel deposits by J. W. Merritt, A. M. Bell and I. B. Cameron between 1976 and 1979.

One-inch sheets 15, 23 and 24 have explanatory memoirs, edited by A. Geikie and were published in 1871, 1867 and 1869 respectively.

SOLID

The distribution and classification of the solid rocks, which range from Silurian to Tertiary in age, are shown in Figure 2. A major zone of faulting, the Southern Upland Fault, divides the area diagonally into regions of sharply contrasting geology and topography. In general, rocks cropping out to the north-west of the fault are gently folded and are not cleaved, whereas those to the south-east of the fault are tightly folded, repeatedly faulted and sheared, and are invariably cleaved.

Lower Palaeozoic rocks, which in this area are predominantly Ordovician in age, underlie the extensive upland tract to the south-east of the Southern Upland Fault. The rounded hills and smooth slopes of these uplands are probably due in large measure to the rapid lithological variations within the Lower Palaeozoic succession coupled with steep dips which bring the more resistant beds to the surface within relatively narrow outcrops (Sissons, 1976). The rocks mainly comprise marine sediments and lavas including dark grey siltstone, black shale, greywacke, conglomerate, red and black radiolarian chert and spilitic lavas: they more rarely include intrusive felsitic rocks and limestone. The strata were folded and faulted along a north-easterly alignment during large-scale earth movements which reached a maximum during late Silurian and early Devonian times (the Caledonian Orogeny).

To the north-west of the Southern Upland Fault rocks belonging to the Lower Old Red Sandstone predominate and contain two structural inliers of Silurian strata. The most extensive inlier occurs in the north-west of the area and is bounded on its southern side by the Carmichael Fault: the other is situated [95 33] at the foot of the Tinto Hills. The Silurian rocks comprise interbedded grey and blue shale and dark grey greywacke with conglomerate bands, overlain by reddish mudstone and flaggy sandstone.

Silurian strata are overlain with little if any unconformity by the Lower Old Red Sandstone which typically comprises greywacke- and quartzite-rich conglomerate passing upwards into reddish brown sandstone containing subordinate beds of red mudstone and conglomerate.

A thick sequence of contemporaneous maroon-grey to dark grey andesitic and basaltic lavas makes up a large part of the Lower Old Red Sandstone succession, commonly interdigitating with the sedimentary rocks. Much of the relatively low-lying yet hummocky and craggy parts of the area, such as between Lamington, Symington, Biggar and Coulter, is underlain by the lavas. Several of the higher hills to the north of the Southern Upland Fault, for example Quothquan Law [988 384] and Biggar Common [016 393], are formed of trachyte, a very hard fine-grained intermediate rock which forms part of the local Lower Old Red Sandstone succession.

The Lower Old Red Sandstone lavas are cut by numerous intrusions of felsitic rock, the most notable being the thick felsite sill or laccolith forming the Tinto Hills.

Rocks younger than the Lower Old Red Sandstone are not widespread. Red sandstone and silty mudstone with thin beds of cornstone, part of the Upper Old Red Sandstone, crop out in the extreme north-west of the survey area, where they rest unconformably on Lower Old Red Sandstone and overstep rocks of Silurian age.

A small structural outlier of Carboniferous strata belonging to the Lower Limestone Group of the Carboniferous Limestone Series occurs [926 316] near Newton.

The area is crossed by many thin dykes and sills of quartz-dolerite of late-Carboniferous (?Permian) age or post-Carboniferous (?Tertiary) age. The latter predominantly trend north-west to south-east.

DRIFT

The survey area was probably glaciated on several occasions during the Pleistocene but apart from a few deposits proved at depth which may be older, the bulk of the drift is assigned to the last (Devensian)

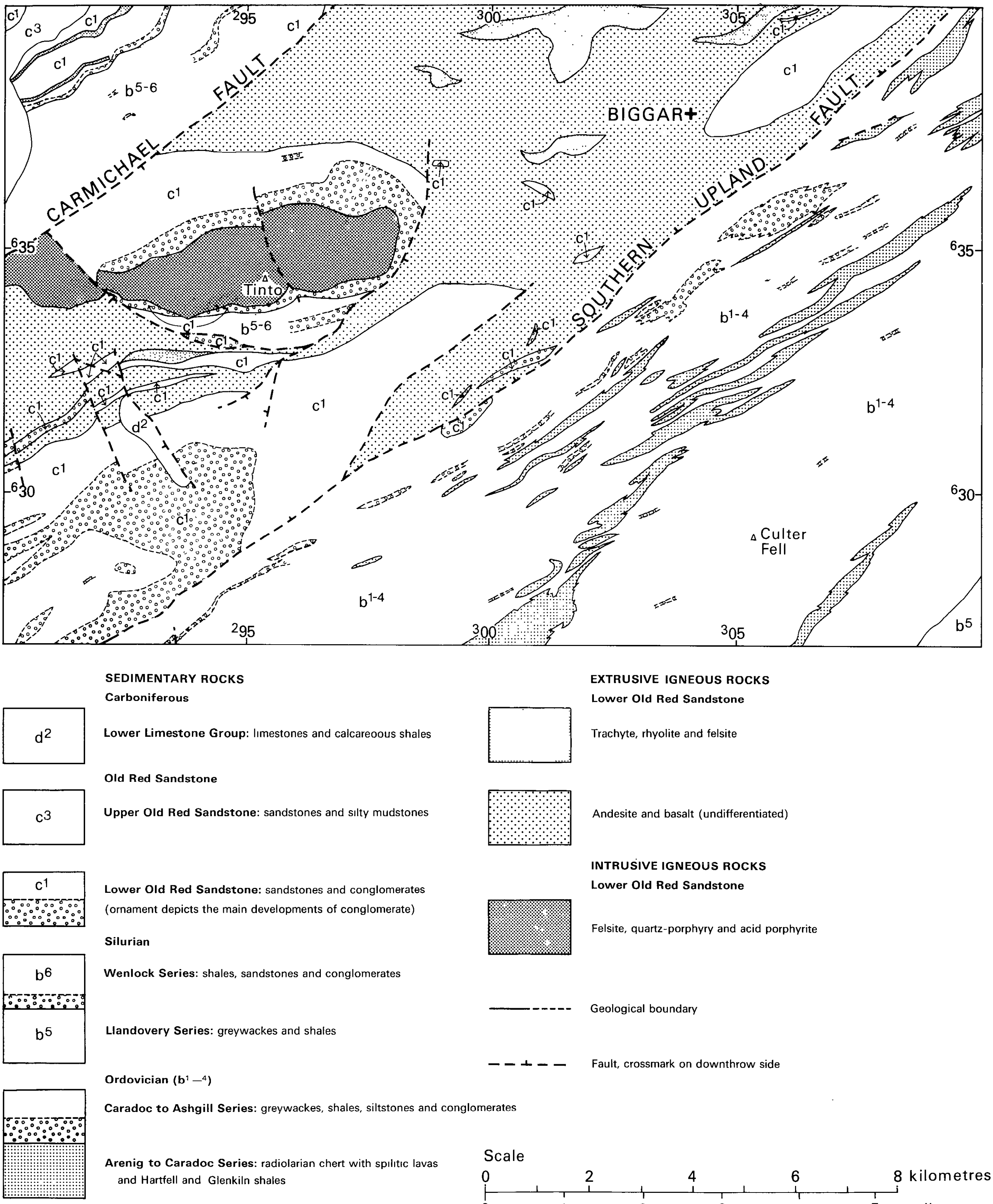


Figure 2 Sketch-map showing the solid geology.

glaciation. At the time of the maximum build-up, ice emanating from the Scottish Highlands advanced across the area and buried the entire landscape. This ice-sheet later retreated northwards to be replaced by more local ice that emanated from the Southern Uplands and which moved from the south-west towards the north-east, directed, at least at lower levels, by the topography of the pre-Glacial landscape. The glacial deposits within the survey area are largely derived from this Southern Uplands ice-sheet.

Tough, stony lodgement tills (boulder clay) accumulated at the base of the ice-sheets during their active life and became plastered over much of the buried landscape, the colour and stone-content of the till largely being controlled by the local bedrock. With the amelioration of the climate some 17 000 years ago (Sissons, 1976) the ice-sheet thinned and the tops of the higher hills such as Tinto became exposed. It is now generally accepted that stagnation of the ice-sheets was followed by wholesale melting in situ. Over large tracts of the area this resulted in heterogeneous accumulations of sandy, gravelly, roughly stratified ablation till dumped in the form of hummocks and undulating valley-floor spreads. Elsewhere meltwater collected into the streams which flowed beneath, within, around and over the surface of the decaying ice, transporting and thereby sorting and abrading rock debris released from the ice and subsequently dumping it as sand and gravel. In places meltwaters became ponded, as for example in temporary ice-caverns and in lakes, and sediment held in suspension settled out to form accumulations of silt and clay, often finely laminated.

As the ice-sheet melted the meltwater system changed continually as old routes periodically became choked and new routes were eroded. Streams which were originally mainly aligned parallel with the general north-easterly direction of ice-movement gradually migrated downslope eventually to occupy the present-day valleys. Evidence of the presence of such streams is widespread, but is perhaps best displayed along the northern flanks of the Tinto Hills where there is a series of anastomosing channels and gravel ridges (Sissons, 1961).

The meltwaters coalesced and formed major sub-glacial watercourses within the larger pre-Glacial valleys where they often cut deep channels in the bedrock. Buried channels, now filled with drift and which may have originated in this way, have been discovered beneath the floodplain of the River Clyde and beneath the 'Biggar' and 'Coulter' gaps. These, together with a buried channel beneath undulating glacial meltwater gravels at Symington, are portrayed in the geological cross-sections on the resource map.

Much of the area became inundated late in the glacial period in response to a regionally high water-table. Lakes occupied the flattish area to the north and west of Thankerton village and the level ground situated immediately south-east of Biggar ('Biggar Flat'). The extent and continuity of these former lakes, however, is problematic (Charlesworth, 1926, Linton, 1934, Sissons, 1961, McLellan, 1969). The fine-grained glaciolacustrine deposits which occupy buried channels, probably accumulated at this time: a maximum recorded thickness of 17.8 m of such sediment was proved at borehole 03 SW 1.

Meltwater streams entering the lake-system formed deltas of sand and gravel whereas gravelly beaches developed by waves winnowing fine-grained material from the submerged glacial deposits. The flat-topped gravel spread beneath Thankerton Moor, 4.1 m thick at borehole 93 NE 9, is thought to have formed in such a lacustrine environment. At Biggar, meltwaters flowing north-eastwards through the 'Coulter Gap' constructed an extensive delta at the western end of the lake occupying 'Biggar Flat'.

Thick deposits of fluvioglacial sand and gravel were laid down by the precursor of the River Clyde in late-Glacial time when the river, or at least a major distributary of it, flowed through the Coulter Gap into the lake at Biggar. The gravels have been subsequently eroded by the River Clyde upstream of Coulterhaugh where remnants of this formerly more extensive deposit now form well defined fluvioglacial terraces some 3 to 8 m above the present day floodplain. However, much of the fluvioglacial gravel remains buried beneath the floodplain alluvium where a maximum recorded thickness of 19.1 m has been proved at borehole 93 SE 5. The fluvioglacial gravels have suffered minimal post-depositional erosion in the Coulter Gap where 11.3 m of sand and gravel was proved at borehole 03 SW 3.

The ice-sheet was completely melted by about 12 500 years ago and milder conditions prevailed until about 10 800 years ago when the climate cooled again and valley glaciers reformed in the heart of the Southern Uplands (Sissons, 1976). During this cold period (Loch Lomond Stadial) summer meltwaters eroded and subsequently redistributed many of the glacial deposits, sculpturing them into what is largely their present form. In the arctic climate solifluxion of material, particularly clayey till, occurred on a large scale, giving rise to the smoothed topography of much of the area. The screes of felsite on the Tinto Hills formed mainly at this time.

Since about 10 300 years ago a relatively mild climate has prevailed. Many of the lakes and small depressions left after glaciation have been infilled with alluvium and peat, as for example the lake occupying 'Biggar Flat'. Peat accumulated over much of the upland area and the present river floodplains developed. In the valley of the River Clyde fine-grained overbank deposits, generally between 1 and 3 m thick, commonly overlie shingly river gravel.

The stratified, waterlain sediments formed in the glacial environment are referred to as glacial meltwater deposits. Two types of deposit may be distinguished on the basis of present-day landforms: a third is distinguished on the basis of lithology. The first, which is often referred to as glacial sand and gravel on older geological maps, is characterised by an irregular topography commonly comprising steep-sided elongated mounds (kames) and sinuous ridges (eskers) separated by low-lying poorly drained land. The steep sides to these features are ice-contact slopes which indicate that deposition occurred in close proximity to ice, either in caves and tunnels, or in river channels and lakes above or marginal to the ice. Closed depressions (kettle-holes), often filled with peat or lake sediments, mark the sites of former ice-masses which have subsequently melted away. A classic area of kettle-and-mound terrain known as the 'Thankerton Kames' (Gregory, 1915) lies midway between Thankerton and Symington, but the locality has been extensively worked for sand and gravel and only the fringes of the complex remain.

The second glacial meltwater deposit, often classified elsewhere as fluvioglacial sand and gravel, characteristically takes the form of gently undulating or terraced outwash spreads of sand and gravel. These deposits are generally more widespread than the moundy type, their grain-size is less variable both laterally and vertically, and they are generally better sorted. The form of these meltwater deposits is in large measure a function of the thickness of ice, if any, on which they were laid down and the amount of post-depositional subsidence consequent on melting of the buried ice. The resulting variation in landscape may be appreciated by comparing the land-form of deposits occupying the valley between Wolfclyde and Biggar, the dissected terrace [902 274] associated with the Mill Burn and the undulating terrace between Thankerton and Symington. The first two have remained flat-topped whereas spreads around Thankerton and Symington are draped over an uneven sub-glacial land-surface.

The term fluvioglacial sand and gravel is reserved for deposits underlying the well defined terraces and floodplain alluvium of the River Clyde, and for the probable lateral continuation of these deposits flooring the Coulter Gap and Biggar Flat. They largely represent the final phase of glacial meltwater deposition.

A third component of the glacial meltwater deposits, the glaciolacustrine sediments, is distinguished on the basis of lithology. Nowhere in the assessed area are such deposits judged to be potentially workable, as they are composed mainly of laminated silt, clay and very fine sand.

PARTICLE-SIZE DISTRIBUTION AND PETROGRAPHY OF THE MINERAL DEPOSITS

Waterlain sediments of sub- and pro-glacial environments comprise the principal sand and gravel resource of the area. Because of the diversity of sedimentary conditions that exist in close proximity in such environments, the deposits may vary rapidly in composition and grading, both laterally and vertically. However, in general, the mineral is relatively gravelly as is illustrated by the plot on a triangular diagram (Figure 3) of the mean gradings of mineral proved at the 54 sample points forming the basis of the assessment. The superimposed grid on this diagram corresponds with the descriptive categories in the IMAU sand and gravel classification scheme depicted in the figure in Appendix C. Sixty per cent of the mineral falls within the 'gravel' category whereas only 2 per cent falls in the 'pebbly sand' category and none classifies as sand.

The mean gradings of the various potentially workable sand and gravel deposits proved in boreholes and pits have been used to calculate the overall mean grading for each deposit over the resource sheet (Table 1). The data are represented graphically in Figures 4 to 7 which show cumulative mean grading curves together with envelopes within which the cumulative mean gradings of the mineral deposits proved at individual sample points lie. The bar graphs demonstrate frequency distribution, the length of each bar representing the percentage by weight of material passing the sieve of the indicated aperture and retained upon the next finest sieve.

Petrographical analyses (pebble-counts) were conducted on six samples of pebbles in the size range +10−14 mm. The samples examined were also used in the mechanical and physical testing described below. To obtain sufficient material of the specified size for a full range of tests, grouping of material from several boreholes was normally necessary: details are given in Table 2. Samples I and II typify the valley-floor deposits of the valley of the River Clyde (block A), III and IV the glacial meltwater deposits at Symington (block C) and Biggar (block D) respectively, and V and VI the valley-floor deposits of the Biggar and Coulter gaps (block B). Visual examination suggests that the pebbles in the specified size range are representative of the gravel fraction as a whole. Moreover, little variation in composition between different size ranges has been noted in pebble-counts on gravels from the neighbouring Lanark (Laxton and Nickless, 1980) and Douglas Water (Shaw and Nickless, 1981) assessment areas.

The petrographical analyses are presented in Table 3 as percentages by weight and by number of clasts. Usually at least 300 pebbles were included in each analysis. A classification scheme based upon the British Standard petrological groups (trade-groups) as outlined in BS 812.1: 1975 has been adopted, but modified to accommodate vein-quartz and the deleterious argillaceous sediments which, as they are not normally quarried, are not embraced by the standard. The gravels examined are mainly composed of rocks belonging to the gritstone trade-group: for example, indurated grits and greywackes matching with Lower Palaeozoic rocks of the Southern Uplands together with some more friable sandstones thought, in the main, to be derived from the Lower Old Red Sandstone. Lower and Upper Palaeozoic sediments are distinguished from each other mainly because of differences in the mechanical and physical properties, the older rocks tending to be more indurated as a result of tectonism during the Caledonian Orogeny. Pebbles from the basalt trade-group are next most abundant and are composed predominantly of indurated andesitic and basaltic lavas from the Lower Old Red Sandstone together with some quartz-dolerite from post-Carboniferous dykes. Clasts of Lower Palaeozoic siltstone and chert are plentiful and are included in the argillite and flint groups respectively. Quartzite, vein-quartz, felsite and porphyry pebbles are a minor component of all samples (except in sample VI where the last two rock types are common) with granite and schist present in trace amounts in some samples.

Valley-floor deposits (*alluvium and fluvioglacial sand and gravel*) Along the floodplain of the River Clyde and within the valleys known respectively as the Coulter and Biggar Gaps, alluvium and peat commonly overlie glacial meltwater deposits. However, as the alluvial and fluvioglacial sand and gravel are generally similar in composition it is not practicable to distinguish them in the assessment. Consequently all potentially workable material is assessed as a whole and described as 'valley-floor deposits'.

The valley-floor deposits include sediments as diverse as overbank alluvial silts and clays, fluvial and fluvioglacial gravels, and there is marked compositional variability. The point is illustrated by the wide envelope about the mean grading curve in Figure 4. The sand and gravel is invariably overlain by

Table 1 Mean grading of potentially workable deposits

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
Valley-floor deposits	3	7	17	18	31	22	2
Fluvioglacial terrace deposits	3	26	30	18	13	5	5
Glacial meltwater deposits (undifferentiated)	9	12	15	16	25	21	2
Till	15	9	13	20	28	14	1

Table 2 Source and classification of aggregate test samples

Sample	Resource block	Geological classification	Source of samples	Depth range (m)
I	A	Valley-floor deposits	NT 03 NW 1 NT 03 NW 4	2.5–22.6 1.7–13.6 15.4–17.6
II	A	Valley-floor deposits	NS 93 SE 5	2.3–21.4
III	C	Glacial meltwater deposits	NS 93 NE 16 NS 93 NE 18 NT 03 NW 2	0.3–1.8 0.4–1.7 0.3–4.6
IV	D	Glacial meltwater deposits	NT 03 NW 6 NT 03 NW 8	0.2–18.3 4.9–17.0
V	B	Valley-floor deposits	NT 03 NW 9 NT 03 NE 1	0.3–19.2 1.2–5.0
VI	B	Valley-floor deposits	NT 03 SW 2 NT 03 SW 3	0.3–11.6 12.7–15.5 0.2–11.4

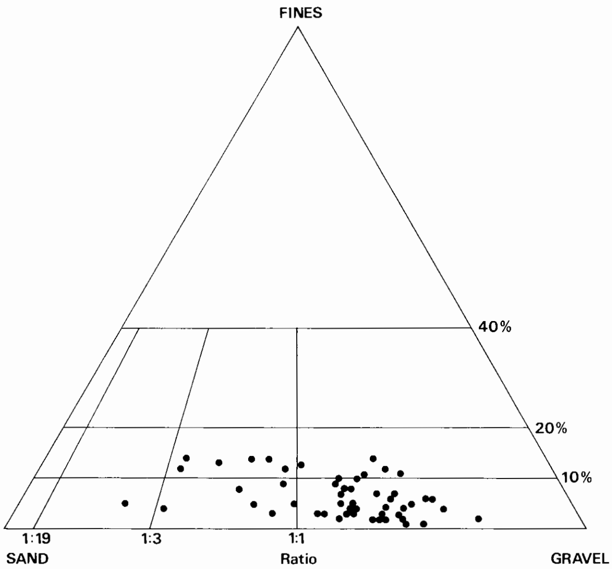


Figure 3 Mean particle-size of mineral proved at the 54 sample points used in the assessment of resources.

non-mineral overbank deposits which generally comprise laminated, grey to brown, sandy clayey silt and which are on average 1.3 m thick. Exceptionally, at borehole 03 NW 4 the overbank material is potentially workable, grading as very silty sand.

Extremes apart, the potentially workable valley-floor deposits show some uniformity in composition in that of the total thickness penetrated in drilling, 73 per cent falls within the gravel category and a further 23 per cent is classified as sandy gravel. Sample points in the valley of the River Clyde and the Coulter Gap reveal compositionally similar gravels. Those in the Biggar Gap however demonstrate a lower proportion of coarse gravel and greater amounts of coarse and medium sand in the deposits.

The valley-floor gravels commonly overlie non-mineral glaciolacustrine deposits: only at boreholes 03 NW 4 and 03 NE 2 is potentially workable sand and gravel proved beneath this material. At these two sites the overlying and underlying gravels are similar in composition.

There is apparently a gradual change in the composition of the valley-floor gravels along the valley

Table 3 Petrographical analyses of aggregate test samples

British Standard trade-groups	Rock type (modified after BS 812)	I	II	III	IV	V	VI
Number of pebbles counted		**367**	**341**	**325**	**386**	**333**	**299**
Basalt	Basalt	4.1 *4.5*	2.6 *2.1*	4.0 *3.4*	9.6 *10.0*	6.3 *6.6*	1.7 *1.9*
	Andesite	8.4 *8.8*	7.3 *6.8*	8.0 *7.1*	12.2 *10.3*	11.4 *11.1*	0.7 *0.7*
Flint	Chert	9.2 *8.6*	10.8 *11.7*	6.8 *7.3*	6.7 *6.4*	6.6 *6.5*	13.7 *13.0*
Granite	Undivided	–	0.3 *0.3*	0.3 *0.3*	–	–	0.3 *0.3*
Gritstone	Greywacke and grit (indurated)	36.0 *36.9*	44.3 *47.2*	41.2 *44.0*	42.0 *44.8*	38.8 *37.1*	60.5 *62.5*
	Sandstone	16.9 *15.7*	9.1 *7.6*	16.3 *14.5*	14.2 *13.0*	13.2 *12.5*	4.4 *4.0*
Porphyry	Felsite	5.7 *5.4*	0.6 *0.5*	1.9 *1.8*	1.3 *1.2*	2.1 *1.8*	–
	Others	1.4 *1.6*	1.2 *1.2*	1.2 *1.0*	2.1 *2.2*	1.5 *1.2*	–
Quartzite	Undivided	6.3 *6.7*	4.4 *3.9*	3.1 *3.4*	2.1 *2.7*	2.1 *2.3*	2.7 *2.7*
Schist	Undivided	0.3 *0.2*	–	–	–	–	–
Others	Vein-quartz	4.9 *4.8*	2.1 *1.8*	1.5 *1.3*	2.3 *2.0*	0.3 *0.3*	0.3 *0.3*
	Argillaceous sediments (siltstone of Ordovician age)	6.8 *6.8*	17.3 *16.9*	15.7 *15.9*	7.5 *7.4*	17.7 *20.6*	15.7 *14.6*

Results are given in frequency per cent with corresponding weight per cent in italics.

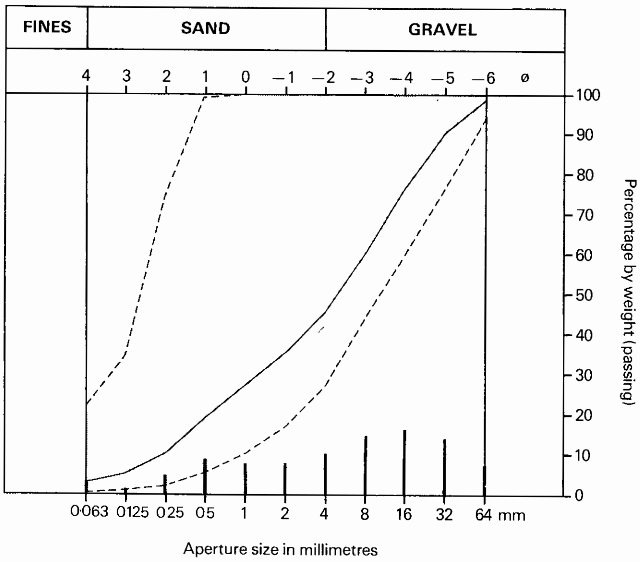


Figure 4 Grading characteristics of resources in the valley-floor deposits (blocks A and B): the continuous line is the cumulative mean; the broken lines define the envelope containing the cumulative mean grading for each separately identified mineral deposit; the frequency distribution of the mean grading (0.063 to 64 mm) is represented by the bar graph.

of the River Clyde. Pebble-counts (Table 3) on sample I, derived from boreholes downstream of Wolfclyde, and sample II, from a borehole at Lamington, reveal a predictable northerly decrease in clasts of Lower Palaeozoic sediments (greywacke, siltstone, chert and Haggis Rock) – that is, away from the Southern Uplands – and a concomitant increase in Upper Palaeozoic rocks (sandstone, lava, felsite and porphyry), together with quartzite and vein-quartz. Sample V, representing the valley-floor gravels of the Biggar Gap, is similar in composition to material from the valley of the River Clyde: the greywacke, sandstone and felsite contents lie between those of samples I and II, but lava, porphyry and siltstone are more abundant and quartzite, vein-quartz and chert less common. In contrast, sample VI from the Coulter Gap is composed almost entirely of Lower Palaeozoic rocks, reflecting the proximity of the Southern Upland Fault which brings these rocks to the surface a little way to the south-east. The presence of minor amounts of quartzite, vein-quartz, granite and schist tends to support the view of McCall and Goodlet (1951) and Eckford (1952) that the region was covered by an ice-sheet emanating from the Highlands prior to being overrun by ice from the Southern Uplands. Furthermore, if it is assumed that the composition of glacial meltwater deposits reflects the range of rock types carried by the former ice sheet in the immediate vicinity, then the results of the pebblecounting support those authors' views that the last ice advance was from the Southern Uplands and along the valley of the River Clyde.

The valley-floor gravels have a mean grading of fines 3 per cent, sand 43 per cent and gravel 54 per cent. The mean cumulative grading curve, Figure 4, illustrates a relative lack of sorting: the frequency distribution reveals some bimodality with peaks in the fine-gravel and medium-sand fractions. The gravel generally includes rare cobbles and is a little more fine than coarse; it is angular to well rounded, the fine-grade gravel tending to be more angular than the coarse. Sand is medium and coarse grained with some fine: it is composed of angular to subrounded rock fragments, predominantly greywacke with siltstone, and subrounded quartz. Its colour varies between shades of yellowish brown, greyish brown and grey depending upon the proportion of rock fragments present. Fines generally occur as disseminated silt though some silt seams were proved.

Fluvioglacial terrace deposits in the valley of the River Clyde The fragmented fluvioglacial terrace deposits, which border the River Clyde upstream of Coulterhaugh, have a mean grading of fines 5 per cent, sand 37 per cent and gravel 58 per cent. The deposit, which was investigated by four sample points, is fairly uniform in grading and composition, as demonstrated by the grading envelope in Figure 5. However, at pit 93 SE 12 the upper 0.4 m proved to be non-mineral. The mean particle-size distribution in Figure 5 shows a unimodal distribution, peaking in the fine gravel (+4 to 16 mm) size range, and illustrates a general lack of sorting. Subangular to well rounded, the gravel contains some cobbles and approximately equal amounts of the coarse and fine fractions, except in pit 93 SE 12 where the fine grade is predominant. The gravels are composed of greywacke and siltstone with lava and sandstone, though chert, felsite, quartzite and vein-quartz are present in minor amounts. The sand, coarse and medium with fine, is generally composed of subangular rock fragments and subrounded to well rounded quartz grains: it is medium-brown to yellow or orange-brown in colour. Fines mainly comprising silt are disseminated throughout the deposit.

Glacial meltwater deposits (undifferentiated) occurring in blocks C and D The compositional variability of the potentially workable glacial meltwater deposits, which range from 'very clayey' sand in borehole 03 NW 8 to coarse gravel in pit 03 NE 9 is illustrated by the width of the envelope about the mean cumulative grading curve in Figure 6. Nevertheless, although eight of the twelve IMAU mineral categories were proved, 61 per cent of the material penetrated in drilling and pitting grades as gravel and 11 per cent as sandy gravel. The mineral has a mean grading of 9 per cent fines, 43 per cent sand and 48 per cent gravel.

The potentially workable glacial meltwater deposits generally comprise a little more fine than coarse gravel and include some cobbles. The cobble and coarse gravel fractions are predominantly rounded to well rounded and contrast with the fine-gravel fraction which is generally more angular and ranges from angular to well rounded. Greywacke, sandstone, siltstone, lava, chert, quartzite, vein-quartz, felsite and porphyry are present in varying proportions. The sand fraction is chiefly of medium to fine grade and is composed of subrounded clasts of quartz with angular to subrounded rock fragments which mainly comprise greywacke being most common in the coarse fraction. The fines are mainly disseminated silt and clay. The overall colour of the material varies from shades of brown to greyish brown depending upon the content of greywacke.

Although sample points 93 NE 26, 93 NE 29 and 03 NE 3 penetrated well sorted sequences, the glacial meltwater sand and gravel is generally poorly sorted as illustrated by the mean cumulative grading curve (Figure 6). The particle-size distribution, however, does peak in the fine gravel range. In general the deposits do not show systematic vertical variation in grading. Nevertheless, fining-upwards sequences are demonstrated by borehole 93 NE 13, 03 NW 3, 03 NW 6, 03 NW 7, 03 NW 8 and 03 NE 3, in each of which the uppermost part of the deposit falls into one

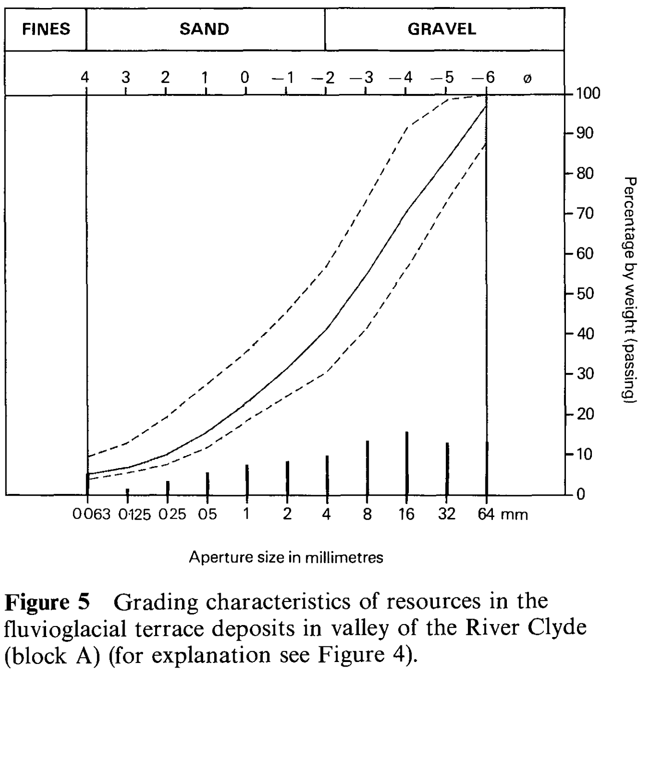


Figure 5 Grading characteristics of resources in the fluvioglacial terrace deposits in valley of the River Clyde (block A) (for explanation see Figure 4).

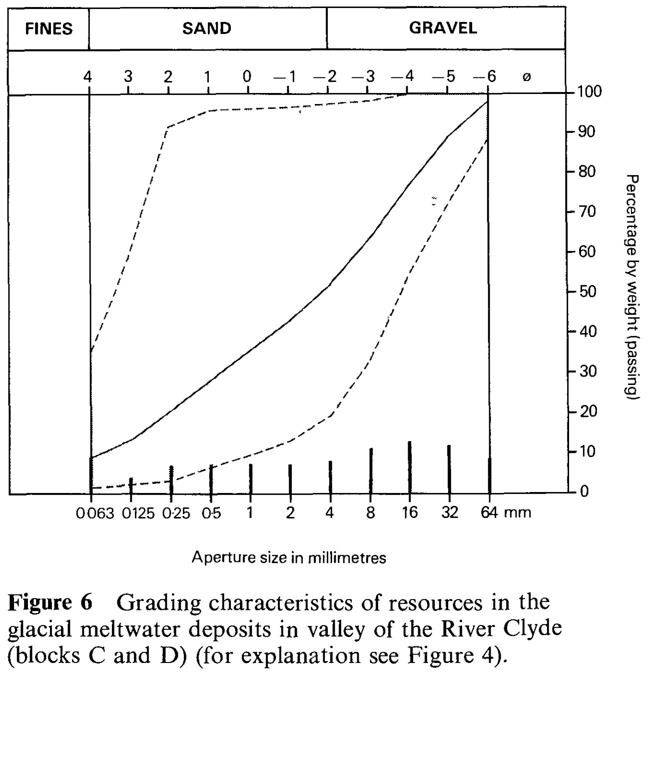


Figure 6 Grading characteristics of resources in the glacial meltwater deposits in valley of the River Clyde (blocks C and D) (for explanation see Figure 4).

of the 'very clayey' mineral categories. A fining-downwards sequence occurs at borehole 03 NW 2.

Greywacke is the dominant component of the glacial meltwater gravels although there is some regional variation: for example, it is more common than in deposits north of the Southern Upland Fault where there is relatively more lava and sandstone. Pebble-counts (Table 3) on samples collected from the deposits around Biggar and in block C, in general, differ only in the lava and siltstone contents. On the lower slopes of the Tinto Hills between Thankerton Moor and Symington there is a discontinuous spread of felsite-rich sand and gravel which is draped over and surrounds moundy deposits of gravel composed predominantly of greywacke.

Till Till is widespread and commonly floors the glacial meltwater and alluvial deposits: locally it is potentially workable. Sandy, gravelly and loosely-bound ablation till typically overlies very stiff, clayey, stony lodgement till. Ablation till is generally thickest over lower ground where it forms hummocky valley-floor spreads: for example, in the valley of the Garf Water upstream of Wiston [957 317] and in the valleys of the Roberton and Ladygill burns which converge on Roberton [945 286]. The lateral impersistence of well sorted materials renders the ablation till inferior to potentially workable glacial meltwater deposits although it might be worked locally. The till is particularly gravelly between Hardington House [9649 3024] and the Wiston Burn where it is commonly mantled by discontinuous spreads of very poorly sorted sand and gravel.

The data from two sample points indicate that the potentially workable till has a mean grading of fines 15 per cent, sand 42 per cent and gravel 43 per cent. The mean cumulative grading curve (Figure 7) illustrates the ill sorted nature of the deposit, the narrowness of the envelope being due to the limited amount of data available. The gravel fraction is fine with coarse and includes some cobbles and boulders; the clasts are mainly angular but range to well rounded. Sand, which is coarse to fine, is angular to subrounded and composed of comminuted rock fragments and quartz. Of the potentially workable till examined the fines content ranges from 10 to 24 per cent and is mainly composed of clay.

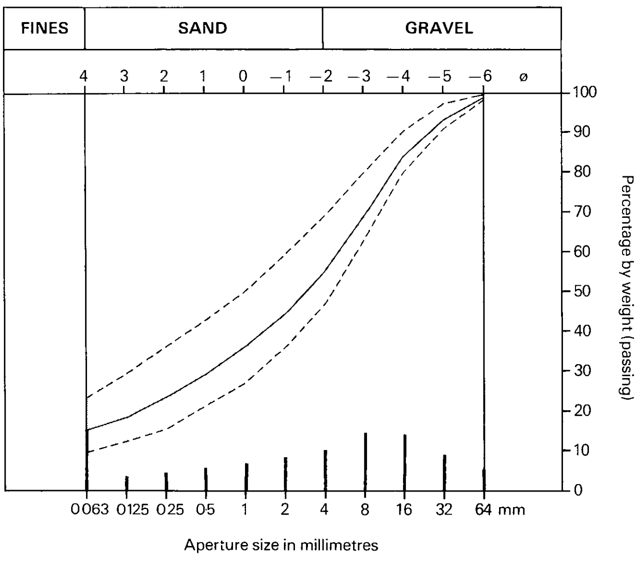


Figure 7 Grading characteristics of resources in the till: the continuous line is the cumulative mean; the broken lines define the envelope containing the cumulative mean grading for each separately identified mineral deposit; the frequency distribution of the mean grading (0.063 to 64 mm) is represented by the bar graph.

MECHANICAL AND PHYSICAL PROPERTIES OF THE AGGREGATE

Tests to determine aggregate impact value (AIV), aggregate crushing value (ACV), 10% fines value, flakiness index, relative density (on oven-dried and surface-dried bases), apparent relative density, water absorption and bulk density (on compacted and uncompacted bases) were undertaken in accordance with British Standard 812:1975 on the six samples listed in Table 2. Although it would have been desirable to test a greater number of samples, the results, which are presented in Table 4, are considered representative.

AIV, ACV and 10% fines value tests are used to judge the strength of an aggregate. AIV is a relative measure of the resistance of an aggregate to sudden load or impact, which in some aggregates differs from the resistance to a slowly applied compressive load as indicated by ACV and 10% fines value. The potential use of an aggregate, particularly as a roadstone, is affected by its resistance to the types of loading characterising these three tests. In measuring the resistance to a slowly applied compressive load the ACV and 10% fines value tests differ in that the ACV test measures compaction produced by applying a gradually increasing load attaining 400 kN after ten minutes: the 10% fines test measures the load which, when applied over ten minutes, produces 10 per cent by weight of comminuted material passing a 2.36-mm sieve. Although the AIV and ACV provide some indication of the strength of intergranular bonding, a misleading impression of aggregate performance may be gained as the tests assess only the amount of cataclastic material passing a 2.36-mm sieve. It is arguably more important, however, in the assessment of the potential of an aggregate, for the clasts to survive loading relatively intact rather than to withstand a high level of comminution. Consequently, values of aggregate impact value residue (AIVR) and aggregate crushing value residue (ACVR), as defined by Ramsay (1965) and Dhir and others (1971), were determined from measurements of the amounts of material exceeding 10 mm that remained after testing.

The resistance of an aggregate to impact and compressive load is a function of petrography, shape and degree of weathering, the last two characteristics 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 and in igneous rocks it depends on the degree of crystal interlocking and the strength of individual crystals, a function of twinning, cleavage and microfracture planes (Ramsay, 1965).

The flakiness index is a measure of the shortest axes of clasts, a pebble being described as flaky if it has a thickness (smallest dimension) of less than 0.6 of its nominal size. The present results support the observations of Ramsay (1965) and Dhir and others (1971) that there is an inverse relationship between this index and the strength of an aggregate. Flakiness in

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

Sample	I	II	III	IV	V	VI
Flakiness index	18	23	16	14	14	19
AIV	17	19	16	15	19	19
AIVR	45	38	42	47	39	36
ACV	14	16	14	15	15	15
ACVR	44	38	41	42	42	39
10% fines value (kN)	270	270	300	280	280	270
Relative density (oven-dried basis)	2.55	2.54	2.51	2.54	2.56	2.56
Relative density (saturated and surface-dried basis)	2.60	2.60	2.58	2.60	2.62	2.61
Apparent relative density	2.68	2.69	2.68	2.70	2.68	2.70
Water absorption (%)	2.0	2.3	2.4	2.3	2.4	2.0
Uncompacted bulk density (kg/m^3)	1760	1760	1520	1750	1700	1690
Compacted bulk density (kg/m^3)	1930	1870	1760	1830	1850	1860

gravels is principally a function of petrography and distance of transportation. In the gravels tested the most flaky clasts are dominantly composed of siltstone and flaggy greywacke: samples II and VI with the highest indices come from nearest the source area of these rock types. The results are higher than those recorded by McMillan and others (1981) for samples from the neighbouring Dolphinton resource sheet area which is almost certainly attributable to the higher siltstone and greywacke content of gravels in the Biggar area. Although the Biggar gravels have high flakiness indices, they are nevertheless stronger in terms of physical testing results than those from the neighbouring Lanark, Douglas Water and Dolphinton resource sheet areas, where clasts are less flaky and compositionally distinct, and comprise mainly less indurated sandstones and lavas.

The results for AIV, ACV, 10% fines, AIVR and ACVR all show similar trends, and the values for flakiness index generally correlate with these determinations. For example, samples II and VI, which have the highest flakiness indices also have the highest AIVs and ACVs and the lowest AIVRs and ACVRs. The results, however, show no easily predictable relationship with petrography, and any differences in the mechanical properties between the aggregate samples probably result more from factors such as distance of transport, length of subaerial exposure, and the shape and roundness of clasts.

Although the gravels of the resource sheet area are relatively strong judged in terms of the mechanical testing results, the suitability of an aggregate for use in concrete manufacture is affected by water absorption and drying shrinkage, surface texture, surface area, organic impurities and chemistry (Edwards, 1970).

The water absorption value of an aggregate is a measure of the absorption of distilled water after immersion for 24 hours, expressed as a percentage of the oven-dry weight. Edwards (1970) demonstrated the importance of this measure by illustrating a broad linear relationship between water absorption and drying shrinkage, both of the aggregate itself and of any concrete prepared from it. Drying shrinkage and wetting expansion of concrete is a prime factor affecting stress-carrying ability and weathering resistance (Building Research Establishment, 1968). Although the water absorption values determined for aggregates from the Biggar area are higher than the mean of 1.48 per cent given by Edwards (1970) for a variety of Scottish and English gravels they are lower than those calculated for aggregates collected in the neighbouring resource assessment areas. The values are higher than the figure quoted by Edwards probably because of the relatively high gritstone content of the gravels within the Biggar resource sheet area, but are lower than the values obtained for the neighbouring areas probably because the gritstone clasts are generally more highly indurated. Flint and quartz generally yield the lowest water absorption values whereas gritstone and siltstone yield the highest: acid igneous rocks usually have lower absorption values than their more basic counterparts. The degree of weathering or induration, however, will affect the absorption of any rock type. There is little variation between the water absorption values obtained for the aggregate samples in this area and what differences there are show no simple relationship with petrography.

Using the graph presented in Edwards (1970) linking water absorption with concrete drying shrinkage, the aggregates examined have inferred concrete drying shrinkage values of between 0.070 and 0.075 per cent. These values lie within the category defined by the Building Research Establishment Digest 35 (1968) of concretes that are suitable for general structural purposes provided that care is exercised when the product is unreinforced or thinly reinforced and exposed to the weather, for the durability is likely to become affected in the course of time. However, such inferred values should be interpreted cautiously. True values can only be obtained by testing concrete blocks.

The relative densities show only slight variation between samples and appear to correlate more with bulk density than with petrography.

The determination of bulk density entails weighing aggregate placed in both a compacted and an uncompacted state into containers of known volume. These tests may be equated with the deposit in situ and as excavated. The compacted bulk density appears to be dependent on the grading of the deposit, the value decreasing with a reduction in gravel content. Values for the uncompacted bulk density, however, do not mirror this trend and bear no obvious relationship to grading.

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 which together with the contours is printed in grey: the geological lines and symbols are 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, parts of which were last surveyed on the scale of 1:10 560 by staff of the Institute's South Lowlands Unit and the Industrial Minerals Assessment Unit between 1976 and 1979. The boundaries are the best interpretation of information available at the time of 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.

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

Mineral resource information The map is divided into resource blocks (see Appendix A), within which the extent of mineral-bearing ground is shown in red. The dark shade denotes where mineral is exposed, that is, the overburden averages less than 1.0 m in thickness: a lighter tone is used to identify where it is present in relatively continuous spreads beneath overburden averaging more than 1.0 m in thickness. Within these areas, however, there may be small patches where sand and gravel is absent or not potentially workable, as for example, around pit 03 NE 5.

A further category, which is shown on the resource map in the lightest tone of red, is recognised where mineral is considered discontinuous. The recognition of categories is subjective, depending on the proportion of boreholes which did not find potentially workable sand and gravel, and the distribution of these barren boreholes within an area. The mineral is described as 'almost continuous' if it is present in 75 per cent or more of the boreholes in a prescribed area and as 'discontinuous' if present in more than 25 per cent but less than 75 per cent of the boreholes in a prescribed area.

Areas where sand and gravel is deemed to be not potentially workable, where superficial deposits do not contain mineral, or where bedrock crops out, are shown uncoloured. Sand and gravel within the built-up area of Biggar but which nevertheless may be potentially workable, is indicated by a red stipple. The same ornament is used for sand and gravel deposits occurring in the north-west of the resource sheet area which are assessed in the Douglas Water report (Shaw and Nickless, 1981).

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 with 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.

THE ASSESSMENT

The mineral-bearing ground is divided into four resource blocks for assessment. The positioning of the block boundaries is a compromise to meet the aims of the survey: on the one hand to provide sufficient sample points on which to base an assessment, and on the other to group together deposits of broadly similar origin and composition. As far as possible the block boundaries are determined by geological lines so that, for example, glacial meltwater gravels and fluvioglacial terrace gravels are separated. Otherwise division is by arbitrary lines which bear no relationship to the geology.

Mineral resources are mainly confined to the valley of the River Clyde and to the 'misfit' valleys of the Well Burn and Biggar Water which are known respectively as the Coulter and Biggar gaps (Figure 1). Block A includes mineral underlying the floodplain and fluvioglacial terraces in the valley of the River Clyde. Mineral flooring the Biggar and Coulter gaps is included in block B: the extensive spread of glacial meltwater gravels between Thankerton and Symington is encompassed by block C. The remainder of the sheet, block D, is mainly upland where mineral is patchy and mainly comprises glacial meltwater gravels in the form of eskers, kames and kame-terraces. Locally till is potentially workable, as judged by the arbitrary criteria adopted for the survey, but because lithology is extremely variable and the distribution of mineral is patchy, no assessment of this resource is offered.

The statistical procedure adopted for the volumetric assessment of the mineral resources is outlined in Appendix B. A 'statistical' assessment is offered for the mineral underlying the floodplain of the River Clyde, for the deposits flooring the Biggar and Coulter gaps, and for the glacial meltwater gravels contained in block C. Other potentially workable deposits, which are mainly included within block D, are too patchy and diverse to assess statistically. Most cover less than one square kilometre and were investigated by a single borehole or pit; for some deposits there are no such data. Consequently, 'inferred' assessments are offered for these deposits based both on sample point data and consideration of the geology and three-dimensional form. For example, much of the mineral identified within block D occurs in eskers which have been assumed to approximate the form of triangular prisms, the volumes of which have been calculated by simple arithmetic. Likewise kames were often considered as hemispheres and kame-terraces as trapezoid prisms. However, the computed volumes must be interpreted cautiously. For example, the procedure tends to underestimate volume because no account has been taken of material that may lie below the general ground level, unless there is evidence to suggest the contrary.

RESULTS

The mineral resources of the sheet area are discussed in the resource block descriptions. Data used in the assessment calculations together with the results are given in Tables 6 to 9: a summary of these data is presented in Table 5. Some conclusions are offered, following the block descriptions, regarding the resources most likely to command attention in the short-to-medium term.

Accuracy of results For deposits assessed statistically in blocks A, B and C the accuracy of the results at the symmetrical 95 per cent probability level ranges from 53 to 68 per cent. 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

Table 5 The sand and gravel resources: summary of statistical and inferred assessments

Resource block and mineral-bearing deposits	Area		Mean thickness		Volume of sand and gravel			Mean grading percentage		
	Block	Mineral	Over-burden	Mineral		Limits at the 95% probability level		Fines $-\frac{1}{16}$	Sand $+\frac{1}{16}-4$	Gravel $+4$
	km^2	km^2	m	m	$m^3 \times 10^6$	$\pm$ %	$\pm m^3 \times 10^6$	mm	mm	mm
SUMMARY OF STATISTICAL ASSESSMENTS										
A Valley-floor deposits	7.9	6.1*	1.5	9.2	56	53	30	3	41	56
B Valley-floor deposits	10.4	4.5	0.9	9.3	42	68	29	4	45	51
C Glacial meltwater gravels	8.9	5.2	0.4	3.0	16	62	10	8	42	50
SUMMARY OF INFERRED ASSESSMENTS										
A Fluvioglacial terrace deposits	7.9	1.2	0.6	5.4	6	Speculative		5	37	58
D Glacial meltwater gravels	232.8	4.7	0.3	4.1	19	Speculative		11	42	47
D Valley-floor deposits (Glade Burn)	232.8	0.4	1.2	3.4	1.3	Speculative		3	39	58

* Figures are rounded. Further details are presented in Tables 6 to 9.

volume of a very much smaller parcel of ground (say, one hundred hectares) containing similar sand and gravel deposits if results from the same number of sample points (as provided by, say, ten boreholes) were used in the calculation. Thus, if closer limits are needed for the quotation of reserves of part of a block it can be expected that data from more than ten sample points will be required, even if the area is quite small.

However, it must again be emphasised that the quoted volume of sand and gravel has no simple relationship with the amount that could be extracted in practice, since 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

Block A

The block includes the floodplain of the River Clyde together with the discontinuous fluvioglacial terraces which border the floodplain upstream of Coulterhaugh [009 345].

At boreholes sited on the floodplain it was often difficult to distinguish alluvial gravels from more deeply buried fluvioglacial gravels. Consequently, for the purposes of assessment, any mineral underlying the floodplain alluvium is described as 'valley-floor deposits'. This resource predominantly lies below the water table (see Figure 13), whereas the fluvioglacial sand and gravel underlying the terraces might be worked dry. Consequently separate assessments are offered for the two deposits. A statistical assessment is presented for the valley-floor deposits whereas only an inferred assessment is possible for the terrace material owing to the paucity of sample points.

Fluvioglacial terrace deposits The fluvioglacial terraces are generally flat-topped and commonly have pronounced back-features. They stand about 8 m above the present-day floodplain near Ladygill [943 281] but gradually fall north-eastwards to lie at only one metre above the river to the north and west of Overburns [9951 3232]. The only sample point to determine the base of the fluvioglacial sand and gravel is borehole 93 SE 1, near Hardington House [9649 3025], which revealed 5.4 m of poorly sorted gravel overlying till, probably on rock, though this was not proved. Hereabout the base of the terrace deposit is approximately at the level of the floodplain.

Terraces occur at two levels near Lamington: pit 93 SE 13 proved 2.0 m of gravel beneath the lower, and on the high terrace, flanking a rock knowe (knoll) upon which the village church and school stand, pit 93 SE 12 demonstrated 0.4 m of pebbly sandy clay overlying 1.2 m of sandy gravel. To the south of Lamington Mains [9822 3204] a narrow terrace was investigated at pit 93 SE 15 which proved 1.9 m of well sorted gravel.

The inferred volumetric assessment is based on borehole 93 SE 1 but data from all the sample points are used in the mean grading calculation. Details are presented in Table 6 and the grading results are shown graphically in Figure 5.

Valley-floor deposits The River Clyde flows north-eastwards from the southern margin of the sheet to Wolfclyde where it swings north-westwards as far as Thankerton Boat [9780 3828] before resuming its north-easterly course. The valley-floor falls from about 221 to 191 m above OD across the area. Meanders are common on the floodplain, and former river courses can often be distinguished, as for example south-west of Coulterhaugh where there is an oxbow lake known as Mary Miller's Pool [003 340].

The Clyde floodplain narrows between Coulterhaugh and Thankerton Bridge [9786 3829] and is only 70 m wide at its narrowest point where the Cleave Burn flows into the river [9921 3763]. Downstream of Lamington Mains [9822 3203] the floodplain divides about an island of bedrock capped by till where nearby dredging of sand and gravel, now discontinued, has resulted in a lake. Sand and gravel was also worked from the floodplain near Sandy's Ford [0084 3474] (Haldane, 1948).

Borehole evidence indicates that the floodplain and low-lying alluvial terraces of the River Clyde conceal buried channels which were probably eroded by glacial

Table 6 Block A: Data from sample points and the assessment of resources

Sample point — Borehole or pit	Recorded thickness — Mineral m	Over-burden m	Waste partings m	Mean grading percentage — 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	Descriptive category*
FLUVIOGLACIAL TERRACE DEPOSITS											
93 SE 1	5.4	0.6	–	4	5	13	20	28	29	1	G
93 SE 12†	1.2+	0.9	–	9	10	17	21	34	9	0	SG
93 SE 13†	2.0+	0.4	–	6	2	11	12	26	31	12	G
93 SE 15†	1.9+	0.3	–	4	5	15	18	34	24	0	G
Mean	5.4	0.6	–	5	5	14	18	29	26	3	G
VALLEY-FLOOR DEPOSITS (alluvium and concealed fluvioglacial sand and gravel)											
92 NE 1	2.0	1.0	–	5	4	10	14	27	38	2	G
92 NE 2	10.0+	0.2	–	4	6	16	17	27	26	4	G
93 NE 14	4.6	1.4	–	1	1	9	18	42	29	0	G
93 NE 15	3.8	2.7	–	4	4	10	16	35	31	0	G
93 SE 3	7.8	1.9	–	2	4	9	21	34	24	6	G
93 SE 5	19.1	2.3	–	2	3	12	20	39	23	1	G
93 SE 7	5.0	1.5	1.2	4	2	13	18	35	27	1	G
03 NW 1	20.1	2.5	–	3	14	28	11	19	23	2	SG
03 NW 4	15.7	0.1	1.8	5	13	19	16	27	19	1	SG
03 SW 1	4.6	1.6	–	1	2	12	17	32	33	3	G
94 SE 15‡	5.0	0.4	–	2	4	13	19	34	22	6	G
Mean	9.2	1.5	–	3	7	17	17	30	24	2	G

* See Appendix C.
† Thicknesses not used in assessment calculations as the mineral deposit was not bottomed.
‡ Borehole sited on adjoining Lanark resource sheet.

Statistical assessment of the valley-floor deposits

Area of mineral bearing ground	6.13 km^2
Area of flooded sand and gravel workings and worked ground	0.22 km^2
Mean thickness of overburden	1.5 m
Mean thickness of mineral	9.2 m
Estimated volume of mineral	**56.4 million m^3**
	±53% or 29.9 million m^3

Inferred assessment of the terrace deposits

Area of mineral bearing ground	1.18 km^2
Estimated volume of mineral based on borehole 93 SE 1	**6.4 million m^3**

meltwaters and which have been subsequently filled with glacial, fluvioglacial and alluvial sediments, all of which may be gravelly.

The boreholes upstream of Mary Miller's Pool demonstrate that the potentially workable valley-floor deposits vary little in composition either laterally or vertically: most of the material comprises more than 50 per cent gravel. The boreholes all bottom in bedrock with some proving till underlying the mineral deposits. At the margin of the floodplain near Longwell [9572 2964], borehole 92 NE 1 proved 2.0 m of sand and gravel overlying till, but 110 m nearer the river, borehole 92 NE 2 encountered mineral to a depth of 10.2 m before being stopped on an obstruction, thus demonstrating the predictable thickening of deposits towards the valley axis.

The valley-floor deposits between Lamington and Lamington Mains may be thicker than those to the south: borehole 93 SE 3 penetrated 7.8 m of mineral on 0.6 m of till on bedrock, compared with borehole 93 SE 5 which proved 19.1 m of mineral overlying sandstone. The northerly continuation beneath the floodplain of the bedrock ridge lying between Lamington Mains and Langholm was probably struck by borehole 93 SE 7 which proved sand and gravel to a depth of only 7.7 m. Hearsay suggests that in the nearby workings sand and gravel was excavated from the bed of the River Clyde at depths of up to 10 m beneath the floodplain.

Downstream of Mary Miller's Pool borehole evidence indicates that the sediments occupying the valley-floor are thicker than those upstream though the mineral component varies greatly in thickness and grading. For example, borehole 03 SW 1 encountered 4.6 m of mineral overlying 17.8 m of laminated glaciolacustrine silts whereas borehole 03 NW 1 proved 20.1 m of mineral on bedrock with no intervening waste. Downstream of the confluence of the Cleave Burn and the River Clyde boreholes 93 NE 14 and 93 NE 15 demonstrated 4.6 and 3.8 m respectively of potentially workable material overlying thick laminated glaciolacustrine sediments. Borehole 94 SE 15 [9882 4055], drilled in connection with the assessment of resources in the Lanark area (Laxton and Nickless, 1980) and sited 560 m to the north of the boundary of the Biggar resource sheet, penetrated 5.0 m of valley-floor deposits which graded as gravel and overlay thin peat on glaciolacustrine deposits to a depth of 25.0 m. Such data have been used in the volume calculation as it is considered that the results are representative of the northern part of the block.

Between the confluences of the Cleave Burn and the

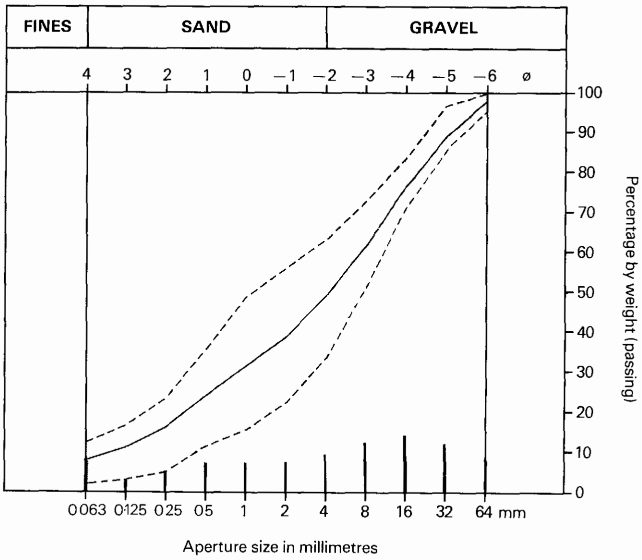


Figure 8 Grading characteristics of resources in the valley-floor deposits of block A: the continuous line is the cumulative mean; the broken lines define the envelope containing the cumulative mean grading of mineral proved in individual boreholes; the frequency distribution of the mean grading (0.063 to 64 mm) is represented by the bar graph.

Culter Water with the River Clyde boreholes show mineral to be thick and the buried glaciolacustrine deposits thin or absent. Borehole 03 NW 4 penetrated 8.0 m of gravel overlying 3.9 m of sandy gravel which coarsened with depth and was separated from a lower 2.2 m of gravel by 1.8 m of glaciolacustrine deposits. In contrast borehole 03 NW 1 encountered 4.0 m of gravel, fining with depth, overlying 16.1 m of sandy gravel resting directly on bedrock. It is probable that originally thicker sequences of glaciolacustrine sediments were deposited at these two localities but they have been subsequently eroded prior to deposition of the sand and gravel.

Several boreholes proved glaciolacustrine sediments to overlie sand and gravel but usually this basal deposit is non-mineral judged in terms of the arbitrary 3:1 overburden to mineral criterion adopted for this survey. Thus, the 2.0 m and 1.5 m of sand and gravel proved by boreholes 03 SW 1 and 93 NE 15 respectively are considered not potentially workable whereas the 2.2 m of sand and gravel proved in borehole 03 NW 4 is mineral.

Overburden ranges in thickness from 0.1 m in borehole 03 NW 4 to 2.7 m in borehole 93 NE 15 and has a mean thickness of 1.5 m. In borehole 03 NW 4 the overbank sediments proved to be mineral, grading as 'very clayey' sand. At all other sample points, however, they comprise laminated sandy clayey silt containing plant remains and are brown in colour, sometimes becoming bluish grey with depth.

A statistical assessment is offered for the valley-floor deposits based upon eleven IMAU boreholes (including one drilled in the Lanark area). Detail is presented in Table 6 and Figure 8.

Block B

The block includes the deposits flooring the Biggar and Coulter gaps and is bounded in the west by the floodplain of the River Clyde. The Biggar and Coulter gaps are misfit valleys branching north-eastwards from the valley of the River Clyde at Wolfclyde and near Coulterhaugh respectively. The two gaps converge on a flat, low-lying area at Biggar public park [05 37] known locally as 'Biggar Flat'; the eastward continuation of this area is also called the 'Biggar Gap' and eventually links with the valley of the River Tweed. Between the two gaps the ground rises to 246 m above OD: till crops out on the lower slopes, bedrock on the hilltops and as knowes. The floors of the gaps which are generally flat and marshy are prone to flooding. Peat has accumulated to the east of Biggar public park. In the Biggar Gap west of the town a small stream usually flows into the River Clyde but the course is often reversed at times of flooding, when the waters divert to the River Tweed.

Mineral is contained within deposits classified as alluvium, fluvioglacial sand and gravel and glacial meltwater deposits: following the procedure adopted for block A they have been grouped together as valley-floor deposits for the purpose of assessment.

Coulter Gap The floor of the Coulter Gap is occupied by fluvioglacial sand and gravel which probably connects laterally with similar gravelly deposits concealed by the floodplain alluvium of the River Clyde. Since deposition, supposedly in late-Glacial times, the fluvioglacial gravel spread has been modifed by fluvial activity, primarily by the Culter Water. An alluvial cone has partially concealed the deposits [033 348] near East Mains.

On the flat alluvial spread separating the floodplains of the River Clyde and the Culter Water near Coulter Maynes [0154 3460], borehole 03 SW 2 proved 2.0 m of poorly sorted 'clayey' gravel passing downwards into 9.3 m of well sorted gravel. A bed of glaciolacustrine silt 1.1 m thick separated this material from a further 2.8 m of fluvioglacial sand and gravel which rested on bedrock. Upstream of Coulter, the Culter Water has a narrow gravelly floodplain which may conceal buried deposits of sand and gravel, but there are insufficient data available to offer an assessment.

A low back-feature separates the floodplain alluvium of the Culter Water from exposed fluvioglacial deposits in the Coulter Gap where borehole 03 SW 3 proved 11.2 m of moderately well sorted gravel overlying bedrock. The fluvioglacial gravels hereabout abut bedrock knowes and consequently have a variable thickness. Although fluvioglacial sand and gravel was not recognised throughout the Coulter Gap, if it is assumed that glacial meltwaters once flowed along the valley towards Biggar Flat it seems likely that the material could be more extensive than is shown on the map. Further investigation in the valley of Well Burn and around Hartree Hotel [0462 3616] may reveal buried, potentially workable sand and gravel. However, mineral was not found by borehole 03 NW 10 near Hartree Mill [0418 3634] which proved 0.5 m of floodplain silt overlying 4.0 m of potentially workable till resting on bedrock.

Coulterhaugh is built on a bedrock knowe partially capped by glacial meltwater deposits. In this vicinity pit 03 SW 5 demonstrated 0.4 m of sand overlying bedrock but nearby sand and gravel is thought to be thicker.

Biggar Gap west of Biggar The floor of the Biggar Gap west of the town is occupied by a flattish spread

Table 7 Block B: Data from sample points and the assessment of resources

Sample point Borehole or pit	Recorded thickness			Mean grading percentage							Descriptive category*
	Mineral m	Over-burden m	Waste partings 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	
VALLEY-FLOOR DEPOSITS											
03 NW 5	6.7	1.7	–	3	8	15	22	33	19	0	G
03 NW 9	20.7	0.3	–	3	4	17	23	32	20	1	G
03 NW 10†	4.0	0.9	–	10	6	12	20	33	18	1	CG
03 NW 14	1.6	0.2	–	4	4	6	13	40	33	0	G
03 NW 17‡	2.0+	0.2	–	7	3	11	16	25	38	0	G
03 NE 1	6.3	1.2	–	5	22	43	12	15	3	0	PS
03 NE 2	4.3	2.6	3.5	5	7	19	22	36	11	0	SG
03 SW 2	14.1	0.3	1.1	5	5	15	20	34	20	1	G
03 SW 3	11.2	0.2	–	3	4	15	21	34	22	1	G
Mean	9.3	0.9	–	4	7	18	20	32	18	1	G

* See Appendix C.
† Although borehole proved potentially workable till, data are not used in the assessment calculation.
‡ Not used in assessment calculation as the mineral deposit was not bottomed.

Statistical assessment of the valley-floor deposits

Area of exposed mineral	1.45 km²
Area of continuous or almost continuous spreads of mineral beneath overburden	3.07 km²
Total area of mineral	4.52 km²
Area of discontinuous spreads of mineral, not assessed	0.95 km²
Mean thickness of overburden	0.9 m
Mean thickness of mineral	9.3 m
Estimated volume of mineral	**42.0 million m³**
	±68% or 28.6 million m³

of sand and gravel which to the east of West Lindsaylands [0214 3679] is concealed by alluvium and peat. Here, deep field ditches commonly reveal silty alluvium resting on shingly sand and gravel. Several elongated mounds of sand and gravel lie on the valley floor, the largest of which is located 200 m to the north of Wolfclyde. Pit 03 NW 17, sited on a smaller mound, revealed 2.0 m of gravel, but the base of the material was not reached.

The thickest mineral deposit was met at borehole 03 NW 5 where 6.7 m of sand and gravel rested on bedrock. The mineral hereabout appears to thin westwards, for pit 03 NW 14 proved only 1.6 m of gravel resting on bedrock. Further west the sand and gravel becomes patchy, as exemplified by pit 03 NW 15 near Netherton [0138 3664] which proved till from the surface.

Moundy glacial deposits in Biggar Park [0312 3714] are separated from the valley-floor deposits by a back-feature which is arbitrarily taken as the block boundary.

Biggar Gap east of Biggar The floor of the Biggar Gap for several kilometres east of the town appears to have been formerly occupied by a lake which was infilled initially with glacial meltwater deposits and later by peat and alluvium. A spread of fluvioglacial sand and gravel, thought to have been deposited as an eastward prograding delta, is exposed around Biggar public park and apparently extends eastwards beneath peat and alluvium. Boreholes indicate that the overburden thickens in this direction, whereas the mineral thins and generally becomes finer grained. Near the park, borehole 03 NW 9 proved 20.7 m of moderately well sorted fluvioglacial sand and gravel resting on bedrock. The mineral comprised more than

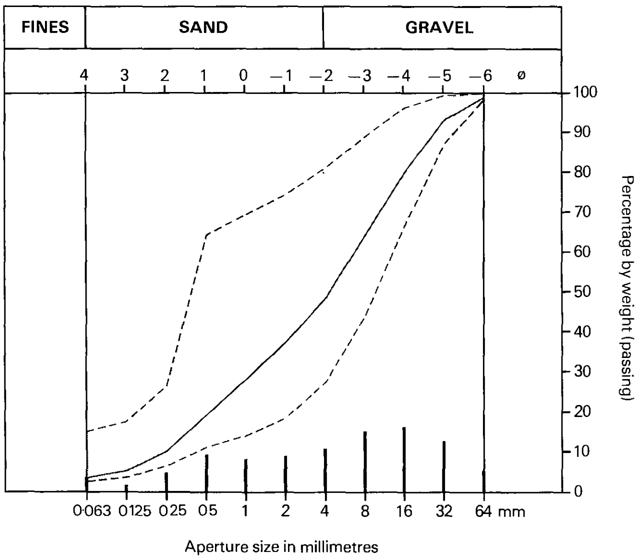


Figure 9 Grading characteristics of resources in the valley-floor deposits of block B: the continuous line is the cumulative mean; the broken lines define the envelope containing the cumulative mean grading of mineral proved in individual boreholes; the frequency distribution of the mean grading (0.063 to 64 mm) is represented by the bar graph.

50 per cent gravel throughout most of the deposit at this site.

Classic deltaic coarsening-upwards sequences were revealed at boreholes 03 NE 1 and 03 NE 2. In the former, 6.3 m of fluvioglacial sand and gravel fined with depth from sandy gravel to a medium-fine sand: the deposit overlay 9.4 m of laminated glaciolacustrine silts which rested on bedrock. Near Spittal Burn borehole 03 NE 2 proved 3.1 m of sandy gravel overlying glaciolacustrine deposits but here a further 1.2 m of sandy gravel was encountered before rockhead.

The Biggar Gap is narrowest in the vicinity of Broadford [0820 3690] where the alluvial flat is less than 250 m wide. The drift deposits hereabout are probably thinner than to the west and composed mainly of silty alluvium. Borehole 03 NE 4 near Parkgatestone [0932 3614] demonstrated 3.8 m of silty alluvium including two thin beds of sand and gravel, the lower of the two overlying bedrock. The resource in this part of the block is likely to be patchy, and no quantitative assessment is possible owing to the paucity of information.

On the basis of six boreholes and one pit a statistical assessment is offered for the potentially workable deposits occupying the Biggar and Coulter gaps. Details are presented in Table 7 and Figure 9. Data from a pit which did not prove the base of the mineral deposit are also shown but have not been used in the calculations.

Block C

The block encompasses the fragmented spread of gravelly glacial meltwater deposits underlying the south-western slopes of the valley of the River Clyde between Thankerton and Symington. Much of the sand and gravel was probably deposited from braided streams flowing over ice which subsequently melted, causing the material to be draped over a hummocky sub-glacial landscape formed principally of till and bedrock. With such a mode of deposition it is to be expected that thickness and grading of the sand and gravel will bear no simple relationship with landform. Many knowes and hills which are gravelly at the surface and at first sight may be interpreted as being wholly constructed of sand and gravel are found to be cored by bedrock or till, as for example at sample points 03 NW 13, 93 NE 16, 93 NE 18 and 93 NE 30 which proved only 1.0 m, 1.5 m, 1.3 m and 1.4 m of gravel respectively. Near Eastfield [0140 3621] borehole 03 NW 2 revealed 4.3 m of sand and gravel, coarsening upwards, overlying till on bedrock, and at Sherifflatts borehole 93 NE 13 proved 3.4 m of sand and gravel, fining upwards and directly overlying bedrock. The glacial meltwater gravels become patchy to the north-east of Thankerton village where borehole 93 NE 12 revealed only 0.7 m of gravel overlying till.

To the north-west of Fallburn [9656 3783] a terrace back-feature separates moundy sand and gravel from a relatively flat-lying spread beneath Thankerton Moor where borehole 93 NE 10 and pit 93 NE 20 proved 1.1 m and 1.3 m respectively of felsite-rich, very poorly sorted gravel. At the former site the gravels passed downwards into 2.4 m of potentially workable till overlying bedrock.

Table 8 Block C: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category*
Borehole or pit	Mineral m	Over-burden m	Waste partings 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	
GLACIAL MELTWATER GRAVELS											
93 NE 10	1.1†	0.2	–	8	10	11	17	37	17	0	G
93 NE 13	3.4	0.4	–	10	7	11	17	29	23	3	CG
93 NE 16	1.5	0.3	–	7	7	11	21	30	24	0	G
93 NE 17	5.6	0.3	–	5	6	12	20	31	22	4	G
93 NE 18	1.3	0.4	–	8	5	16	16	27	28	0	G
93 NE 20‡	1.3+	0.8	–	9	8	15	16	28	24	0	G
93 NE 29‡	2.3+	0.3	–	4	9	43	19	21	4	0	SG
93 NE 30	1.4	0.2	–	3	6	7	18	38	28	0	G
93 NE 31‡	1.5+	0.3	–	3	4	13	17	31	32	0	G
03 NW 2	4.3	0.3	–	8	12	30	14	20	14	2	SG
03 NW 3	7.3	1.0	2.4	13	11	15	17	23	20	1	CG
03 NW 11‡	1.9+	0.1	–	2	4	13	14	23	34	10	G
03 NW 12‡	2.0+	0.2	–	2	3	11	22	26	30	6	G
03 NW 13	1.0	0.3	–	2	3	16	23	30	26	0	G
03 NW 16‡	1.6+	0.2	–	7	5	11	17	27	33	0	G
Mean	3.0	0.4	–	8	8	16	18	27	21	2	G

* See Appendix C.
† Overlying 2.4 m of potentially workable till which is not included in the assessment calculation.
‡ Not used in assessment calculation as the mineral deposit was not bottomed.

Statistical assessment of the glacial meltwater gravels

Area of exposed mineral	5.22 km^2
Area of continuous or almost continuous spreads of mineral beneath overburden	0.02 km^2
Total area of mineral	5.24 km^2
Area of discontinuous spreads of mineral, not assessed	0.17 km^2
Area of worked out sand and gravel	0.90 km^2
Mean thickness of overburden	0.4 m
Mean thickness of mineral	3.0 m
Estimated volume of mineral	**15.7 million m^3**
	±62% or 9.7 million m^3

A linear complex of esker ridges and kames, the 'Thankerton Kames' of Gregory (1915), formerly stretched northwards from Westside [9863 3442] near Symington across the valley of the River Clyde to [9843 3902] near Parkhouse, and a subsidiary string of gravelly mounds and ridges occupies the valley of the Kirk Burn. The features were best developed at Holm Braes [980 372] where they were up to 9 m high (Goodlet, 1970) but as is indicated on the resource map, this central part of the complex in effect has been worked out. However, in the area surrounding the workings the ridges have been removed to ground level only and potentially workable gravel remains at depth, whereas the periphery of the deposit, which falls within block D, has not been worked to any great extent.

To the north-east of St John's Kirk borehole 93 NE 17 was positioned some 1 to 2 m above the general ground level on a spur of the most prominent esker. Here 0.7 m of felsite-rich gravel overlay 4.9 m of greywacke-rich gravel on till, the uppermost deposit appearing to have been draped over the lower one forming the esker.

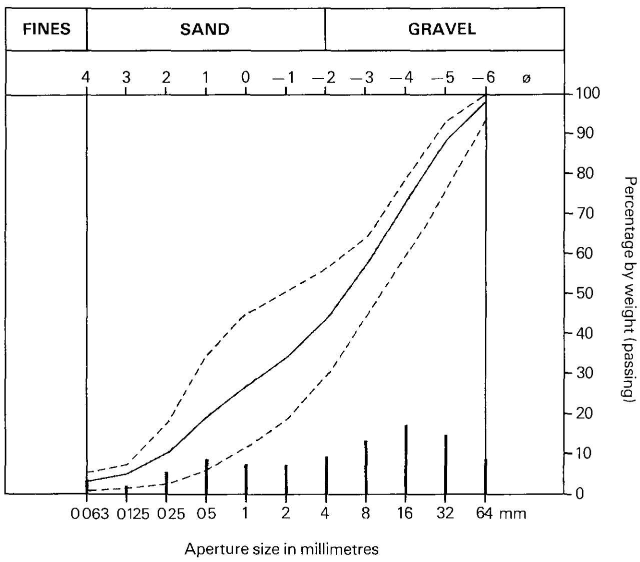


Figure 10 Grading characteristics of resources in the glacial meltwater gravels of block C: the continuous line is the cumulative mean; the broken lines define the envelope containing the cumulative mean grading of mineral proved in individual boreholes; the frequency distribution of the mean grading (0.063 to 64 mm) is represented by the bar graph.

The glacial meltwater deposits may anywhere conceal drift-filled channels excavated by streams that ran beneath the ice-sheet as it decayed. This phenomenon is indicated at borehole 03 NW 3 where 6.3 m of sand and gravel overlay, in downward sequence, fine-grained glaciolacustrine deposits, sand and gravel, till, bottoming at 18.6 m in bedrock. Small tributaries of the River Clyde have commonly channelled through the meltwater deposits to expose till. Any alluvial deposits such as those in the valley of Spittle Burn at Fallburn are probably thin and not potentially workable.

The overburden in block C ranges in thickness from 0.1 m in pit 03 NW 11 to 1.0 m in borehole 03 NW 3 and, for the block as a whole, has a mean thickness of 0.4 m.

A statistical assessment is offered for the glacial meltwater deposits based upon seven boreholes and two pits: details are presented in Table 8 and Figure 10. Pits not proving the full thickness of mineral are not used in the calculations.

Block D

The block comprises all of the resource assessment area outwith blocks A, B and C, much of which is rolling upland mantled by till up to about 335 m above OD with bedrock cropping out on the highest ground. The few potentially workable sand and gravel deposits are widely scattered and diverse. Locally till is potentially workable, especially where it forms hummocky spreads on the valley-floor.

The procedure adopted for assessing the resources of this block has been outlined earlier. Inferred assessments are offered for twelve areas which have been chosen in order that, as far as is practically possible, deposits of broadly similar geology are grouped together.

The assessment of the 'discontinuous spreads of mineral' (the areas shown in the lightest tone of pink on the resource map) is based on the grouping of sample point data for all areas where this category has been recognised. The volume calculation involves the product of mean mineral thickness and area, the latter being reduced in proportion to the ratio of the number of sample points proving mineral to non-mineral.

Warrenhill area Elongate mounds of glacial meltwater deposits are present in the misfit valley to the north of Warrenhill [9484 3884], where they are surrounded by undulating deposits of gravelly till. Borehole 93 NW 3, sited on a ridge about 5 m high, trending north-west, proved 3.9 m of sand and gravel overlying stiff till. Similar deposits were demonstrated, but not bottomed, beneath a mound to the west of Blackshouse [9476 3981] where pit 93 NW 6 revealed 2.0 m of sand and gravel. At both sample points overburden was 0.2 m thick and the mineral comprised poorly sorted 'clayey' sandy gravel.

To the west of Warrenhill the Cleuch Burn flows within a flat-bottomed valley, sometimes known as the 'Carmichael Gap', which links in the west with the valley of the Carmichael Burn. A gravel-filled channel may underlie the alluvium in the Carmichael Gap, but no evidence to confirm this has been found.

Valley of the Glade Burn Alluvial silt and clay underlying the floodplain of the Glade Burn are thought to conceal patchy glacial meltwater deposits. Borehole 93 NE 9 proved 1.2 m of overburden on 4.1 m of gravel which coarsened with depth and overlay bedrock.

Northern slopes of the Tinto Hills The steeper slopes are extensively mantled by a thin gravelly hillwash whereas the gentler lower slopes are floored by hummocky, gravelly ablation till. There are numerous low gravelly ridges and mounds which are often closely associated with meltwater channels. However, only the more extensive features are identified on the resource map.

In the vicinity of Howgate [9199 3519] gravelly ridges trend down the hillside in a northerly direction before contouring around to the east past Lochlyock [9331 3605] and Woodend [9464 3668]. The features

Table 9 Block D: Data from sample points and the assessment of resources

Sample point Borehole or pit	Recorded thickness Mineral m	Over-burden m	Waste partings m	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	Descriptive category*
GLACIAL MELTWATER GRAVELS											
Warrenhill area											
93 NW 3	3.9	0.2	–	14	18	18	12	21	16	1	CSG
93 NW 6	2.0+	0.2	–	14	35	19	8	11	13	0	CSG
Mean	3.2	0.2	–	14	24	18	11	17	15	1	CSG
Northern slopes of the Tinto Hills											
93 NW 4	1.7+	0.5	–	6	4	7	13	24	38	8	G
93 NE 25	1.9+	0.3	–	5	10	35	10	20	20	0	SG
Mean	2.0	0.4	–	5	7	22	11	22	29	4	G
Covington–Hardington–Roberton area											
92 NW 1	1.3	0.5	–	6	9	10	12	23	36	4	G
93 SE 8	2.1+	0.1	–	11	5	9	13	26	36	0	CG
93 SE 9	2.0+	0.2	–	12	7	8	14	25	25	9	CG
93 SE 11	1.4+	0.2	–	14	7	10	13	29	27	0	CG
Mean	2.5	0.3	–	11	7	9	13	26	31	3	CG
Quothquan area											
93 NE 26	5.2+	–	–	4	3	14	16	26	32	5	G
93 NE 27	1.4+	0.9	–	No grading data available							
93 NE 28	1.0	0.4	–	13	31	16	10	20	10	0	CSG
Mean	1.9	0.4	–	6	8	14	15	25	28	4	G
Biggar Park											
03 NW 7	5.5+	0.4	–	12	35	16	13	13	9	2	CSG
Mean	7.5	0.4	–	12	35	16	13	13	9	2	CSG
Valley of the Biggar Burn											
03 NW 6	18.1+	0.2	–	10	7	13	18	26	21	5	CG
03 NW 8	16.6	0.4	–	14	22	14	15	20	14	1	CSG
Mean	8.7	0.3	–	12	14	13	17	23	18	3	CSG
Skirling area											
03 NE 3	13.2	0.2	–	12	9	18	19	25	16	1	CSG
03 NE 9	1.5+	0.2	–	2	2	6	10	35	45	0	G
Mean	3.7	0.3	–	11	8	17	18	26	19	1	CG
Pyatknowe–Thriepland area											
03 NE 6	1.9+	0.2	–	11	7	11	15	28	26	2	CS
Mean	1.5	0.2	–	11	7	11	15	28	26	2	CG
Mean	3.9	0.3	–	11	14	13	15	23	21	3	CG
VALLEY-FLOOR DEPOSITS											
Glade Burn											
03 NE 9	4.1	1.2	–	3	6	13	20	31	23	4	G
Mean	3.4	1.2	–	3	6	13	20	31	23	4	G

* See Appendix C.

Inferred assessment of the glacial meltwater gravels of the Warrenhill area

Area of exposed mineral	0.19 km^2
Mean thickness of overburden	0.2 m
Mean thickness of mineral	3.2 m
Estimated volume of mineral	**0.6 million m^3**

Inferred assessment of the glacial meltwater gravels on the slopes of the Tinto Hills

Area of exposed mineral	0.41 km^2
Mean thickness of overburden	0.4 m
Mean thickness of mineral†	2.0 m
Estimated volume of mineral	**0.8 million m^3**

Inferred assessment of the glacial meltwater gravels of the Quothquan area

Area of exposed mineral	0.27 km²
Mean thickness of overburden	0.4 m
Mean thickness of mineral†	1.9 m
Estimated volume of mineral	**0.5 million m³**

Inferred assessment of the glacial meltwater gravels in the valley of the Biggar Burn

Area of exposed mineral	0.60 km²
Area of concealed mineral	0.03 km²
Total area of mineral	0.63 km²
Mean thickness of overburden	0.3 m
Mean thickness of mineral†	8.7 m
Estimated volume of mineral	**5.5 million m³**

Inferred assessment of the glacial meltwater gravels in the Skirling area

Area of exposed mineral	0.32 km²
Mean thickness of overburden	0.3 m
Mean thickness of mineral†	3.7 m
Estimated volume of mineral	**1.2 million m³**

Inferred assessment of the glacial meltwater gravels in the Lamington–Wandel area

Area of exposed mineral	0.42 km²
Mean thickness of overburden	0.7 m
Mean thickness of mineral†	3.0 m
Estimated volume of mineral	**1.3 million m³**

Inferred assessment of the valley-floor deposits of the Glade Burn

Area of discontinuous spreads of mineral beneath overburden	0.55 km²‡
Mean thickness of overburden	1.2 m
Mean thickness of mineral†	3.4 m
Estimated volume of mineral	**1.3 million m³**

Inferred assessment of the glacial meltwater gravels of the Covington–Hardington–Roberton area

Area of exposed discontinuous spreads of mineral	2.27 km²‡
Mean thickness of overburden	0.3 m
Mean thickness of mineral†	2.5 m
Estimated volume of mineral	**3.8 million m³**

Inferred assessment of the glacial meltwater gravels at Biggar Park

Area of exposed mineral	0.25 km²
Mean thickness of overburden	0.4 m
Mean thickness of mineral†	7.5 m
Estimated volume of mineral	**1.9 million m³**

Inferred assessment of the glacial meltwater gravels at Toftcombs

Area of exposed mineral	0.14 km²
Mean thickness of overburden†	0.2 m
Mean thickness of mineral†	2.9 m
Estimated volume of mineral	**0.4 million m³**

Inferred assessment of the glacial meltwater gravels in the Pyatknowe–Thriepland area

Area of exposed mineral	0.13 km²
Mean thickness of overburden	0.2 m
Mean thickness of mineral†	1.5 m
Estimated volume of mineral	**0.2 million m³**

Inferred assessment of the glacial meltwater gravels on the slopes of Backstane Hill and in the valley of Mill Burn

Area of exposed mineral	0.43 km²
Mean thickness of overburden†	0.2 m
Mean thickness of mineral†	7.2 m
Estimated volume of mineral	**3.1 million m³**

† Mean thickness has been estimated.
‡ The area of mineral-bearing ground is taken as two thirds of the area shown as discontinuous spreads of mineral.

which are fully described by Sissons (1961) vary in height from 3 to 10 metres and mainly comprise poorly sorted, felsite-rich sand and gravel. In the vicinity of Howgate, pit 93 NW 4, positioned on a low mound, proved 1.7 m of gravel, but on another mound nearby, pit 93 NW 5 encountered 1.2 m of stiff till.

In the valley of Kirk Burn to the north-east of Tinto, eskers and kames, trending eastwards and up to 12 metres high, form part of the 'Thankerton Kames' (block C). Pit 93 NE 25, sited on top of an esker, revealed 1.9 m of sandy gravel containing a high proportion of greywacke. Eskers forming the southernmost part of the 'Thankerton Kames' occur between Broadlees [9852 3535] and Westside, where scrapes in 3 to 4 metre high ridges revealed very poorly sorted sand and gravel.

Covington–Hardington–Roberton area (the discontinuous spreads of mineral) With the exception of a small gravelly knowe [972 385] near the railway viaduct crossing the valley of the Glade Burn, the glacial deposits of the Covington area are thin and any potentially workable material is patchy. Between Newtown of Covington [9775 3913] and the floodplain of the River Clyde soils are very gravelly: nonetheless borehole 93 NE 11 proved stiff till to a depth of 4.7 m. Elsewhere pits were dug where soils are particularly gravelly but none proved sand and gravel. Pit 93 NE 23, sited to the west of Newtown of Covington, proved till which is judged to be potentially workable, but an assessment is not offered for this material as it is very patchy and would be difficult to work commercially.

To the south-west of Symington the slopes of the valley bordering the floodplain of the River Clyde are also gravelly. Here too, however, sand and gravel is patchy, and the stony soils have resulted from a winnowing of clay and sand from very gravelly till which may be locally potentially workable. South-west of Symington Mains Farm [9959 3403] soils are particularly gravelly, but borehole 93 SE 6 penetrated only 0.3 m of 'clayey' pebbly sand overlying till on bedrock.

There is a similar situation between the Garf Water and Hardington House [965 302], where an undulating terrace is floored by patchy glacial meltwater deposits resting on very gravelly till. Although hearsay suggests that thick deposits of sand and gravel are locally present, the sample points reveal very little. Pits 93 SE 8, 93 SE 9 and 93 SE 11 proved 2.1 m, 2.0 m and 1.4 m respectively of very poorly sorted 'clayey' gravel becoming clay-bound with depth. Borehole 93 SE 2 proved 5.6 m of non-mineral till possibly resting on bedrock.

Moundy glacial deposits form the interfluve separating the Roberton Burn and the Ladygill Burn near Roberton. The poorly sorted gravelly deposits, which have been deeply dissected by meltwaters, pass imperceptibly into hummocky gravelly ablation till flooring the valleys of the two burns. As in the Hardington area, the gravelly soils hereabout are largely developed on weathered gravelly till rather than sand and gravel, as indicated by borehole 92 NW 1 which proved only 1.3 m of very poorly sorted gravel passing downwards into a stiff, gravelly till with pockets of sandy material.

A poorly developed and deeply dissected kame-terrace [949 292] occupies the lower slopes of

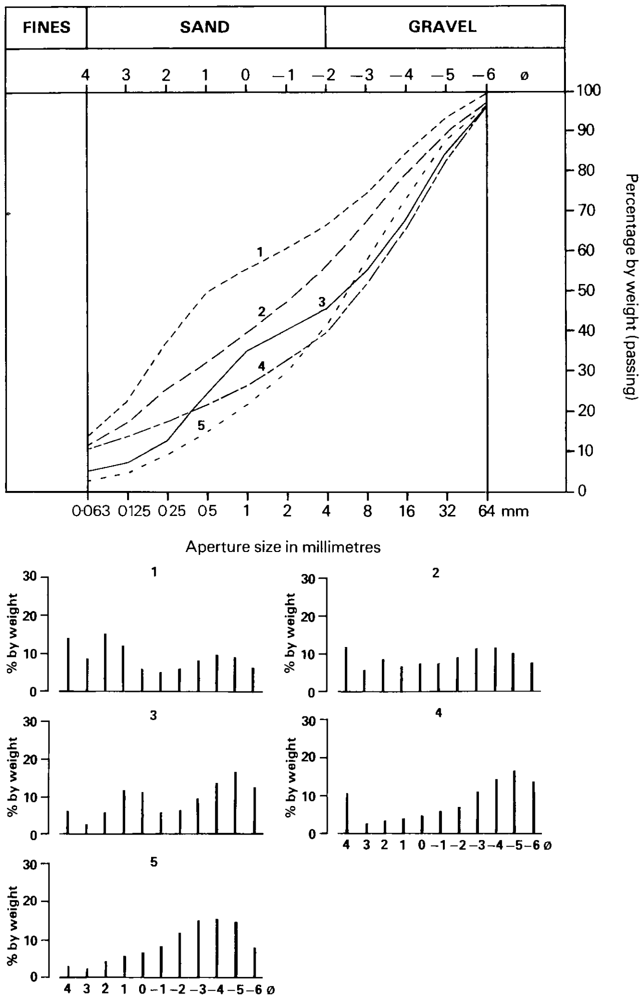


Figure 11 Grading characteristics of resources in the glacial meltwater gravels of block D.

1 Warrenhill area
2 Valley of the Biggar Burn
3 Northern slopes of the Tinto Hills
4 Covington–Hardington–Roberton area
5 Valley of Glade Burn

Dungavel Hill to the north-east of Roberton. There are no sample points in this area, but a small sand pit [9464 2901] is recorded on the old geological map.

Backstane Hill A number of small gravel deposits rest on the southern slopes of Backstane Hill [909 279] above 280 m above OD and also occupy the nearby valley of Mill Burn. However, most of them fall on the neighbouring Douglas Water resource sheet (Shaw and Nickless, 1981) where the deposits are shown as unassessed. In light of the information made available during the present survey an assessment of the deposits is now possible. In the col separating Backstane Hill and Pillmore Hill to the south-east, there are gravelly knowes, ridges and a kame-terrace in which a section [9150 2782] revealed about 20 m of moderately well sorted sand and gravel.

Quothquan area A spread of sand and gravel occupies the eastern side of the valley of the River Clyde at the foot of Quothquan Law [988 384] where it includes a northerly-trending esker, part of the 'Thankerton Kames'. The esker is up to 10 m high and section 93 NE 26 within an old pit at the northern end of the feature revealed 5.2 m of well sorted gravel. The esker apart, mineral is probably thin, as is indicated by pit

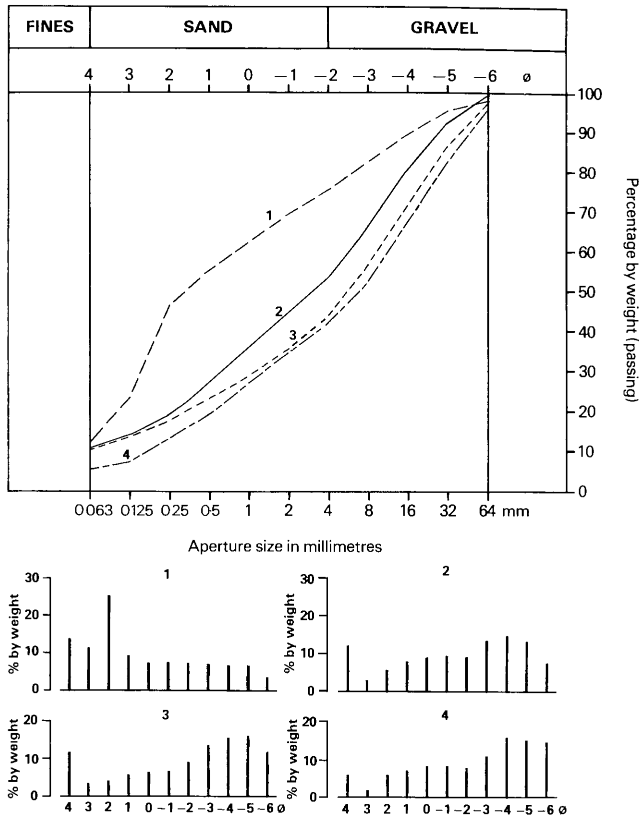


Figure 12 Grading characteristics of resources in the glacial meltwater gravels of block D.

1 Biggar Park area
2 Skirling area
3 Pyatknowe–Thriepland area
4 Quothquan areas

93 NE 28 near Quothquan Law Farm [9830 3820] which proved 1.0 m of 'clayey' sandy gravel on till.

Biggar Park Within Biggar Park [031 371] an esker trending north-east is surrounded by a low lying, moundy spread of sand and gravel. The esker is not as extensive as the one at Quothquan, and rarely exceeds 5 m in height. Borehole 03 NW 7, sited some 100 m to the south of the esker, proved sand and gravel, coarsening with depth. However, only 5.5 m was proved before the hole was abandoned owing to a rock obstruction, possibly bedrock. Although there were no exposures along the esker from which to take samples, scrapes revealed a cobble-gravel.

Valley of the Biggar Burn During the deglaciation of the area, glacial meltwater deposits accumulated in the valley of the Biggar Burn, probably in the form of ice-marginal terraces. The deposits are most widespread to the north of Annavale [039 386], where they have been deeply dissected by the Biggar Burn, which has often cut down into till or bedrock. Estimating the extent of mineral in this area is difficult as it probably occupies a meltwater channel, now partially exhumed, which was either incised into gravelly till or bedrock: consequently the contacts between the gravel deposits and the valley-sides are steep. The situation is further complicated because gravelly till, redistributed by solifluxion and hillwash, partially obscures the sand and gravel deposits. For example, sand and gravel may underlie the stiff till revealed by pit 03 NW 20. Both the boreholes in this area are deep, 03 NW 6 proving

18.1 m of very poorly sorted sand and gravel overlying bedrock and 03 NW 8 proving 16.6 m of sand and gravel, coarsening downwards, resting on stiff till.

Sand and gravel was worked at Rowhead [0387 3804] where Haldane (1948) noted up to about 3 m of bedded material, but the pit is now disused.

Toftcombs At Mid Toftcombs [0565 3980] moundy sand and gravel deposits have been dug extensively and the workings reinstated. To the south-west of the old pit a narrow esker survives which stands up to 10 m high. To the north-east of the old pit a moundy area has been largely untouched, probably because it was too sandy to warrant extraction. Although the reinstated land is considered in the assessment to have been worked out, the material was worked dry, and therefore some mineral may remain below the water-table.

Skirling area A number of eskers, kames and kame terraces occur around Skirling. A discontinuous esker about 1 km in length extends northwards from the Manse [0744 3980]. It is most extensive at Geldies Knowe where it stands up to 6 m high: in the north it merges with a kame terrace which has been deeply dissected by meltwaters. Borehole 03 NE 3 was sited on this gently undulating terrace and proved 13.2 m of sand and gravel overlying bedrock. However, the thickness of mineral hereabout is probably quite variable. Another esker lies along the northern boundary of the survey area, 500 m north-west of Wintermuir [0654 3978], but it is generally less than 3 m high.

Steep-sided kames up to 8 m high which are gravelly at surface occur in the village [077 392] and near Galalaw [082 397]. These features are linked by a low-lying, discontinuous esker which crosses the valley from the latter site to become superimposed on the valley-side as a kame-terrace. Although pit 03 NE 9 revealed 1.5 m of shingly gravel the mean thickness of the mineral here is thought to be about 5 m.

Gravelly soils are widespread in the Skirling area but they are considered to be mainly developed from a gravelly ablation till like that revealed at pits 03 NE 3 and 03 NE 7, where samples may have proved to be potentially workable if they had been selected for particle-size analysis.

Pyatknowe–Thriepland area The soils on the north-west-facing slopes of Thriepland Hill [043 346] and Pyatknowe Hill [062 356] are exceptionally gravelly, the clasts being almost wholly composed of local siltstone and greywacke which readily breaks into angular fragments. Between Pyatknowe [0540 3607] and Culterallers House [026 340] the ground, which is very hummocky and gravelly, has been identified on older geological maps as moraine. However, this interpretation is not followed here as it seems that the hummocky topography is caused by the bedrock being near the surface, as shown for example by pits 03 NW 18 and 03 NW 19.

Scattered moundy deposits of sand and gravel border Biggar Flat to the north of Pyatknowe and Bamflatt [0714 3650]. Pit 03 NE 5, sited on a low-lying terrace, possibly a former beach to the lake which once occupied Biggar Flat, proved only 0.9 m of sand and gravel overlying till. On a low gravelly ridge situated about 300 m to the south-west of this feature, pit 03 NE 6 revealed 1.9 m of poorly sorted 'clayey' gravel.

Lamington–Wandel area Mounds of sand and gravel occur [9890 3214] near Easterton Burn and [9854 3118] near Lamington. At the Lamington site gravel was once worked on a small scale. At neither locality is mineral thought to be more than a few metres thick.

Upstream of Lamington, remnants of a hummocky gravelly spread, probably once much more extensive, border the floodplain and fluvioglacial terraces of the River Clyde. Small patches occur around Hartside [9654 2960] but the deposit is most extensive to the south of Woodend [9501 2804], where it merges south-eastwards into a hummocky spread of gravelly ablation till flooring the valley of the Wandel Burn. Poorly sorted sand and gravel is revealed at a number of small exposures, the largest being at Woodend where very poorly sorted, clay-bound gravel crops out in a river cliff 4 m high. Site-investigation boreholes at Woodend Bridge [950 281] penetrated up to 2.8 m of such material. Sand and gravel was formerly worked at a small pit [9482 2745] at Wandel near to two small kettle-holes floored by till.

CONCLUSIONS

The sand and gravel resources of the survey area have been described systematically and the results of the assessment summarised in Table 5. It must be repeated that the survey concerns the estimation of resources rather than reserves and that the assessment of the workability of deposits is judged solely in terms of the four arbitrary criteria stated in the introduction to the report. No account is taken of prevailing environmental or economic considerations and the quoted volumetric estimates bear no simple relationship to the amount of sand and gravel that could be extracted in practice. The chief aim of the survey is to provide a factual, geologically based assessment of the sand and gravel against which the economic, social and environmental costs in developing the resource can be weighed.

Bearing in mind that detailed exploration and evaluation is required to establish the whereabouts of reserves, it is possible nonetheless to indicate, with some degree of certainty, those resources which will command attention in the short-to-medium term.

Undoubtedly the most important factor governing the future development of the sand and gravel resources in the assessed area is the position of the deposits relative to the water-table. An attempt is made in Figure 13 to distinguish resources which are predominantly either above or below the water-table. The map is of necessity a generalisation and must therefore be interpreted with some caution. However, it is immediately apparent that the total area of potentially workable sand and gravel is greatly reduced if, as at present, dredging operations should not be permitted. Were it not for this restriction the valley-floor deposits of blocks A and B would offer the best prospects for large-scale exploitation because the material is generally the best sorted, most durable and 'clean', and is the most consistently thick of the various mineral deposits.

If the resources contained within blocks A and B are excluded it is evident that the glacial meltwater gravels of block C are probably of most potential interest in the short-to-medium term. Although the thickness of

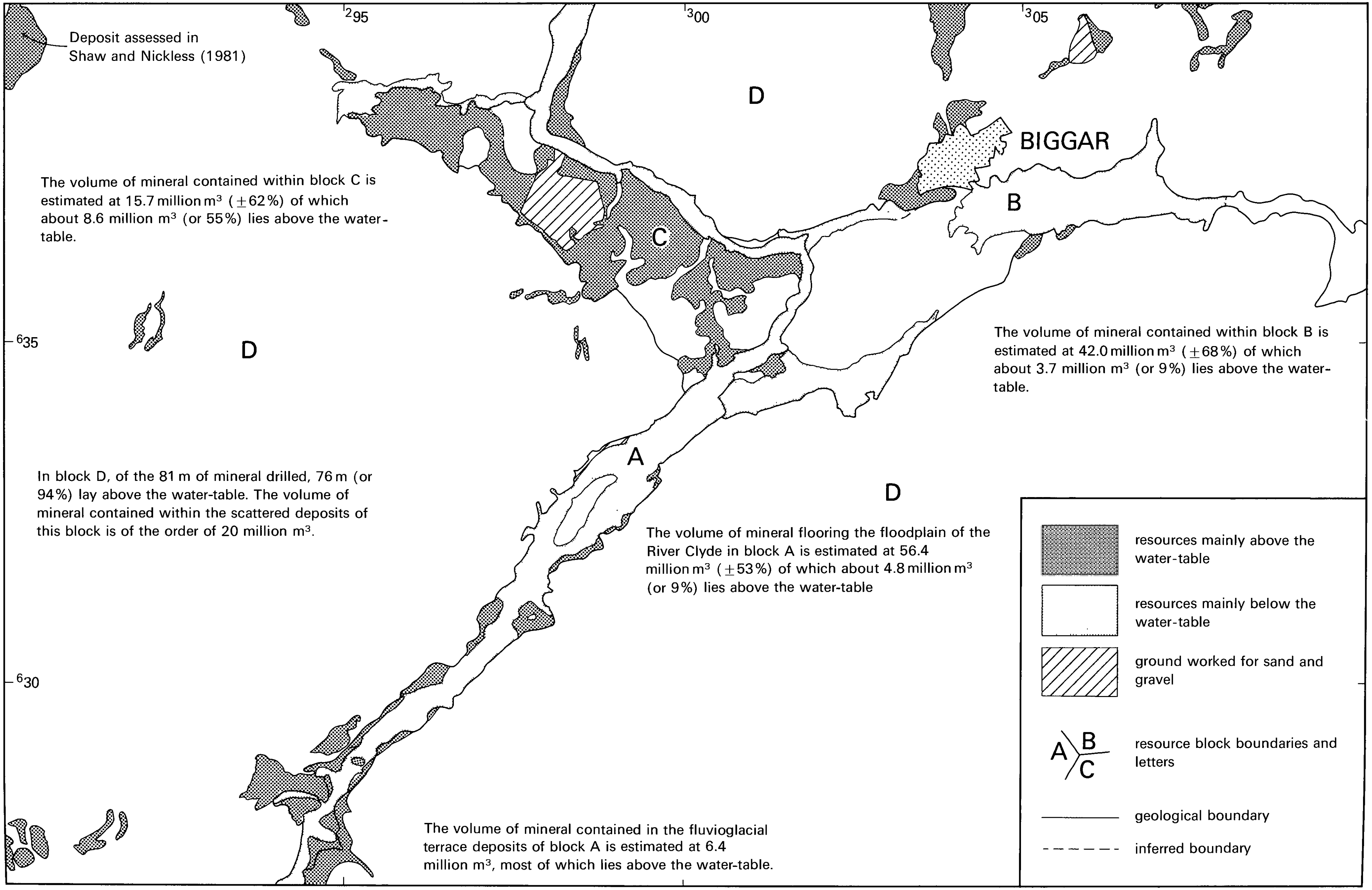


Figure 13 Generalised map showing resources of sand and gravel lying above and below the water-table.

the deposits varies considerably (Table 5) the mineral generally comprises over 50 per cent gravel and less than 10 per cent fines. The gravels are reasonably durable, as suggested by the results of the mechanical and physical testing which are summarised in Table 4. Although greywackes and siltstones together form over 50 per cent of the gravel, the results of the water absorption tests indicate that concretes made from the material need not have severe shrinkage properties if care is exercised. The mineral deposits occupying the north-west part of the block are probably too thin and poorly sorted to warrant early detailed evaluation.

With few exceptions, the scattered and diverse mineral deposits of block D are individually probably not sufficiently widespread to attract large-scale exploitation. However, many of the small deposits, for example the fluvioglacial terrace deposits in the valley of the River Clyde, might be worked from a centrally positioned processing plant. The mineral of block D is generally the most poorly sorted of all the resources and is commonly clay-bound. The most attractive deposits for further investigation are probably those in the valley of the Biggar Burn to the north of Biggar, and those to the north-west of Skirling.

APPENDIX A

FIELD AND LABORATORY PROCEDURES

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

The mineral shown on each 1:25 000 sheet is divided into resource blocks. The arbitrary size selected, 10 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. Exceptionally, other schemes for subdividing the resource sheet area (for example, the use of 'resource sub-blocks') may be used where these are considered to be more appropriate.

A reconnaissance of the ground is carried out to record and sample any exposures, and inquiries are made to ascertain what borehole information is available. In addition, shallow trenches may be cut to investigate the grading of deposits, particularly in very coarse material, and to test the geology prior to commencing the drilling programme. 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 (sometimes referred to as 'percussion' 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 Institute's laboratories.

Other methods of drilling and sampling are occasionally employed, for example the Minuteman power auger rig, and downhole tests such as U4 and SPT may be carried out. The Minuteman, which is small and portable, is normally used when access to land with shell rigs would be difficult to arrange and when information is requested quickly.

The auger tool comprises a continuous-'flight' 76-mm (3-inch) spiral auger; the use of this equipment, as with all 'open-hole' drilling methods, inevitably leads to the mixing and contamination of the sampled material. Thus, data relating to depth and composition cannot always be accurately determined.

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

Detailed records may be consulted at the appropriate office of the Institute: the address is shown on page ii of this report, next to the preface.

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 (Hull, pp. 192–193 *in* Thurrell, 1981). 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

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

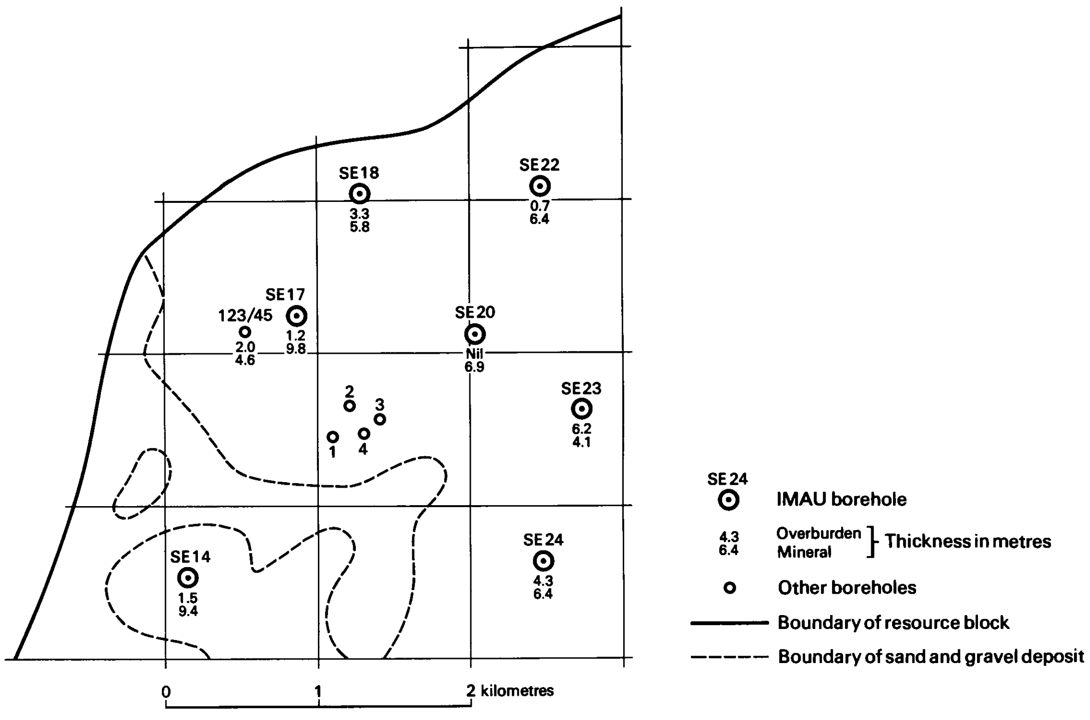
For groups of closely spaced boreholes a discretionary weighting factor may be applied to avoid bias (see note on weighting below). The standard deviation for mean thickness $S_{\bar{l}_m}$, expressed as a proportion of the mean thickness, is given by

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

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

6 The sampled area in each resource block is coloured pink on the map. Wherever possible, calculations relate to the mineral within mapped geological boundaries (which may not necessarily correspond to the limits of deposit). Where the area

Example of resource block assessment: map of fictitious block, 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	$\frac{1}{2}$	1.2	1.6	9.8	7.2	Hydrogeology Unit record
123/45	$\frac{1}{2}$	2.0		4.6		
1	$\frac{1}{4}$	2.7	2.6	7.3	5.8	Close group of four boreholes (commercial)
2	$\frac{1}{4}$	4.5		3.2		
3	$\frac{1}{4}$	0.4		6.8		
4	$\frac{1}{4}$	2.8		5.9		
Totals	$\Sigma w = 8$		$\Sigma wl_o = 20.2$		$\Sigma wl_m = 52.0$	
Means			$\overline{wl_o} = 2.5$		$\overline{wl_m} = 6.5$	

Calculation of confidence limits

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

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

L_1 is calculated as

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

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 usually small relative to those in thickness. The relationship $S_A/S_{\bar{l}_m} \leqslant \frac{1}{3}$ is assumed in all cases. It follows from equation [2] that

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

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

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

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

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

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

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

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

per cent, and when n is greater than 20, as

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

per cent (weighting factors may be included: see paragraph 15).

11 The application of this procedure to a fictitious area is illustrated in the diagram which accompanies this Appendix.

Inferred assessment

12 If the sampled area of mineral in a resource block is between 0.1 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 0.1 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 $\frac{1}{16}$ mm) and coarser than pebbles (more than 64 mm in diameter). Because deposits containing more than 10 per cent fines are not embraced by this system a modified binary classification based on Willman (1942) has been adopted.

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

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

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

Thus it is possible to classify the mineral into one of twelve descriptive categories (illustrated at the end of this appendix). The procedure is as follows:

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

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

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

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. Subsequently, the descriptive categories of the mineral for each borehole are modified according to the results obtained from the mean particle size analysis of the samples.

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, 1975), are as follows.

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

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

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

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

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

Classification of gravel, sand and fines

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

I Gravel

II 'Clayey' gravel

III 'Very clayey' gravel

IV Sandy gravel

V 'Clayey' sandy gravel

VI 'Very clayey' sandy gravel

VII Pebbly sand

VIII 'Clayey' pebbly sand

IX 'Very clayey' pebbly sand

X Sand

XI 'Clayey' sand

XII 'Very clayey' sand

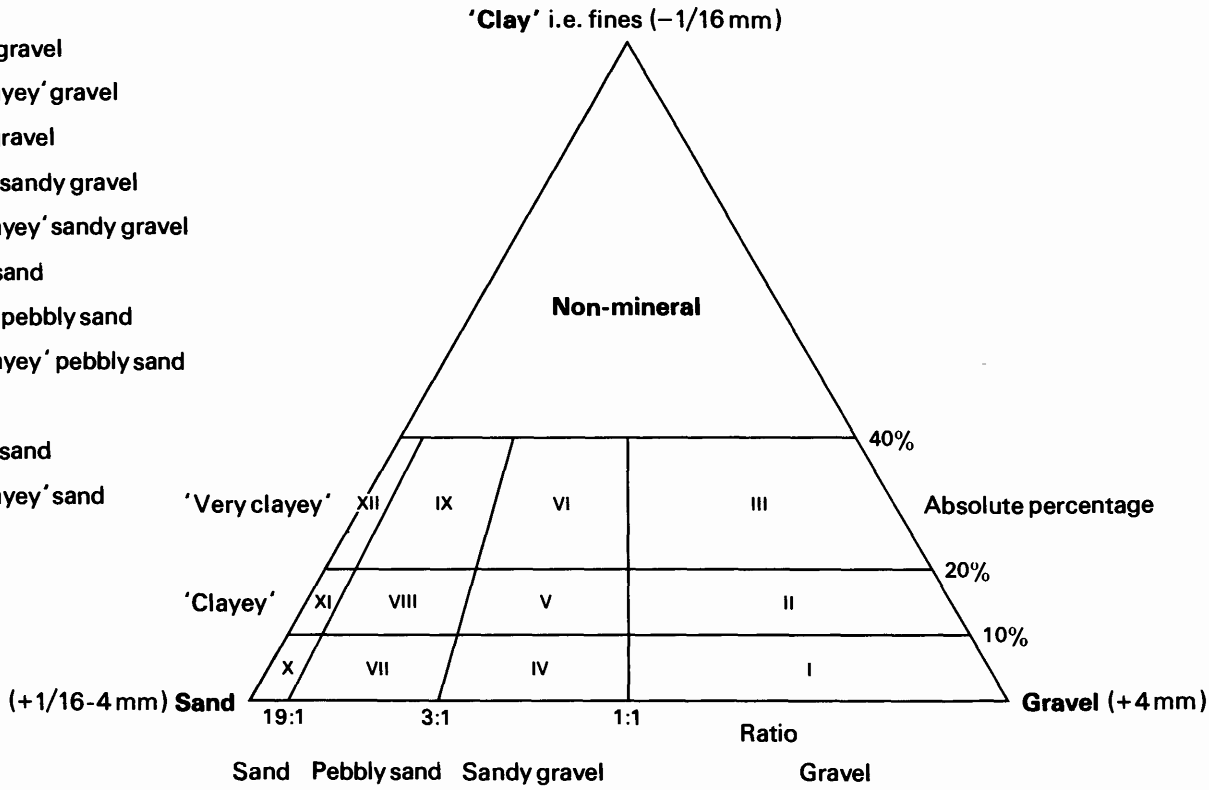


Diagram showing the descriptive categories used in the classification of sand and gravel

APPENDIX D

EXPLANATION OF THE ASSESSMENT RECORDS

Annotated example

NT 03 SW 2[1] 0175 3441[2] Coulter Maynes, Coulter[3] BLOCK B

Surface level + 202.8 m (+ 665 ft)[4]	Overburden 0.3 m[7]
Water struck at + 200.4 m[5]	Mineral 11.3 m
203 and 152 mm percussion[6]	Waste 1.1 m
November 1979	Mineral 2.8 m
	Bedrock 0.5 m +[9]

LOG

Geological classification	Lithology	Thickness[8] m	Depth m
	Soil	0.3	0.3
Alluvium[10]	a 'Clayey' gravel, poorly sorted[11] Gravel: fine and coarse with rare cobbles, angular to well rounded, greywacke, siltstone, chert, maroon mudstone and vein-quartz Sand: coarse and medium with fine, composed of angular rock fragments with subangular to subrounded quartz clasts, orangey grey-brown Fines: silt and clay, disseminated and in seams	2.0	2.3
Fluvioglacial sand and gravel	b Gravel Gravel: fine with coarse and some cobbles, subrounded to well rounded, siltstone, greywacke and lava with felsite, chert and vein-quartz Sand: coarse with medium and some fine, composed of angular rock fragments and subangular to subrounded quartz clasts, grey-brown Fines: silt and clay, disseminated	9.3	11.6
Glaciolacustrine deposits	Silt, medium brown, containing rare pebbles composed of greywacke and vein-quartz	1.1	12.7
Fluvioglacial sand and gravel	c Sandy gravel Gravel: fine with some coarse, as above in composition Sand: medium and coarse with fine, composed of subrounded quartz clasts and angular rock fragments, medium grey Fines: silt, disseminated	2.8	15.5
Lower Devonian[16]	Sandstone, fine to medium grained, composed of subangular to subrounded quartz with feldspar, andesite and some calcite clasts, blue-grey and red. Containing some calcite veins	0.3	15.8
	Siltstone with mudstone and fine sandstone partings, calcareous, maroon with rare, ferrous green reduction spots. Containing calcite veins (up to 4 mm in thickness) which exhibit listric surfaces	0.2+	16.0

(... continued)

GRADING

	Mean for deposit[15] percentages			Depth below surface (m)[12]		percentages[13]							
	Fines	Sand	Gravel			Fines	Sand			Gravel			
						$-^1/16$	$+^1/16-^1/4$	$+^1/4-1$	$+1-4$	$+4-16$	$+16-64$	$+64$	
a	13	31	56	0.3	1.3	8	4	12	19	32	20	5	
				1.3	2.3	18	6	10	11	24	31	0	
				Mean		13	5	11	15	28	26	2	
b	3	33	64	2.3	3.3	4	3	5	14	39	35	0	†[14]
				3.3	4.3	6	3	9	17	35	26	4	†
				4.3	5.5	3	2	9	17	36	33	0	†
				5.5	6.5	1	2	12	21	43	21	0	†
				6.5	7.5	2	2	10	23	42	21	0	†
				7.5	8.5	1	2	10	20	40	23	4	†
				8.5	9.5	1	1	8	24	40	26	0	†
				9.5	10.5	3	3	17	22	41	14	0	†
				10.5	11.6	3	4	16	23	38	16	0	†
				Mean		3	2	11	20	39	24	1	
c	7	68	25	12.7	13.7	6	13	29	23	19	10	0	†
				13.7	15.5	7	14	31	24	20	4	0	†
				Mean		7	14	30	24	19	6	0	
a&b	5	33	62	Mean		5	3	11	19	37	24	1	
a to c	5	40	55	Mean		5	5	15	20	34	20	1	

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

1 Registration number
Each Industrial Minerals Assessment Unit (IMAU) borehole and shallow pit is identified by a Registration Number. This consists of two statements:

1 The number of the 1:25 000 sheet on which the record lies, for example NT 03

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

Thus the full Registration Number is NT 03 SW 2. Usually this is abbreviated to 03 SW 2 in the text.

2 The National Grid reference
National Grid references in this publication lie within the 100-km squares NS and NT. Grid references are given to eight figures, accurate to within 10 m for sample point locations. (In the text, six-figure grid references are used for more extensive locations, for example, for farms. There are a few four-figure grid references.)

3 Location
The position of the sample point 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 sample point 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 Method and date of sampling
Modified shell-and-auger rigs were used for the drilling of the boreholes 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. Where appropriate other methods of sampling are stated (for example, pit sampling).

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

8 Thickness and depth
All measurements were made in metres.

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

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 description of other deposits and bedrock is 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. If, exceptionally, grading results are not available, an attempt may be made to estimate the descriptive category of the mineral by comparing the grading and field descriptions of similar material with the deposit in question.

14 Bailed samples
Fully representative sampling of natural aggregate 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 ($-\frac{1}{16}$ mm) and coarse gravel ($+16$ mm) may be lower. Samples obtained by the bailing technique (that is, from deposits below the water-table) are indicated with a dagger, 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, if these vary. The classification used is shown in the table at the end of Appendix C. Where two or more units of mineral are distinguished, the mean grading for each unit is given in addition to the combined calculation for the log. For multiple mineral units, each is designated by a letter, for example, **a**, **b**, etc.

16 Rocks of the Lower Old Red Sandstone are referred to in the borehole logs as Lower Devonian, this name referring to the age of the rocks and not to the stratigraphic group in which they are commonly included. The Upper Old Red Sandstone is of Devono-Carboniferous age.

APPENDIX E

LIST OF BOREHOLES AND SHALLOW PITS USED IN THE ASSESSMENT OF RESOURCES

Borehole*	Grid reference
1 INDUSTRIAL MINERALS ASSESSMENT UNIT BOREHOLES	
NS 92 NW	
1	9412 2850
NS 92 NE	
1	9550 2924
2	9560 2918
NS 93 NW	
3	9495 3902
NS 93 NE	
9	9540 3864
10	9622 3858
11	9785 3943
12	9755 3838
13	9764 3727
14	9827 3930
15	9842 3782
16	9854 3740
17	9868 3639
18	9981 3661
NS 93 SE	
1	9626 3001
2	9734 3151
3	9735 3067
4	9860 3262
5	9805 3186
6	9965 3406
7	9918 3321
NT 03 NW	
1	0010 3681
2	0066 3608
3	0055 3507
4	0172 3635
5	0217 3667
6	0399 3951
7	0329 3710
8	0401 3825
9	0453 3683
10	0442 3643
NT 03 NE	
1	0559 3711
2	0699 3714
3	0744 3978
4	0980 3638
NT 03 SW	
1	0048 3413
2	0175 3441
3	0288 3457

Pit*	Grid reference
2 INDUSTRIAL MINERALS ASSESSMENT UNIT PITS (SHALLOW PITS DUG BY EXCAVATOR)	
NS 92 NE	
3	9546 2965
NS 93 NW	
4	9206 3537
5	9219 3501
6	9447 3976
NS 93 NE	
19	9596 3899
20	9561 3827
21	9699 3928
22	9651 3759
23	9738 3880
24	9758 3767
25	9799 3574
26	9830 3876
27	9826 3875
28	9831 3805
29	9955 3722
30	9925 3676
31	9948 3622
32	9989 3553
NS 93 SE	
8	9690 3125
9	9677 3056
10	9752 3291
11	9755 3185
12	9785 3101
13	9765 3098
14	9893 3493
15	9820 3175
NT 03 NW	
11	0013 3633
12	0013 3597
13	0094 3577
14	0173 3657
15	0111 3644
16	0172 3606
17	0274 3682
18	0396 3533
19	0391 3526
20	0403 3916
NT 03 NE	
5	0563 3659
6	0501 3626
7	0740 3953
8	0743 3935
9	0810 3946
NT 03 SW	
4	0025 3454
5	0101 3454
6	0353 3487

* By sheet quadrant.

APPENDIX F

INDUSTRIAL MINERALS ASSESSMENT UNIT
BOREHOLE AND SHALLOW PIT RECORDS

NS 92 NW 1 | 9412 2850 | Ladygill Burn Bridge, Roberton | BLOCK D

Surface level + 244.7 m (+ 803 ft)
Water not struck
203 mm percussion
October 1979

Overburden 0.5 m
Mineral 1.3 m
Waste 4.7 m
Bedrock 0.1 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Glacial meltwater deposits	Gravel, poorly sorted Gravel: coarse with fine and some cobbles (up to 130 mm in diameter), subrounded to well rounded, greywacke with grey siltstone, grey-green sandstone and lava Sand: coarse to fine, subrounded, quartz with rock fragments, medium brown Fines: silt, disseminated	1.3	1.8
Till	Clay, gravelly, sandy, stiff, reddish brown with angular to well rounded clasts of lava, sandstone, greywacke, porphyry, chert and vein-quartz. Containing some sandy pockets but becoming more clayey with depth below 4.0 m	4.7	6.5
Ordovician	Greywacke, fine to medium grained, indurated, blue-grey. Containing subangular quartz clasts up to 2 mm in diameter	0.1+	6.6

GRADING

Mean for deposit percentages			Depth below surface (m)		percentages						
Fines	Sand	Gravel			Fines	Sand			Gravel		
					$-1/16$	$+1/16-1/4$	$+1/4-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
6	31	63	0.5	1.8	6	9	10	12	23	36	4

NS 92 NE 1 9550 2924 Longwell, Roberton BLOCK A

Surface level + 214.2 m (+ 703 ft)
Water not struck
203 mm percussion
October 1979

Overburden 1.0 m
Mineral 2.0 m
Waste 0.7 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Clay, sandy, silty, medium brown. Containing fine, subrounded, quartzose sand	0.8	1.0
	Gravel Gravel: coarse with fine and rare cobbles, rounded to well rounded, mainly composed of greywacke with lava, chert, vein-quartz and white quartzite Sand: coarse and medium with fine, angular to subrounded, quartz with greywacke fragments, medium grey-brown Fines: disseminated silt and clay	2.0	3.0
Till	Clay, gravelly, yellow-medium brown, stiff, containing numerous cobbles and boulders	0.7+	3.7
	Borehole terminated owing to boulder obstruction		

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 $+4-16$	$+16-64$	$+64$
5	28	67	1.0	2.0	5	4	11	14	28	38	0
			2.0	3.0	5	5	10	13	25	38	4
			Mean		5	4	10	14	27	38	2

NS 92 NE 2 9560 2918 Longwell, Roberton BLOCK A

Surface level + 214.3 m (+ 703 ft)
Water struck at + 211.5 m
203 mm percussion
October 1979

Overburden 0.2 m
Mineral 10.0 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium on fluvioglacial sand and gravel	Gravel Gravel: fine and coarse with some cobbles, mainly rounded to well rounded, greywacke with grey-green, red and yellow sandstones, siltstone, chert, lava, felsite and vein-quartz. Stained black between 2.7 and 2.9 m Sand: coarse and medium with fine, composed of subrounded quartz clasts with angular to subangular rock fragments, medium brown Fines: silt, disseminated with a thin orange-brown, laminated seam at 7.5 m	10.0+	10.2

Borehole terminated on obstruction, possibly bedrock

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 $+4-16$	$+16-64$	$+64$	
4	39	57	0.2	1.2	11	7	11	5	24	42	0	
			1.2	2.2	9	5	10	12	24	36	4	
			2.2	3.2	5	3	8	12	28	44	0	
			3.2	4.2	2	3	19	16	22	20	18	†
			4.2	5.2	1	5	22	26	31	15	0	†
			5.2	6.2	3	8	25	23	24	17	0	†
			6.2	7.2	2	11	21	18	26	22	0	†
			7.2	8.2	3	5	13	20	34	25	0	†
			8.2	9.2	2	5	12	19	32	24	6	†
			9.2	10.2	2	5	18	20	25	22	8	†
			Mean		4	6	16	17	27	26	4	

NS 92 NE 3 9546 2965 Longwell, Roberton BLOCK D

Surface level c + 246.0 m (c + 807 ft)
Water not struck
Pit
August 1979

Waste 1.8 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, pebbly, mottled, orange-brown to pale grey-blue, cohesive becoming stiff. Containing subangular to well rounded clasts, mainly composed of greywacke and micaceous siltstone with felsite, basalt, quartzite and vein-quartz	0.6	0.8
	Clay, sandy, pebbly, orange-brown becoming medium brown, cohesive, with coarse to fine sand and some pebbles of similar composition to those in the above deposit	1.0+	1.8

NS 93 NW 3 9495 3902 Warrenhill, Covington BLOCK D

Surface level + 225.0 m (+ 738 ft)
Water not struck
203 mm percussion
October 1979

Overburden 0.2 m
Mineral 3.9 m
Waste 1.3 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	'Clayey' sandy gravel, poorly sorted Gravel: fine and coarse with cobbles, subrounded to well rounded. greywacke, lava, red and white sandstones, felsite and vein-quartz Sand: fine, medium and coarse, subangular to subrounded, quartz with rock fragments, medium brown Fines: silt and clay, disseminated	3.9	4.1
Till	Clay, pebbly, soft to 4.3 m becoming stiff to hard, reddish brown, containing angular to rounded clasts of red and yellow sandstones, greywacke, felsite, lava, coal, chert and vein-quartz	1.3+	5.4
	Borehole terminated owing to boulder obstruction		

GRADING

Mean for deposit percentages			Depth below surface (m)		percentages						
Fines	Sand	Gravel			Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
14	48	38	0.2	1.2	14	20	19	13	20	14	0
			1.2	2.2	10	15	19	13	25	18	0
			2.2	2.7	15	17	15	13	19	17	4
			2.7	4.1	17	19	17	11	20	16	0
			Mean		14	18	18	12	21	16	1

NS 93 NW 4 9206 3537 Howgate, Carmichael BLOCK D

Surface level + c 293.0 m (c + 961 ft)
Water struck at + 291.3 m
Pit
August 1979

Overburden 0.5 m
Mineral 1.7 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Glacial sand and gravel	Gravel, poorly sorted Gravel: coarse with fine and some cobbles and boulders (up to 300 mm in diameter), angular to well rounded, dark grey sandstone, lava, greywacke, felsite and some vein-quartz Sand: coarse with medium and fine, rock fragments and quartz, grey-brown Fines: silt and clay, disseminated	1.7+	2.2

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
6	24	70	0.5	2.2	6	4	7	13	24	38	8

NS 93 NW 5 9219 3501 Hare Cleuch, Carmichael BLOCK D

Surface level c + 311.0 m (c + 1020 ft)
Water not struck
Pit
August 1979

Waste 1.5 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, sandy, pebbly, orange-brown, very stiff, with angular to rounded clasts composed of greywacke, yellow sandstone, lava, siltstone, felsite and vein-quartz	1.2+	1.5

NS 93 NW 6	9447 3976	Blackshouse, Pettinain	BLOCK D

Surface level c + 227.0 m (c + 745 ft)
Water not struck
Pit
October 1979

Overburden 0.2 m
Mineral 2.0 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	'Clayey' sandy gravel, poorly sorted Gravel: coarse and fine with rare cobbles, subrounded to well rounded, grey-green and red sandstones with lava, felsite, greywacke and vein-quartz Sand: fine with medium and some coarse, subangular to subrounded, quartz, pale reddish brown Fines: silt, disseminated	2.0+	2.2

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
14	62	24	0.2	1.2	14	36	18	8	11	13	0
			1.2	2.2	14	33	19	8	12	14	0
			Mean		14	35	19	8	11	13	0

NS 93 NE 9	9540 3864	Thankerton Moor, Covington	BLOCK D

Surface level + 209.0 m (+ 686 ft)
Water struck at + 207.3 m
203 mm percussion
November 1979

Overburden 1.2 m
Mineral 4.1 m
Bedrock 0.6 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Alluvium	Silt, clayey, pebbly, mottled medium grey to orange brown. Containing some fine gravel composed of felsite and lava from 0.9 m	0.8	1.2
Glacial meltwater deposits	Gravel Gravel: fine and coarse with cobbles below 3.2 m, angular to well rounded, the fine tending to be more angular than the coarse, greywacke, siltstone, felsite and lava with yellow sandstone, white quartzite, chert and vein-quartz. Coarsening with depth Sand: coarse and medium with fine, composed of angular greywacke and siltstone fragments and subangular to subrounded quartz clasts, grey-brown Fines: silt and clay, disseminated	4.1	5.3
Lower Devonian	Andesitic lava, fine grained, containing amygdales of calcite and chlorite, and thin veins of calcite, reddish grey, fresh with some listric surfaces	0.6+	5.9

(... continued)

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	
3	39	58	1.2	2.2	2	4	14	27	42	11	0	†
			2.2	3.2	2	7	9	23	37	22	0	†
			3.2	4.2	4	6	10	15	26	28	11	†
			4.2	5.3	3	8	17	16	20	32	4	†
			Mean		3	6	13	20	31	23	4	

NS 93 NE 10 9622 3858 Perryflats, Covington BLOCK C

Surface level + 209.3 m (+ 687 ft)
Water not struck
203 mm percussion
October 1979

Overburden 0.2 m
Mineral 3.5 m
Bedrock 0.4 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	a Gravel, poorly sorted Gravel: fine with coarse (up to 55 mm in diameter), angular to rounded, felsite and greywacke with lava, white, red and grey-green sandstones and vein-quartz Sand: coarse to fine, subrounded, quartz and rock fragments, medium to dark brown Fines: silt and clay, disseminated	1.1	1.3
Till	b 'Very clayey' sandy gravel Gravel: fine with coarse and rare cobbles, as above in shape and composition but containing a lower proportion of felsite Sand: coarse to fine, angular to subrounded, quartz and rock fragments, medium to dark brown Fines: silt and clay, content variable throughout deposit but generally increasing with depth	2.4	3.7
Lower Devonian	Andesitic lava, dark maroon, containing amygdales of chlorite, calcite, agate and zeolite	0.4+	4.1

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	8	38	54	0.2	1.3	8	10	11	17	37	17	0
b	24	46	30	1.3	3.7	24	13	14	19	21	9	0
a&b	19	43	38	Mean		19	12	13	18	26	12	0

NS 93 NE 11 9785 3943 Newtown of Covington, Covington BLOCK D

Surface level + 207.8 m (+ 682 ft)
Water not struck
203 mm percussion
October 1979

Waste 4.7 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Clay, gravelly, mottled, medium to dark brown and dark reddish brown, cohesive to 1.6 m becoming very stiff with a higher gravel content. Gravel angular to rounded and composed of felsite, red sandstone, greywacke, grey-green mudstone, lava and pink quartzite	4.3+	4.7
	Borehole terminated owing to boulder obstruction		

NS 93 NE 12 9755 3838 Burnmouth, Covington BLOCK C

Surface level + 200.5 m (+ 658 ft)
Water struck at + 195.6 m
203 mm percussion
October 1979

Waste 5.0 m
Bedrock 0.1 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial meltwater deposits	Clay, silty, pale grey-brown, slightly mottled. Containing some gravel and coarse sand from 1.2 m	1.6	2.0
	Gravel Gravel: fine and coarse, subrounded to well rounded, the finer fraction tending to be more angular than the coarse. Composed of grey-green and yellow sandstones with greywacke, basalt, quartzite, felsite and vein-quartz Sand: medium with coarse and some fine, quartz with rock fragments, orange-brown Fines: disseminated silt and clay	0.7	2.7
Till	Clay, gravelly, medium brown, very stiff with cobbles of basaltic lava and pebbles of greywacke, sandstone, lava, felsite and vein-quartz	2.3	5.0
Lower Devonian	Andesitic lava, containing amygdales of calcite and chlorite, maroon with listric surfaces on fracture planes	0.1+	5.1

NS 93 NE 13 9764 3727 Sherifflatts, Covington BLOCK C

Surface level + 229.9 m (+754 ft)
Water struck at + 228.5 m
203 mm percussion
October 1979

Overburden 0.4 m
Mineral 3.4 m
Bedrock 0.2 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial meltwater deposits	a 'Very clayey' sandy gravel, poorly sorted Gravel: fine with coarse, angular to rounded, felsite with greywacke, lava, grey-green sandstone, white quartzite and vein-quartz Sand: coarse to fine, angular to subangular, quartz and rock fragments, medium brown Fines: silt and clay, disseminated	1.0	1.4
	b Gravel Gravel: fine and coarse with some cobbles, as above in shape and composition Sand: coarse with medium and some fine, angular to subangular, quartz and felsite fragments, medium orange-brown Fines: silt and clay, disseminated	2.4	3.8
Lower Devonian	Andesitic lava, reddish grey, brecciated, containing angular fragments of andesite and amygdales mainly composed of calcite (up to 2 mm in diameter) with some calcite veins	0.2+	4.0

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	23	41	36	0.4	1.4	23	14	14	13	25	11	0	
b	4	32	64	1.4	2.4	2	2	9	24	35	28	0	†
				2.4	3.8	5	5	10	16	28	28	8	†
				Mean		4	4	9	19	31	28	5	
a&b	10	35	55	Mean		10	7	11	17	29	23	3	

NS 93 NE 14 — 9827 3930 — Parkhouse, Covington — BLOCK A

Surface level + 193.8 m (+636 ft)
Water struck at + 191.7 m
203 and 152 mm percussion
November 1979

Overburden 1.4 m
Mineral 4.6 m
Waste 20.4 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium (on fluvioglacial sand and gravel?)	Silt, sandy, yellow-brown, containing some gravel to base	1.2	1.4
	Gravel Gravel: fine with coarse and rare cobbles, subrounded to well rounded, the fine tending to be more angular than the coarse, greywacke, siltstone, felsite, lava, chert, red and yellow-brown sandstones, white quartzite and vein-quartz Sand: coarse with medium and traces of fine composed of angular to subangular rock fragments and subangular to subrounded quartz clasts, grey-brown Fines: silt, disseminated	4.6	6.0
Glaciolacustrine deposits	Silt, sandy, clayey, laminated, medium grey-brown very fine sand and silt, medium grey silt and maroon clay partings	14.1	20.1
Till	Clay, gravelly, stiff, reddish brown containing angular to rounded pebbles and cobbles composed of greywacke, lava, felsite porphyry, chert, red sandstone and vein-quartz	6.3+	26.4

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 $+4-16$	$+16-64$	$+64$	
1	28	71	1.4	2.4	1	1	13	20	33	32	0	†
			2.4	3.4	0	1	11	19	45	24	0	†
			3.4	4.4	1	1	5	20	49	24	0	†
			4.4	6.0	1	2	9	15	40	33	0	†
			Mean		1	1	9	18	42	29	0	

NS 93 NE 15 9842 3782 Thankerton Boat, Covington BLOCK A

Surface level + 194.6 m (+ 638 ft)
Water struck at + 191.9 m
203 and 152 mm percussion
December 1979

Overburden 2.7 m
Mineral 3.8 m
Waste 13.8 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium (on fluvioglacial sand and gravel?)	Silt, medium brown, containing plant remains	1.3	1.5
	Silt, medium blue-grey with orange-brown staining. Containing root remains	1.2	2.7
	Gravel Gravel: fine and coarse with rare cobbles, subangular to well rounded, the fine tending to be more angular than the coarse. Composed of greywacke, silstone and lava with felsite, chert, white quartzite and vein-quartz Sand: coarse and medium with fine, composed of subrounded quartz clasts and angular greywacke fragments, grey-brown Fines: silt, disseminated	3.8	6.5
Glaciolacustrine deposits	Silt, sandy, clayey, laminated with grey-brown very fine sand and silt, grey silt and maroon clay partings	9.0	15.5
Fluvioglacial sand and gravel	Gravel Gravel: coarse and fine (up to 60 mm in diameter), mainly subrounded to rounded, greywacke and siltstone with lava, felsite quartzite and vein-quartz Sand: fine with medium and some coarse, angular to subangular greywacke fragments with subrounded quartz clasts, grey-brown Fines: silt, disseminated	1.5	17.0
Till	Clay, gravelly, stiff, reddish brown, containing angular to rounded pebbles and cobbles of greywacke, felsite, vein-quartz, lava and sandstone	3.3+	20.3

GRADING

Mean for deposit percentages			Depth below surface (m)		percentages							
Fines	Sand	Gravel			Fines	Sand			Gravel			
					$-1/16$	$+1/16-1/4$	$+1/4-1$	$+1-4$	$+4-16$	$+16-64$	$+64$	
4	30	66	2.7	5.0	3	3	8	15	36	35	0	†
			5.0	6.5	4	4	13	19	34	26	0	†
			Mean		4	4	10	16	35	31	0	

NS 93 NE 16	9854 3740	Holm Braes, Thankerton	BLOCK C

Surface level + 216.8 m (+ 711 ft)
Water struck at + 215.8 m
203 mm percussion
October 1979

Overburden 0.3 m
Mineral 1.5 m
Waste 2.0 m
Bedrock 0.5 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial meltwater deposits	Gravel, poorly sorted Gravel: fine and coarse with some cobbles, subangular to well rounded, the fine tending to be more angular than the coarse, greywacke, yellow-brown sandstone, felsite, quartzite, lava, chert and vein-quartz Sand: coarse with medium and fine, composed of angular to subangular rock fragments with subangular to subrounded quartz clasts, medium brown Fines: silt and clay, disseminated	1.5	1.8
Till	Clay, pebbly, stiff, mottled, red to yellow-brown, containing subangular to well rounded pebbles of greywacke, sandstone, felsite, chert, quartzite and vein-quartz	2.0	3.8
Lower Devonian	Andesitic lava, grey-maroon, containing white and pale green zeolite and chlorite amygdales up to 3 mm in diameter	0.5+	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	
7	39	54	0.3	1.3	10	9	11	20	27	23	0	
			1.3	1.8	2	2	9	24	38	25	0	†
			Mean		7	7	11	21	30	24	0	

NS 93 NE 17 9868 3639 St Ninian's Chapel, Symington BLOCK C

Surface level + 229.7 m (+ 754 ft)
Water struck at + 227.7 m
203 mm percussion
October 1979

Overburden 0.3 m
Mineral 5.6 m
Waste 1.1 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial meltwater deposits	Gravel, poorly sorted Gravel: fine and coarse with some cobbles, subangular to well rounded, the fine tending to be more angular than the coarse, greywacke and felsite with lava, siltstone, sandstone and vein-quartz, felsite less common below 1.0 m Sand: coarse with medium and some fine, subangular to subrounded, quartz with rock fragments, medium to dark brown Fines: silt and clay, disseminated	5.6	5.9
Till	Clay, pebbly, stiff to hard, reddish brown, containing angular to rounded pebbles of greywacke, siltstone, lava and felsite	1.1+	7.0

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 $+4-16$	$+16-64$	$+64$	
5	38	57	0.3	1.0	5	5	11	10	22	37	10	
			1.0	2.0	8	10	14	27	32	9	0	
			2.0	3.0	2	2	7	24	44	21	0	†
			3.0	4.0	3	2	8	25	37	13	12	†
			4.0	5.0	2	6	9	13	30	40	0	†
			5.0	5.9	5	8	24	20	20	16	7	†
			Mean		5	6	12	20	31	22	4	

NS 93 NE 18 9981 3661 Annieston, Symington BLOCK C

Surface level + 216.9 m (+ 712 ft)
Water struck at + 215.7 m
203 mm percussion
October 1979

Overburden 0.4 m
Mineral 1.3 m
Waste 2.3 m
Bedrock 0.2 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial meltwater deposit	Gravel Gravel: coarse and fine with some cobbles (up to 90 mm diameter), mainly rounded to well rounded, greywacke, siltstone, lava, yellow-brown sandstone, chert, felsite, porphyry and vein-quartz Sand: coarse and medium with fine, subangular, quartz and rock fragments, grey-brown Fines: silt and clay, disseminated	1.3	1.7
Till	Clay, gravelly, stiff to hard, yellow-brown becoming medium brown with red patches. Containing angular to subrounded pebbles of lava with greywacke, siltstone, felsite and chert	2.3	4.0
Lower Devonian	Andesitic lava, maroon, containing acicular hornblende crystals (up to 1 mm in length) and rare amygdales of white zeolite (up to 2 mm in diameter)	0.2+	4.2

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
8	37	55	0.4	1.7	8	5	16	16	27	28	0

NS 93 NE 19 9596 3899 Perryflats, Covington BLOCK D

Surface level c + 215.0 m (c + 705 ft)
Water not struck
Pit
August 1979

Waste 1.7 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	'Clayey' sandy gravel, poorly sorted Gravel: coarse and fine with some cobbles, angular to rounded, lava with greywacke, felsite and vein-quartz Sand: coarse to fine, angular, rock fragments and quartz, medium brown Fines: clay and silt	0.6	1.0
	Clay, gravelly, sandy, medium brown, hard, with pebbles of lava, greywacke, felsite and vein-quartz, and coarse to fine sand	0.7+	1.7

NS 93 NE 20 | 9561 3827 | Thankerton Moor, Covington | BLOCK C

Surface level c + 214.0 m (c + 702 ft)
Water struck at + 211.9 m
Pit
October 1979

Overburden 0.8 m
Mineral 1.3 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.8	0.8
Glacial meltwater deposits	Gravel, poorly sorted Gravel: fine and coarse with cobbles (up to 200 mm across), angular to well rounded, felsite with lava and greywacke Sand: coarse and medium with fine, mainly subangular, quartz and rock fragments, reddish brown Fines: silt and clay, disseminated	1.3+	2.1

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
9	39	52	0.8	2.1	9	8	15	16	28	24	0

NS 93 NE 21 | 9699 3928 | Meadowflat, Covington | BLOCK D

Surface level c + 207.0 m (c + 679 ft)
Water not struck
Pit
August 1979

Waste 2.0 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, pebbly, mottled yellow-brown to grey-brown, cohesive becoming very stiff. Clasts mainly angular and composed of basaltic lava, becoming increasingly common with depth	1.8+	2.0

NS 93 NE 22 | 9651 3759 | Fallburn, Covington | BLOCK D

Surface level c + 223.0 m (c + 732 ft)
Water not struck
Pit
October 1979

Waste 2.0 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Clay, gravelly, sandy, mottled pale brown to orange, stiff. Containing clasts up to 400 mm in diameter, mainly subangular and composed of felsite with greywacke and lava	1.6+	2.0

NS 93 NE 23 | 9738 3880 | Glade Burn, Covington | BLOCK D

Surface level c + 200.0 m (c + 656 ft)
Water not struck
Pit
August 1979

Overburden 0.3 m
Mineral 1.4 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	'Clayey' sandy gravel Gravel: coarse and fine with cobbles and boulders, mainly angular to subangular and composed of lava with some rounded greywacke, felsite and vein-quartz pebbles. Clasts of lava becoming larger and more numerous towards base Sand: coarse to fine, subangular, rock fragments and quartz, grey-brown Fines: clay, deposit stiff	1.4+	1.7

Pit terminated on obstruction composed of lava and thought to be very close to bedrock. No grading data available

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NS 93 NE 24 | 9758 3767 | Sherifflatts, Thankerton | BLOCK C

Surface level c + 215.0 m (c + 705 ft)
Water not struck
Pit
August 1979

Waste 0.9 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, gravelly, sandy, grey-brown, stiff, with clasts of greywacke, sandstone, lava and felsite, and some coarse to fine sand	0.6+	0.9

NS 93 NE 25 | 9799 3574 | Burn Strip, Symington | BLOCK D

Surface level c + 263.0 m (c + 863 ft)
Water not struck
Pit
August 1979

Overburden 0.3 m
Mineral 1.9 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial meltwater deposits	Sandy gravel Gravel: coarse and fine, coarsening below 1.8 m and containing cobbles (up to 250 mm across), rounded to well rounded, lava, felsite, greywacke, chert, quartzite and vein-quartz Sand: medium with coarse and fine, fining below 1.8 m, subrounded, quartz with rock fragments, medium to dark brown Fines: silt and clay, disseminated	1.9+	2.2

(... continued)

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
5	55	40	0.3	1.8	3	9	40	10	20	18	0
			1.8	2.2	9	15	19	7	21	29	0
			Mean		5	10	35	10	20	20	0

NS 93 NE 26 9830 3876 Gravel Pit, Parkhouse, Libberton BLOCK D

Surface level c + 213.0 m (c + 699 ft) Mineral 5.2 m +
Water not struck
Pit
October 1979

LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial meltwater deposits	Gravel (fining with depth) Gravel: coarse and fine with cobbles up to 200 mm across, subangular to well rounded, the fine more angular than the coarse, greywacke, grey-green sandstone, felsite, lava, chert, quartzite and vein-quartz Sand: coarse and medium with some fine, subangular to rounded, felsite and greywacke fragments with quartz, grey-brown Fines: silt, disseminated	5.2+	5.2

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
4	33	63	0.0	4.0	3	1	11	17	28	34	6
			4.0	5.2	9	6	25	14	21	25	0
			Mean		4	3	14	16	26	32	5

NS 93 NE 27	9826 3875	Quothquan Law, Libberton	BLOCK D

Surface level c + 209.0 m (c + 686 ft)
Water not struck
Pit
October 1979

Overburden 0.9 m
Mineral 1.4 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Head	Clay, gravelly, sandy, yellow-brown, stiff	0.7	0.9
Glacial meltwater deposits	Gravel Gravel: coarse and fine with numerous cobbles, subangular to well rounded, the fine more angular than the coarse. Composed of greywacke, felsite, basalt, andesite, chert, quartzite and vein-quartz Sand: coarse with medium and fine, subangular, rock fragments with quartz, grey-brown Fines: disseminated silt	1.4+	2.3

Large angular blocks of lava at base, probably near bedrock. No grading data available

NS 93 NE 28	9831 3805	Quothquan Law Farm, Libberton	BLOCK D

Surface level + 202.9 m (+ 666 ft)
Water struck at 201.5 m
Pit
October 1979

Overburden 0.4 m
Mineral 1.0 m
Waste 0.8 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial meltwater deposits	'Clayey' sandy gravel Gravel: fine with coarse, subangular to well rounded, greywacke, felsite, sandstone, lava and vein-quartz Sand: fine with medium and coarse, rounded, quartz with rock fragments, pale brown Fines: silt, disseminated	1.0	1.4
Till	Clay, gravelly, stiff, pale grey-brown containing clasts of greywacke	0.8+	2.2

GRADING

Mean for deposit percentages			Depth below surface (m)		percentages						
Fines	Sand	Gravel			Fines	Sand			Gravel		
					$-1/16$	$+1/16-1/4$	$+1/4-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
13	57	30	0.4	1.4	13	31	16	10	20	10	0

NS 93 NE 29 9955 3722 Annieston, Symington BLOCK C

Surface level c + 201.0 m (c + 659 ft)
Water not struck
Pit
August 1979

Overburden 0.3 m
Mineral 2.3 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial meltwater deposits	Sandy gravel, well sorted Gravel: fine with some coarse (up to 40 mm in diameter), mainly rounded to well rounded, greywacke, felsite, lava, sandstone and vein-quartz. Absent between 0.8 and 1.1 m Sand: medium with coarse and some fine, composed mainly of rounded quartz clasts with some subangular to subrounded felsite fragments which become rarer below 0.8 m, orange-brown Fines: silt, disseminated and in thin seams with a laminated, orange-brown and pink clayey silt parting between 1.05 and 1.10 m	2.3+	2.6

GRADING

Mean for deposit percentages: Fines	Sand	Gravel	Depth below surface (m)		percentages: Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
4	71	25	0.3	2.6	4	9	43	19	21	4	0

NS 93 NE 30 9925 3676 Annieston, Symington BLOCK C

Surface level + 224.0 m (+ 735 ft)
Water not struck
Pit
October 1979

Overburden 0.2 m
Mineral 1.4 m
Waste 0.3 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	Gravel Gravel: fine and coarse with rare cobbles, subrounded to well rounded, greywacke, siltstone, lava, felsite, chert and sandstone Sand: coarse with medium and fine, subangular to well rounded, rock fragments and quartz, pale brown Fines: silt, disseminated	1.4	1.6
Till	Clay, gravelly, very stiff, yellow-grey, containing mainly well rounded pebbles and some coarse, angular sand	0.3+	1.9

GRADING

Mean for deposit percentages: Fines	Sand	Gravel	Depth below surface (m)		percentages: Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
3	31	66	0.2	1.6	3	6	7	18	38	28	0

NS 93 NE 31 9948 3622 Symington Station, Symington BLOCK C

Surface level c + 229.0 m (c + 751 ft)
Water struck at + 227.8 m
Pit
August 1979

Overburden 0.3 m
Mineral 1.5 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial meltwater deposits	Gravel Gravel: coarse and fine with cobbles, mainly rounded to well rounded, greywacke, felsite, lava, chert, sandstone, porphyry and vein-quartz Sand: coarse and medium with some fine, mainly subangular, rock fragments and quartz, grey-brown Fines: silt and clay, disseminated	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
3	34	63	0.3	1.8	3	4	13	17	31	32	0

NS 93 NE 32 9989 3553 Symington Mill, Symington BLOCK C

Surface level c + 220.0 m (c + 722 ft)
Water not struck
Pit
October 1979

Waste 1.2 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, gravelly, orange-brown, stiff, with subrounded to well rounded pebbles, mainly composed of greywacke, and weathered basalt boulders up to 500 mm in diameter	1.0+	1.2
	Pit terminated on boulder composed of basalt		

NS 93 SE 1 9626 3001 Hardington House, Wiston BLOCK A

Surface level + 218.8 m (+ 718 ft)
Water struck at + 212.6 m
203 mm percussion
October 1979

Overburden 0.6 m
Mineral 5.4 m
Waste 0.4 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Fluvioglacial sand and gravel	Gravel, poorly sorted Gravel: coarse and fine with some cobbles, mainly subrounded to rounded, greywacke, siltstone, lava, grey, red and white sandstones, felsite, chert, quartzite and vein-quartz Sand: coarse and medium with fine, composed of subrounded quartz clasts with subangular rock fragments, medium brown Fines: silt, disseminated	5.4	6.0
Till	Clay, gravelly, stiff to hard, yellow-brown, containing angular to subrounded pebbles of greywacke, siltstone, lava, quartzite and vein-quartz	0.4+	6.4
	Borehole terminated owing to boulder obstruction		

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 $+4-16$	$+16-64$	$+64$
4	38	58	0.6	1.6	6	7	10	16	26	35	0
			1.6	3.0	5	2	10	23	29	26	5
			3.0	4.5	2	3	13	20	33	29	0
			4.5	6.0	4	8	17	19	24	28	0
			Mean		4	5	13	20	28	29	1

NS 93 SE 2 9734 3151 Hardington Mains, Wiston BLOCK D

Surface level + 223.4 m (+ 733 ft)
Water not struck
203 mm percussion
October 1979

Waste 5.9 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, sandy, pebbly, orange-brown with mainly angular pebbles of grey-blue sandstone, felsite and greywacke, and fine with medium and coarse sand. Cohesive becoming stiff and containing a raft of weathered, medium grained, blue-grey sandstone between 5.1 and 5.5 m	5.6+	5.9

NS 93 SE 3 9735 3067 Burnfoot, Lamington BLOCK A

Surface level + 209.6 m (+ 688 ft)
Water struck at + 206.9 m
203 mm percussion
October 1979

Overburden 1.9 m
Mineral 7.8 m
Waste 0.6 m
Bedrock 0.2 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Aluvium on fluvioglacial sand and gravel	Silt, clayey, stiff, medium to dark brown, containing some fine sand and rare pebbles	1.5	1.9
	Gravel Gravel: fine and coarse with cobbles (up to 200 mm in diameter), mainly rounded to well rounded, greywacke, siltstone, grey-green sandstone, lava, chert, felsite and vein-quartz Sand: coarse with medium and some fine, composed of angular rock fragments with subangular quartz clasts, medium grey Fines: silt, disseminated	7.8	9.7
Till	Clay, pebbly, very stiff, medium brown, containing fragments of lava	0.6	10.3
Lower Devonian	Andesitic lava, brecciated, containing numerous calcite veins and amygdales of calcite and white zeolite	0.2+	10.5

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 $+4-16$	$+16-64$	$+64$	
2	34	64	1.9	2.9	1	2	9	22	35	31	0	†
			2.9	3.9	2	4	8	21	35	30	0	†
			3.9	4.9	1	1	5	17	39	27	10	†
			4.9	5.9	2	2	11	22	32	31	0	†
			5.9	6.9	1	3	7	18	32	16	23	†
			6.9	7.9	2	7	13	22	33	13	10	†
			7.9	8.9	2	4	9	21	39	25	0	†
			8.9	9.7	3	10	15	20	26	17	9	†
			Mean		2	4	9	21	34	24	6	

NS 93 SE 4	9860 3262	Lamington Mains, Lamington	BLOCK A

Surface level + 209.4 m (+ 687 ft)
Water not struck
203 mm percussion
October 1979

Waste 3.4 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, gravelly, medium to dark reddish brown, stiff to hard with angular to rounded pebbles of greywacke, siltstone, sandstone, quartzite, basalt, andesite, felsite and porphyry	3.2+	3.4
	Borehole terminated on an obstruction composed of grey-green sandstone, possibly bedrock		

NS 93 SE 5	9805 3186	Lamington Tower, Lamington	BLOCK A

Surface level + 206.8 m (+ 678 ft)
Water struck at + 204.6 m
203 and 152 mm percussion
September 1979

Overburden 2.3 m
Mineral 19.1 m
Bedrock 0.1 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Aluvium on fluvioglacial sand and gravel	Silt, sandy, laminated, grey-brown	1.4	1.7
	Clay, medium blue-grey, containing root remains	0.6	2.3
	Gravel Gravel: fine with coarse and some cobbles (up to 150 mm in diameter), subangular to well rounded, greywacke and siltstone with red sandstone, lava, chert, felsite, porphyry, quartzite and vein-quartz Sand: coarse with medium and some fine, composed of angular to subangular greywacke and siltstone fragments with some subangular quartz clasts. Medium to dark grey-brown Fines: silt, disseminated. Raft of reddish maroon till between 19.9 and 20.0 m	19.1	21.4
Lower Devonian	Sandstone, medium grained, containing subangular clasts of quartz with feldspar and angular fragments of andesite (up to 3 mm across), reddish blue-grey	0.1+	21.5

(... continued)

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	
2	35	63	2.3	3.3	2	3	14	25	32	24	0	†
			3.3	4.3	0	2	6	19	40	33	0	†
			4.3	5.3	0	1	7	21	35	30	6	†
			5.3	6.3	2	1	11	24	35	27	0	†
			6.3	7.3	1	1	13	27	34	24	0	†
			7.3	8.3	0	2	20	25	33	20	0	†
			8.3	9.3	1	2	25	20	34	18	0	†
			9.3	10.3	1	4	10	20	40	20	5	†
			10.3	11.3	1	2	10	17	50	20	0	†
			11.3	12.3	1	1	4	12	68	14	0	†
			12.3	13.3	0	1	4	11	40	44	0	†
			13.3	15.3	3	4	14	21	34	24	0	†
			15.3	16.3	2	3	13	21	40	21	0	†
			16.3	17.3	2	3	10	18	48	19	0	†
			17.3	18.5	2	2	12	24	45	15	0	†
			18.5	20.0	12	3	11	20	30	24	0	†
			20.0	21.4	4	5	15	24	36	16	0	†
			Mean		2	3	12	20	39	23	1	

NS 93 SE 6   9965 3406   Symington Mains Farm, Symington   BLOCK D

Surface level + 214.5 m (+ 704 ft)
Water not struck
203 mm percussion
October 1979

Waste 1.6 m
Bedrock 0.4 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	'Clayey' pebbly sand Gravel: coarse and fine, subangular to subrounded, mainly greywacke and lava Sand: mainly fine, subrounded, quartz, orange-brown Fines: disseminated silt	0.3	0.5
Till	Clay, sandy, pebbly, medium grey-brown with clasts of greywacke, lava, weathered grey sandstone and vein-quartz, and fine with medium sand	1.1	1.6
Lower Devonian	Sandstone, fine to medium grained, dull reddish grey-green, with subangular to subrounded clasts composed of quartz with feldspar and rock fragments. Thin maroon siltstone partings	0.4+	2.0

NS 93 SE 7 9918 3321 Langholm, Lamington BLOCK A

Surface level + 203.7 m (+ 668 ft)
Water struck at + 202.2 m
203 mm percussion
October 1979

Overburden 1.5 m
Mineral 2.0 m
Waste 1.2 m
Mineral 3.0 m
Bedrock 1.5 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Aluvium	Clay, silty, containing some very fine sand, mottled, orangey medium brown becoming blue-grey below 1.0 m	1.1	1.5
	a Gravel Gravel: fine and coarse with some cobbles, mainly rounded to well rounded, greywacke and siltstone with lava, red sandstone, chert, felsite, porphyry and vein-quartz Sand: coarse with medium and traces of fine, composed of subangular rock fragments with subrounded quartz clasts, medium to dark grey Fines: silt, disseminated and in seams	2.0	3.5
	Silt, containing some clay and very fine sand with thin peaty seams and root remains, blue-grey. Becoming pebbly towards base	1.2	4.7
Fluvioglacial sand and gravel	b Gravel Gravel: fine with coarse, as above. Sand: coarse and medium with traces of fine, as above. Fines: silt, disseminated and in seams	3.0	7.7
Lower Devonian	Sandstone, medium to coarse grained with rare pebbles of andesite (up to 30 mm in diameter). Containing quartz with feldspar and andesite clasts and partially cemented by calcite. Thinly bedded, well sorted, reddish blue-grey, weathered to 9.0 m, becoming harder	1.5+	9.2

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	2	25	73	1.5	2.5	1	1	7	17	38	31	5	†
				2.5	3.5	3	2	10	15	35	35	0	†
				Mean		2	1	8	16	37	34	2	
b	5	37	58	4.7	5.7	2	2	12	16	38	30	0	†
				5.7	6.7	3	5	22	21	31	18	0	†
				6.7	7.7	10	3	12	19	34	22	0	†
				Mean		5	3	15	19	35	23	0	
a&b	4	33	63	Mean		4	2	13	18	35	27	1	

NS 93 SE 8 9690 3125 Castledykes, Wiston BLOCK D

Surface level c + 230.0 m (c + 755 ft)
Water not struck
Pit
October 1979

Overburden 0.1 m
Mineral 2.1 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial meltwater deposits	'Clayey' gravel Gravel: coarse and fine with cobbles, mainly subrounded to well rounded, greywacke, lava, felsite, porphyry, red and grey-green sandstones, chert and vein-quartz Sand: coarse and medium with fine, mainly subangular and composed of rock fragments, yellow-brown Fines: silt and clay, disseminated	2.1+	2.2

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
11	27	62	0.1	2.2	11	5	9	13	26	36	0

NS 93 SE 9 9677 3056 Hardington House, Wiston BLOCK D

Surface level c + 219.0 m (c + 719 ft)
Water struck at + 216.8 m
Pit
October 1979

Overburden 0.2 m
Mineral 2.0 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	'Clayey' gravel Gravel: coarse and fine with cobbles, angular to well rounded, greywacke and vein-quartz Sand: coarse with medium and fine, angular to subrounded, rock fragments with quartz, pale brown Fines: clay, deposit cohesive	2.0+	2.2

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
12	29	59	0.2	1.2	10	6	7	11	27	33	6
			1.2	2.2	14	8	9	16	24	18	11
			Mean		12	7	8	14	25	25	9

NS 93 SE 10 9752 3291 Meadowfoot, Wiston BLOCK D

Surface level c + 263.0 m (c + 863 ft)
Water not struck
Pit
August 1979

Waste 1.9 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, pebbly, sandy, mottled pale grey-green and orange becoming medium blue-grey and grey-brown, firm becoming very stiff. Containing subangular to well rounded pebbles and cobbles of basalt and some angular sand	1.7+	1.9

NS 93 SE 11 9755 3185 Hardington Mains, Wiston BLOCK D

Surface level c + 220.0 m (c + 722 ft)
Water not struck
Pit
August 1979

Overburden 0.2 m
Mineral 1.4 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	'Clayey' gravel, poorly sorted Gravel: fine and coarse with some cobbles, subangular to well rounded, greywacke, siltstone, lava and vein-quartz Sand: coarse to fine, quartz and rock fragments, orange-brown Fines: clay, disseminated	1.4+	1.6

GRADING

Mean for deposit percentages			Depth below surface (m)		percentages						
Fines	Sand	Gravel			Fines	Sand			Gravel		
					$-1/16$	$+1/16-1/4$	$+1/4-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
14	30	56	0.2	1.6	14	7	10	13	29	27	0

NS 93 SE 12 9785 3101 Laming, Lamington BLOCK A

Surface level c + 217.0 m (c + 712 ft)
Water not struck
Pit
October 1979

Overburden 0.9 m
Mineral 1.2 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Fluvioglacial sand and gravel	Clay, sandy, pebbly, hard, yellow-brown, containing fine to medium sand and fine, subangular to well rounded gravel composed mainly of greywacke	0.4	0.9
	Sandy gravel Gravel: fine with some coarse, subangular to well rounded, greywacke and siltstone Sand: coarse to fine, subangular to well rounded, rock fragments and quartz, yellow-brown Fines: clay, disseminated	1.2 +	2.1

GRADING

Mean for deposit percentages			Depth below surface (m)		percentages						
Fines	Sand	Gravel			Fines	Sand			Gravel		
					$-1/16$	$+1/16-1/4$	$+1/4-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
9	48	43	0.9	2.1	9	10	17	21	34	9	0

NS 93 SE 13 9765 3098 Lamington School, Lamington BLOCK A

Surface level c + 212.0 m (c + 696 ft)
Water not struck
Pit
October 1979

Overburden 0.4 m
Mineral 2.0 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 and boulders (up to 300 mm in diameter), coarsening downwards, subangular to well rounded, greywacke and siltstone with lava, chert, sandstone and vein-quartz Sand: coarse and medium with some fine, subangular rock fragments and quartz, yellow-brown Fines: silt, disseminated	2.0+	2.4

GRADING

Mean for deposit percentages			Depth below surface (m)		percentages						
Fines	Sand	Gravel			Fines	Sand			Gravel		
					$-1/16$	$+1/16-1/4$	$+1/4-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
6	25	69	0.4	1.4	9	2	10	9	27	31	12
			1.4	2.4	2	2	12	16	25	31	12
			Mean		6	2	11	12	26	31	12

NS 93 SE 14	9893 3493	Westside, Symington	BLOCK D

Surface level c + 230.0 m (c + 755 ft)
Water not struck
Pit
August 1979

Waste 1.2.m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, gravelly, sandy, medium to dark brown, stiff. Containing coarse and fine, angular to rounded pebbles of felsite, sandstone, greywacke, quartzite and vein-quartz with coarse to fine, subangular sand composed of quartz and rock fragments	1.0+	1.2

NS 93 SE 15	9820 3175	Lamington Mains, Lamington	BLOCK A

Surface level + 210.7 m (+ 691 ft)
Water not struck
Pit
August 1979

Overburden 0.3 m
Mineral 1.9 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	Gravel, well sorted Gravel: fine and coarse with rare cobbles, subangular to well rounded, greywacke, siltstone, sandstone, lava, chert, quartzite and vein-quartz Sand: coarse and medium with some fine, angular to subrounded, rock fragments and quartz, orange-brown Fines: silt, disseminated, content decreasing with depth	1.9+	2.2

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
4	38	58	0.3	1.3	6	5	12	19	36	22	0
			1.3	2.2	2	4	19	18	32	25	0
			Mean		4	5	15	18	34	24	0

NT 03 NW 1 0010 3681 Cormiston Towers, Libberton BLOCK A

Surface level + 196.6 m (+ 645 ft)
Water struck at + 194.1 m
203 and 152 mm percussion
December 1979

Overburden 2.5 m
Mineral 20.1 m
Bedrock 0.2 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	1.0	1.0
Alluvium	Silt, medium brown, containing some very fine, subrounded, quartzose sand	0.6	1.6
	Silt, medium grey with medium brown sandy laminae	0.9	2.5
	a Gravel, fining downwards Gravel: coarse and fine with cobbles (up to 200 mm in diameter), mainly rounded to well rounded, greywacke and siltstone with lava, yellow-brown sandstone, white quartzitic sandstone, felsite and vein-quartz Sand: coarse and medium with fine, composed of angular greywacke and siltstone fragments with subangular to subrounded quartz clasts medium grey-brown Fines: silt, disseminated and in medium-brown and medium-grey seams	4.0	6.5
Fluvioglacial sand and gravel	b Sandy gravel, well sorted Gravel: coarse and fine with rare cobbles, mainly subrounded to well rounded, greywacke, pink and orange felsites, lava, white and red sandstones, pink quartzite, chert and vein-quartz Sand: medium with fine and coarse, subrounded, quartz with some rock fragments, yellow-brown Fines: silt, disseminated	16.1	22.6
Lower Devonian	Andesitic lava, maroon, containing well rounded xenoliths of grey basaltic lava (up to 3 mm in diameter) with veins of calcite and chlorite which exhibit listric surfaces	0.2+	22.8

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	4	30	66	2.5	3.5	2	5	9	9	24	35	16	†
				3.5	4.5	9	1	5	11	25	39	10	†
				4.5	5.5	2	4	15	19	30	30	0	†
				5.5	6.5	2	4	15	20	43	16	0	†
				Mean		4	4	11	15	30	30	6	
b	3	59	38	6.5	7.5	1	5	34	5	16	39	0	†
				7.5	8.5	4	7	53	5	6	25	0	†
				8.5	9.5	2	14	30	12	23	16	3	†
				9.5	10.5	3	15	31	10	14	22	5	†
				10.5	11.5	1	10	30	12	28	19	0	†
				11.5	12.5	2	17	42	11	16	12	0	†
				12.5	13.5	2	10	43	17	15	13	0	†
				13.5	15.3	2	12	43	11	16	16	0	†
				15.3	17.3	5	36	24	5	9	21	0	†
				17.3	18.3	3	19	31	17	11	19	0	†
				18.3	20.0	7	28	23	8	13	21	0	†
				20.0	21.0	4	13	21	10	23	29	0	†
				21.0	22.6	2	14	19	15	24	22	4	†
				Mean		3	17	32	10	16	21	1	
a&b	3	53	43	Mean		3	14	28	11	19	23	2	

NT 03 NW 2 0066 3608 Eastfield, Symington BLOCK C

Surface level + 204.3 m (+ 670 ft)
Water struck at + 197.6 m
203 and 152 mm percussion
September 1979

Overburden 0.3 m
Mineral 4.3 m
Waste 2.6 m
Bedrock 0.2 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial meltwater deposits	a Gravel Gravel: fine and coarse with some cobbles (up to 140 mm in diameter), mainly rounded to well rounded, greywacke, lava, red, green and white sandstones, felsite, porphyry and vein-quartz Sand: coarse and medium with fine, subrounded, quartz and rock fragments, medium brown Fines: silt, disseminated	2.1	2.4
	b 'Clayey' pebbly sand Gravel: fine with some coarse, subangular to well rounded, as above in composition Sand: medium with fine and coarse, as above in shape, composition and colour Fines: silt, disseminated	2.2	4.6
Till	Clay, gravelly, sandy, stiff, mottled, medium brown to red-brown becoming grey-brown below 6.0 m. Containing angular to rounded pebbles of greywacke, lava, felsite and sandstone with sandy lenses	2.6	7.2
Lower Devonian	Sandstone, medium grained with angular to subangular clasts composed of quartz and feldspar with lava, dark reddish grey. Containing maroon mudflakes and thin, maroon mudstone partings	0.2+	7.4

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	5	40	55	0.3	1.3	6	6	13	15	25	35	0
				1.3	2.4	5	7	19	17	29	17	6
				Mean		5	7	16	17	27	25	3
b	10	72	18	2.4	4.6	10	17	43	12	14	4	0
a & b	8	56	36	Mean		8	12	30	14	20	14	0

NT 03 NW 3 0055 3507 Symington House, Symington BLOCK C

Surface level + 206.1 m (+ 676 ft)
Water struck at + 202.3 m
203 and 152 mm percussion
September 1979

Overburden 1.0 m
Mineral 6.3 m
Waste 2.4 m
Mineral 1.0 m
Waste 7.7 m
Bedrock 0.2 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial meltwater deposits	Silt, pebbly, sandy, firm, yellow-brown. Containing some subrounded to well rounded pebbles of greywacke	0.6	1.0
	a 'Clayey' sandy gravel, poorly sorted Gravel: fine and coarse, subangular to well rounded, greywacke and lava with porphyry and vein-quartz Sand: medium, fine and coarse, subangular to subrounded, rock fragments and quartz, yellowish brown Fines: silt and clay, disseminated	3.0	4.0
	b Gravel, fining downwards Gravel: coarse and fine with cobbles, subangular to well rounded, greywacke, lava, chert and vein-quartz Sand: coarse and medium with fine, composed of angular rock fragments with subangular quartz clasts, medium grey-brown Fines: silt and clay, disseminated and in seams	3.3	7.3
Glaciolacustrine deposits	Silt, laminated with some clay and very fine sandy seams, medium brown becoming grey-brown and grey by 8.0 m	2.4	9.7
Glacial meltwater deposits	c 'Clayey' gravel Gravel: fine with coarse and some cobbles, angular to rounded, the fine tending to be more angular than the coarse, greywacke, lava, chert, felsite and vein-quartz Sand: coarse with medium and some fine, composed of angular rock fragments and subangular to subrounded quartz clasts, medium grey-brown Fines: silt and clay, disseminated	1.0	10.7
Till	Clay, gravelly, stiff, orange-brown, containing clasts up to 250 mm in diameter and composed of greywacke, lava, sandstone and vein-quartz	1.8	12.5
Glaciolacustrine deposits	Silt, clayey, stiff, laminated with maroon-grey and blue-grey seams up to 10 mm in thickness. Containing rare pebbles up to 5 mm in diameter	5.9	18.4
Lower Devonian	Andesitic lava, brecciated, containing amygdales of calcite and chlorite, and calcite veins, dark maroon	0.2+	18.6

(... continued)

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	18	49	33	1.0	2.0	16	11	17	13	22	21	0	
				2.0	3.0	20	24	18	12	13	13	0	
				3.0	4.0	18	18	18	16	17	13	0	
				Mean		18	17	18	14	17	16	0	
b	8	37	55	4.0	5.0	4	5	7	15	36	29	4	†
				5.0	6.0	6	7	15	16	23	28	6	†
				6.0	7.3	14	12	17	16	21	20	0	†
				Mean		8	8	13	16	26	26	3	
c	11	43	46	9.7	10.7	11	4	10	29	30	16	0	†
a&b	13	42	45	Mean		13	13	15	14	22	21	2	
a to c	13	43	44	Mean		13	11	15	17	23	20	1	

NT 03 NW 4 0172 3635 Wolfclyde, Symington BLOCK A

Surface level + 199.5 m (+ 655 ft)
Water struck at + 197.1 m
203 and 152 mm percussion
September 1979

Overburden 0.1 m
Mineral 13.5 m
Waste 1.8 m
Mineral 2.2 m
Bedrock 0. 2 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Alluvium	a 'Very clayey' sand Sand: fine with medium and traces of coarse, subrounded, quartz with rock fragments, medium brown Fines: silt, disseminated and in seams	1.6	1.7
Fluvioglacial sand and gravel	b Gravel Gravel: fine and coarse with cobbles, subrounded to well rounded, greywacke with lava, siltstone, chert, felsite, prophyry, grey sandstone and vein-quartz Sand: coarse and medium with some fine, angular to rounded, greywacke and siltstone fragments with quartz, medium brown Fines: silt, disseminated	8.0	9.7
	c Sandy gravel, coarsening downwards Gravel: fine and coarse with some cobbles, as above in composition Sand: medium with fine and coarse, angular to rounded, quartz and rock fragments, medium brown Fines: silt, disseminated	3.9	13.6
Glaciolacustrine deposits	Silt, firm, laminated with medium grey and brownish grey partings	0.4	14.0
	Silt, clayey, pebbly, medium grey-brown, containing rare subrounded to well rounded pebbles (up to 40 mm in diameter) composed of greywacke, lava, felsite and vein-quartz	1.4	15.4
Fluvioglacial sand and gravel	d Gravel Gravel: fine with coarse and rare cobbles (up to 90 mm in diameter), angular to well rounded, the fine tending to be more angular than the coarse, greywacke with felsite, lava, chert, yellow sandstone, white quartzite, porphyry, Haggis Rock and vein-quartz Sand: coarse with medium and fine, angular to subrounded, rock fragments and quartz, medium to dark grey-brown Fines: silt, disseminated	2.2	17.6
Lower Devonian	Basaltic lava, containing pyroxene crystals up to 1 mm in length and exhibiting listric surfaces. Grey-green and weathered with orange-brown staining	0.2+	17.8

(... continued)

GRADING

	Mean for deposit percentages			Depth below surface (m)		percentages							
	Fines	Sand	Gravel			Fines	Sand			Gravel			
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$	
a	23	77	0	0.1	1.7	23	52	24	1	0	0	0	
b	3	40	57	1.7	2.7	6	8	9	15	25	37	0	
				2.7	3.7	6	3	18	17	33	23	0	†
				3.7	4.7	1	1	13	20	32	33	0	†
				4.7	5.7	2	2	10	20	41	25	0	†
				5.7	6.7	5	5	17	22	35	16	0	†
				6.7	7.7	1	5	18	25	26	25	0	†
				7.7	8.7	2	6	24	23	29	9	7	†
				8.7	9.7	3	5	14	24	26	21	7	†
				Mean		3	4	15	21	31	24	2	
c	3	56	41	9.7	10.7	4	16	35	15	23	7	0	†
				10.7	11.7	5	20	34	9	23	9	0	†
				11.7	12.7	2	17	30	11	17	23	0	†
				12.7	13.6	2	11	15	7	22	35	8	†
				Mean		3	16	29	11	21	18	2	
d	3	33	64	15.4	16.4	4	8	8	20	46	14	0	†
				16.4	17.6	3	7	8	16	45	21	0	†
				Mean		3	7	8	18	46	18	0	
b&c	3	45	52	Mean		3	8	20	17	28	22	2	
b to d	3	44	53	Mean		3	8	18	18	31	21	1	
a to d	5	48	47	Mean		5	13	19	16	27	19	1	

NT 03 NW 5 0217 3667 West Lindsaylands, Culter BLOCK B

Surface level + 200.2 m (+ 657 ft)
Water struck at + 198.5 m
203 mm percussion
October 1979

Overburden 1.7 m
Mineral 6.7 m
Bedrock 0.4 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
	Made ground	0.5	1.0
Alluvium	Clay, pebbly, mottled, orange-brown to grey-green, containing some angular fragments of lava	0.7	1.7
Glacial meltwater deposits	a Gravel Gravel: fine and coarse with rare cobbles, mainly well rounded, greywacke and siltstone with red and white sandstones, lava, felsite and chert. Stained orange-brown to 2.4 m Sand: coarse with medium and some fine, angular to subrounded, greywacke and siltstone fragments with quartz, medium brown Fines: silt, disseminated	2.0	3.7
	b Sandy gravel Gravel: fine with coarse, as above in composition Sand: coarse and medium with fine, subrounded, quartz and rock fragments, grey-brown Fines: silt, disseminated	4.7	8.4
Lower Devonian	Andesitic lava, dull reddish grey, containing numerous amygdales (up to 8 mm in diameter) of chlorite, white and green zeolites with agate and calcite, and veins of calcite	0.4+	8.8

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	1	26	73	1.7	2.7	1	1	8	16	42	32	0	†
				2.7	3.7	1	2	8	17	45	27	0	†
				Mean		1	2	8	16	43	30	0	
b	4	54	42	3.7	4.7	7	29	15	13	19	17	0	†
				4.7	5.7	3	9	21	35	27	5	0	†
				5.7	6.7	2	5	17	30	35	11	0	†
				6.7	7.7	2	5	22	21	30	20	0	†
				7.7	8.4	3	7	17	25	31	17	0	†
				Mean		4	11	18	25	28	14	0	
a&b	3	45	52	Mean		3	8	15	22	33	19	0	

NT 03 NW 6 0399 3951 Balwaistie, Biggar BLOCK D

Surface level + 245.0 m (+ 804 ft)
Water struck at + 228.1 m
203 mm percussion
September 1979

Overburden 0.2 m
Mineral 18.1 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	a 'Very clayey' sandy gravel Gravel: coarse and fine (up to 45 mm in diameter), mainly rounded to well rounded, the fine tending to be more angular than the coarse, greywacke, sandstone, lava, felsite and vein-quartz Sand: medium, coarse and fine, subrounded, quartz with rock fragments, medium brown Fines: silt, disseminated	1.0	1.2
	b Gravel, poorly sorted Gravel: fine and coarse with cobbles (up to 130 mm across), subrounded to well rounded, as above in composition Sand: coarse and medium with fine, angular to subrounded, rock fragments and quartz, medium to dark brown Fines: silt and clay, disseminated	17.1+	18.3
	Borehole terminated owing to obstruction composed of basaltic lava, possibly bedrock		

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	22	40	38	0.2	1.2	22	12	15	13	19	19	0	
b	9	38	53	1.2	2.4	8	11	17	17	31	16	0	
				2.4	3.4	8	8	11	13	26	23	11	
				3.4	4.4	8	10	19	14	27	22	0	
				4.4	5.4	9	3	11	27	25	25	0	
				5.4	6.4	9	7	10	12	22	33	7	
				6.4	7.4	8	7	10	20	20	19	16	
				7.4	8.4	10	6	12	12	34	21	5	
				8.4	9.4	9	5	12	22	28	24	0	
				9.4	10.4	8	5	15	14	25	24	9	
				10.4	11.4	12	5	12	28	29	14	0	
				11.4	12.4	10	3	9	21	29	12	16	
				12.4	13.4	15	3	6	22	34	20	0	
				13.4	14.4	12	5	6	18	31	28	0	
				14.4	15.4	10	4	6	14	22	29	15	
				15.4	16.4	9	9	12	13	24	33	0	
				16.4	18.3	2	10	28	21	18	11	10	†
				Mean		9	7	13	18	26	21	6	
a&b	10	38	52	Mean		10	7	13	18	26	21	5	

NT 03 NW 7 0329 3710 Biggar Park, Biggar BLOCK D

Surface level + 202.5 m (+ 664 ft)
Water struck at + 199.6 m
203 mm percussion
September 1979

Overburden 0.4 m
Mineral 5.5 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial meltwater deposits	a 'Very clayey' pebbly sand Gravel: fine with coarse, angular to rounded, greywacke, sandstone, felsite, lava and chert Sand: fine with some medium and a little coarse, subrounded, quartz with rock fragments, medium brown Fines: silt, disseminated and in seams, content increasing with depth	2.8	3.2
	b Sandy gravel Gravel: fine and coarse with cobbles, angular to well rounded, the fine tending to be more angular than the coarse, greywacke, lava, red and green sandstones, felsite, chert and vein-quartz Sand: coarse and medium with fine, angular to subangular, rock fragments and quartz, grey-brown Fines: silt, disseminated and in seams	2.7+	5.9

Borehole terminated owing to obstruction, possibly bedrock

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	22	74	4	0.4	1.4	17	61	12	4	4	2	0	
				1.4	2.4	21	63	12	2	1	1	0	
				2.4	3.2	28	54	8	5	4	1	0	†
				Mean		22	60	11	3	3	1	0	
b	3	52	45	3.2	4.2	1	5	15	21	29	19	10	†
				4.2	5.9	4	10	24	25	21	16	0	†
				Mean		3	8	21	23	24	17	4	
a&b	12	64	24	Mean		12	35	16	13	13	9	2	

NT 03 NW 8 | 0401 3825 | Loaningdale, Biggar | BLOCK D

Surface level + 228.0 m (+ 748 ft)
Water struck at + 210.8 m
203 and 152 mm percussion
December 1979

Overburden 0. 4 m
Mineral 16.6 m
Waste 0.5 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.4	0.4
Glacial meltwater deposits	a 'Very clayey' sand Gravel: fine, subangular, greywacke Sand: fine with a little medium and traces of coarse, subrounded, quartz, medium brown Fines: silt, disseminated and in seams	4.5	4.9
	b Sandy gravel Gravel: fine and coarse with rare cobbles (up to 75 mm in diameter), mainly subrounded to well rounded, the fine tending to be more angular than the coarse, greywacke, siltstone, lava, chert, felsite and vein-quartz Sand: medium, coarse and fine, composed of subrounded quartz clasts with angular to subangular rock fragments, medium grey-brown Fines: silt, disseminated and in seams	3.3	8.2
	c Gravel Gravel: fine and coarse with some cobbles, as above in composition Sand: coarse and medium with fine, composed of angular greywacke fragments and subrounded quartz clasts, brownish grey Fines: silt and clay, disseminated	8.8	17.0
Till	Clay, pebbly, stiff, reddish brown, containing fragments of andesitic lava	0.5+	17.5
	Borehole terminated owing to obstruction		

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	36	61	3	0.4	4.9	36	56	4	1	3	0	0
b	8	65	27	4.9	5.9	5	22	26	18	15	14	0
				5.9	6.9	9	19	28	17	15	12	0
				6.9	8.2	10	11	30	23	18	8	0
				Mean		8	17	28	20	16	11	0
c	6	41	53	8.2	9.2	2	4	13	17	29	32	3
				9.2	10.2	8	8	17	16	28	23	0
				10.2	11.2	7	10	12	18	29	19	5
				11.2	12.2	10	9	12	16	32	21	0
				12.2	13.2	7	5	13	17	33	25	0
				13.2	14.2	6	9	14	13	29	29	0
				14.2	16.0	4	5	15	27	35	14	0
				16.0	17.0	1	5	16	34	28	16	0
				Mean		6	7	14	20	31	21	1
b & c	6	47	47	Mean		6	9	18	20	27	19	1
a to c	14	51	35	Mean		14	22	14	15	20	14	1

NT 03 NW 9 0453 3683 Boghall, Biggar BLOCK B

Surface level + 199.7 m (+ 655 ft)
Water struck at + 198.6 m
203 and 152 mm percussion
November 1979

Overburden 0.3 m
Mineral 20.7 m
Bedrock 0.2 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	Gravel Gravel: fine and coarse with some cobbles, subangular to well rounded, the fine tending to be more angular than the coarse, greywacke, siltstone, lava, felsite, chert, white quartzitic sandstone, pink quartzite and vein-quartz Sand: coarse and medium with some fine, composed of angular to subangular rock fragments with subangular quartz clasts, medium grey-brown Fines: silt and clay disseminated with a laminated silt seam between 19.2 and 19.6 m	20.7	21.0
Lower Devonian	Sandstone, fine to medium grained, composed of angular to subangular rock fragments and quartz with feldspar and some calcite clasts. Grey-blue with some reddish tinges and containing calcite veins (up to 5 mm in thickness) which exhibit listric surfaces	0.2+	21.2

GRADING

Mean for deposit percentages			Depth below surface (m)		percentages							
Fines	Sand	Gravel			Fines	Sand			Gravel			
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64	
3	44	53	0.3	1.3	13	9	13	18	22	20	5	
			1.3	2.3	3	3	6	16	37	35	0	†
			2.3	3.3	2	2	11	23	35	27	0	†
			3.3	4.3	7	2	11	24	35	21	0	†
			4.3	5.3	1	3	14	24	40	18	0	†
			5.3	6.3	1	2	10	24	42	21	0	†
			6.3	7.3	1	1	7	14	37	40	0	†
			7.3	8.3	1	1	13	17	40	28	0	†
			8.3	9.3	2	1	15	18	41	21	2	†
			9.3	10.3	1	3	24	28	32	12	0	†
			10.3	11.3	1	2	19	29	30	10	9	†
			11.3	12.3	1	2	15	29	41	12	0	†
			12.3	13.3	2	6	15	18	32	27	0	†
			13.3	14.3	3	1	17	33	32	14	0	†
			14.3	15.3	3	2	17	34	26	18	0	†
			15.3	16.3	1	1	12	24	32	30	0	†
			16.3	17.3	3	13	35	9	20	13	7	†
			17.3	18.3	2	8	29	13	26	19	3	†
			18.3	19.2	3	12	26	32	21	6	0	†
			19.2	21.0	No grading data available							
			Mean		3	4	17	23	32	20	1	

NT 03 NW 10 | 0442 3643 | Hartree Mill, Biggar | BLOCK B

Surface level + 197.7 m (+ 649 ft)
Water struck at + 195.8 m
203 mm percussion
September 1979

Overburden 0.9 m
Mineral 4.0 m
Bedrock 0.4 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.4	0.4
Alluvium	Silt, mottled, grey, containing root remains	0.5	0.9
Till	'Clayey' gravel Gravel: fine with coarse and some cobbles (up to 140 mm in diameter), angular to well rounded but mainly subrounded to rounded, greywacke, lava, felsite, chert and vein-quartz Sand: coarse with medium and some fine, composed of angular rock fragments with subangular to subrounded quartz clasts, grey-brown Fines: clay and silt, disseminated with a seam between 2.8 and 2.9 m. Content decreasing with depth	4.0	4.9
Lower Devonian	Andesitic lava, brecciated, containing amygdales of calcite, chlorite and pale green zeolite with veins of calcite, dark maroon	0.4+	5.3

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	
10	38	52	0.9	1.9	21	10	17	19	25	8	0	
			1.9	2.9	10	3	13	23	38	13	0	†
			2.9	3.9	5	5	11	19	29	26	5	†
			3.9	4.9	4	4	7	18	40	27	0	†
			Mean		10	6	12	20	33	18	1	

NT 03 NW 11 | 0013 3633 | Annieston Cottages, Symington | BLOCK C

Surface level c + 208.0 m (c + 682 ft)
Water not struck
Pit
August 1979

Overburden 0.1 m
Mineral 1.9 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial meltwater deposits	Gravel Gravel: coarse and fine with numerous cobbles and some boulders (up to 300 mm in diameter), mainly subrounded to well rounded, greywacke, grey-green sandstone, lava, felsite, chert, quartzite and vein-quartz Sand: coarse and medium with some fine, subangular to subrounded, rock fragments and quartz, medium brown Fines: silt, disseminated	1.9+	2.0

(... continued)

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
2	31	67	0.1	1.0	1	4	13	14	23	35	10
			1.0	2.0	2	4	13	15	23	32	11
			Mean		2	4	13	14	23	34	10

NT 03 NW 12 0013 3597 Clachan Burn, Symington BLOCK C

Surface level c + 209.0 m (c + 686 ft)
Water not struck
Pit
August 1979

Overburden 0.2 m
Mineral 2.0 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	Gravel Gravel: coarse and fine with numerous cobbles, subangular to well rounded, greywacke, lava, grey-green sandstone, felsite and vein-quartz Sand: coarse with medium and some fine, angular to rounded, rock fragments and quartz, medium brown Fines: silt, disseminated	2.0+	2.2

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
2	36	62	0.2	1.2	2	3	12	21	27	35	0
			1.2	2.2	2	3	10	23	25	25	12
			Mean		2	3	11	22	26	30	6

NT 03 NW 13 0094 3577 Eastfield, Symington BLOCK C

Surface level c + 208.0 m (c + 682 ft)
Water not struck
Pit
August 1979

Overburden 0.3 m
Mineral 1.0 m
Waste 1.0 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial meltwater deposits	Gravel Gravel: fine and coarse with rare cobbles, subrounded to well rounded, greywacke and lava with felsite and vein-quartz Sand: coarse and medium with some fine, subangular to rounded, rock fragments and quartz, pale brown Fines: silt, disseminated	1.0	1.3
Till	Clay, silty, sandy, pebbly, firm, yellow-brown. Containing subangular to subrounded pebbles (generally less than 50 mm in diameter) and fine sand	1.0+	2.3

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	42	56	0.3	1.3	2	3	16	23	30	26	0

NT 03 NW 14 0173 3657 West Lindsaylands, Biggar BLOCK B

Surface level + 201.9 m (+ 662 ft)
Water not struck
Pit
November 1979

Overburden 0.2 m
Mineral 1.6 m
Bedrock 0.1 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	Gravel Gravel: fine and coarse with rare cobbles (up to 150 mm in diameter), subrounded to well rounded, the fine more angular than the coarse, lava, sandstone, greywacke, siltstone, chert, felsite and vein-quartz Sand: coarse with medium and some fine, subangular to rounded, quartz with greywacke and siltstone fragments, pale brown Fines: silt, disseminated	1.6	1.8
Lower Devonian	Sandstone, fine to medium grained, composed of subrounded to rounded quartz with feldspar clasts and lava fragments (up to 2 mm across) and containing maroon mudflakes, grey-green	0.1+	1.9

(... continued)

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	23	73	0.2	1.8	4	4	6	13	40	33	0

NT 03 NW 15 0111 3644 Netherton, Libberton BLOCK B

Surface level c + 202.0 m (c + 663 ft)
Water not struck
Pit
November 1979

Waste 1.6 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, gravelly, yellow-brown becoming pale brown and increasingly gravelly with depth, very stiff. Containing angular to well rounded clasts (up to 350 mm in diameter) composed of greywacke, sandstone, basalt, porphyry and felsite	1.3+	1.6

NT 03 NW 16 0172 3606 Wolfclyde, Culter BLOCK C

Surface level c + 204.0 m (c + 669 ft)
Water not struck
Pit
August 1979

Overburden 0.2 m
Mineral 1.6 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	Gravel Gravel: coarse and fine with cobbles and boulders (up to 300 mm diameter), subangular to well rounded, the fine tending to be more angular than the coarse, greywacke, grey-green sandstone and lava with felsite, chert and vein-quartz Sand: coarse and medium with fine, subangular to subrounded, rock fragments and quartz, pale brown Fines: clay and silt, disseminated	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
7	33	60	0.2	1.8	7	5	11	17	27	33	0

NT 03 NW 17 0274 3682 East Lindsaylands, Biggar BLOCK B

Surface level c + 202.0 m (c + 663 ft)
Water not struck
Pit
August 1979

Overburden 0.2 m
Mineral 2.0 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	Gravel Gravel: coarse and fine with cobbles and boulders (up to 400 mm diameter), mainly subrounded to well rounded, greywacke, lava, felsite and vein-quartz Sand: coarse and medium with fine, subangular to rounded, quartz and rock fragments, pale brown Fines: silt and clay, disseminated	2.0+	2.2

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
7	30	63	0.2	1.2	7	3	9	15	27	39	0
			1.2	2.2	7	4	13	17	22	37	0
			Mean		7	3	11	16	25	38	0

NT 03 NW 18 0396 3533 Thriepland, Broughton BLOCK D

Surface level c + 214.0 m (c + 702 ft)
Water not struck
Pit
October 1979

Waste 1.1 m
Bedrock 0.1 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, stony, angular greywacke fragments with a yellow to pale grey clay matrix	0.9	1.1
Ordovician	Siltstone, containing some fine sandstone partings, grey-green, weathered to orange-brown along fracture planes some of which exhibit listric surfaces	0.1+	1.2

NT 03 NW 19 0391 3526 Thriepland, Broughton BLOCK D

Surface level c + 210.0 m (c + 689 ft)
Water not struck
Pit
October 1979

Waste 0.8 m
Bedrock 0.5 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, mottled, pale grey to yellow, cohesive becoming stiff towards base	0.6	0.8
Ordovician	Shale, finely bedded with dark grey-blue and grey-green beds up to 2 mm in thickness. Weathered to orange-brown along fracture planes and containing thin veins of quartz	0.5+	1.3

NT 03 NW 20 0403 3916 Hillend, Biggar BLOCK D

Surface level c + 246.0 m (c + 807 ft)
Water not struck
Pit
August 1979

Waste 1.6 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, gravelly, sandy, stiff with angular to well rounded clasts of greywacke, lava, quartzite and vein-quartz	1.4+	1.6

NT 03 NE 1 0559 3711 Heavyside, Biggar BLOCK B

Surface level + 196.6 m (+ 645 ft)
Water struck at + 195.4 m
203 and 152 mm percussion
September 1979

Overburden 1.2 m
Mineral 6.3 m
Waste 9.4 m
Bedrock 0.3 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Peat	1.2	1.2
Fluvioglacial sand and gravel	a Sandy gravel, fining downwards Gravel: fine with some coarse (up to 35 mm in diameter), angular to well rounded, the fine tending to be more angular than the coarse, mainly composed of greywacke with lava, felsite, white quartzite and vein-quartz Sand: medium with coarse and some fine, angular to subrounded, greywacke fragments with quartz, medium grey Fines: silt, disseminated and in seams	3.8	5.0
	b Sand, fining downwards Sand: medium and fine, angular to subrounded, greywacke fragments and quartz, medium grey Fines: silt, disseminated and in seams	2.5	7.5
Glaciolacustrine deposits	Silt, laminated, medium grey with thin reddish brown seams and some very fine sand partings. Becoming medium brown below 10.4 m	9.4	16.9
Lower Devonian	Andesitic agglomerate, fragments (up to 40 mm across) in a reddish maroon matrix. Containing some thin calcite veins	0.3+	17.2

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	63	31	1.2	2.2	6	5	10	29	47	3	0	†
				2.2	4.0	9	8	32	19	22	10	0	†
				4.0	5.0	1	20	59	11	8	1	0	†
				Mean		6	10	33	20	25	6	0	
b	4	96	0	5.0	6.0	3	25	72	0	0	0	0	†
				6.0	7.5	4	48	48	0	0	0	0	†
				Mean		4	39	57	0	0	0	0	
a&b	5	77	18	Mean		5	22	43	12	15	3	0	

NT 03 NE 2 0699 3714 Spittal Burn, Skirling BLOCK B

Surface level + 195.5 m (+ 641 ft)
Water struck at + 194.0 m
203 mm percussion
September 1979

Overburden 2.6 m
Mineral 3.1 m
Waste 3.5 m
Mineral 1.2 m
Bedrock 0.4 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Clay, gravelly, sandy, yellow-brown becoming grey-brown below 1.5 m. Containing fine and coarse pebbles with mainly medium sand	2.4	2.6
Fluvioglacial sand and gravel	a Sandy gravel Gravel: fine with some coarse (generally not exceeding 30 mm in diameter), subangular to subrounded with some well rounded, greywacke and siltstone with grey-green sandstone, lava and felsite Sand: coarse and medium with fine composed of subangular rock fragments with quartz clasts, grey-brown Fines: silt, disseminated	3.1	5.7
Glaciolacustrine deposits	Silt, laminated, medium grey with some grey-brown, very fine sand partings	3.5	9.2
Fluvioglacial sand and gravel	b Sandy gravel Gravel: fine with coarse and rare cobbles (up to 140 mm in diameter), composed of angular to subangular siltstone fragments with subangular to well rounded greywacke, felsite, quartzite and vein-quartz clasts Sand: coarse and medium with fine, composed of angular siltstone and greywacke fragments with subrounded quartz clasts, grey-brown Fines: silt and clay, disseminated and in thin seams	1.2	10.4
Ordovician	Siltstone, blue-grey, containing some calcite crystals and quartz veins. Exhibiting a poor slaty cleavage, folded bedding and listric surfaces. Weathered and fractured with extensive orange-brown staining	0.4+	10.8

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	3	50	47	2.6	3.6	4	7	16	30	34	9	0	†
				3.6	4.6	2	8	28	17	32	13	0	†
				4.6	5.7	3	7	16	20	48	6	0	†
				Mean		3	8	20	22	38	9	0	†
b	9	47	44	9.2	10.4	9	6	19	22	29	15	0	†
a&b	5	48	47	Mean		5	7	19	22	36	11	0	

NT 03 NE 3 0744 3978 Geldies Knowe, Skirling BLOCK D

Surface level + 252.0 m (+ 827 ft)
Water not struck
203 mm percussion
September 1979

Overburden 0.3 m
Mineral 13.2 m
Bedrock 0.2 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial meltwater deposits	a 'Very clayey' sandy gravel Gravel: fine with coarse, angular to subrounded, greywacke with lava and some vein-quartz Sand: fine with medium and coarse, subrounded, quartz and rock fragments, medium brown Fines: silt and clay, disseminated	1.0	1.3
	b Sandy gravel, well sorted Gravel: fine with coarse, subrounded to well rounded, greywacke, grey-green sandstone, Haggis Rock, lava, quartzite and vein-quartz Sand: coarse and medium with some fine, composed of angular rock fragments and subrounded quartz clasts, medium to dark brown Fines: silt, disseminated and in seams	4.0	5.3
	c Gravel Gravel: coarse and fine with some cobbles (up to 80 mm in diameter), as above in composition Sand: coarse and medium with fine, as above in composition and colour Fines: silt and clay, disseminated	4.0	9.3
	d 'Clayey' sandy gravel, poorly sorted Gravel: fine with coarse, as above in composition Sand: coarse to fine, as above in composition and colour Fines: silt and clay, disseminated	4.2	13.5
Lower Devonian	Sandstone, medium grained with some coarse clasts and rare andesite pebbles (up to 15 mm in diameter). Clasts angular to subangular and composed of quartz with feldspar, andesite and some calcite. Containing calcite veins, dark reddish grey	0.2+	13.7

(... continued)

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	30	50	20	0.3	1.3	30	23	17	10	15	5	0
b	8	59	33	1.3	2.3	7	4	20	26	33	10	0
				2.3	3.3	8	8	29	30	21	4	0
				3.3	4.3	9	8	17	21	27	18	0
				4.3	5.3	8	9	34	29	16	4	0
				Mean		8	7	25	27	24	9	0
c	5	32	63	5.3	6.3	3	7	17	16	25	32	0
				6.3	7.3	6	4	10	14	27	39	0
				7.3	8.3	6	5	8	13	29	32	7
				8.3	9.3	8	7	14	13	29	29	0
				Mean		5	6	12	14	28	33	2
d	18	44	38	9.3	10.3	16	10	14	16	28	16	0
				10.3	11.3	19	10	15	22	27	7	0
				11.3	12.3	17	9	13	19	30	12	0
				12.3	13.5	18	14	20	16	24	8	0
				Mean		18	11	15	18	27	11	0
b&c	7	45	48	Mean		7	6	19	20	26	21	1
b to d	10	46	44	Mean		10	8	18	20	26	17	1
a to d	12	46	42	Mean		12	9	18	19	25	16	1

NT 03 NE 4	0980 3638	Parkgatestone, Broughton	BLOCK B

Surface level + 193.7 m (+ 635 ft)
Water struck at + 192.3 m
203 mm percussion
December 1979

Waste 4.2 m
Bedrock 0.3 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Alluvium	Silt, clayey, medium blue-grey with plant remains and decomposing fragments of wood. Containing rare pebbles of siltstone (up to 25 mm in diameter) below 1.2 m	1.0	1.4
	'Clayey' sandy gravel Gravel: coarse and fine (up to 45 mm in diameter), mainly composed of angular to subrounded blue-grey siltstone and greywacke with some subrounded to rounded felsite, andesite and vein-quartz Sand: mainly fine, angular to subangular, rock fragments with some quartz, blue-grey Fines: disseminated silt	0.8	2.2
	Silt, blue-grey, laminated with fine sand partings and thin peaty seams	1.2	3.4
Fluvioglacial sand and gravel	Gravel Gravel: coarse and fine with some cobbles (up to 90 mm in diameter), subangular to well rounded, greywacke, siltstone, lava, felsite, yellow-brown sandstone, chert and vein-quartz. Clasts stained orange-brown Sand: medium with coarse and fine, angular to subangular, quartz and rock fragments, orange-medium brown Fines: silt, disseminated and in medium grey and orange-brown seams	0.8	4.2
Ordovician	Siltstone, medium to dark grey with thin grey-green, fine sandstone partings and containing thin quartz veins. Stained orange-brown along joint and fracture planes	0.3+	4.5

NT 03 NE 5	0563 3659	Blackbyres, Broughton	BLOCK D

Surface level c + 204.0 m (c + 669 ft)
Water not struck
Pit
August 1979

Waste 1.8 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial meltwater deposits	Gravel Gravel: coarse and fine with cobbles, rounded to well rounded, greywacke, sandstone, lava, basalt, felsite and vein-quartz Sand: coarse to fine, subangular to subrounded, quartz and rock fragments, medium to dark brown Fines: silt and clay, disseminated	0.9	1.2
Till	Clay, gravelly, stiff, orange-brown. Containing coarse with fine pebbles and numerous cobbles and boulders (up to 300 mm diameter) towards base of pit	0.6+	1.8

NT 03 NE 6   0501 3626   Pyatknowe, Broughton   BLOCK D

Surface level c + 207.0 m (c + 679 ft)
Water not struck
Pit
October 1979

Overburden 0.2 m
Mineral 1.9 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	'Clayey' gravel, poorly sorted Gravel: fine and coarse with rare cobbles (up to 200 mm diameter), subangular to well rounded, the fine tending to be more angular than the coarse, greywacke with sandstone and chert Sand: coarse and medium with fine, angular to subrounded, quartz and rock fragments, pale brown Fines; clay, disseminated	1.9+	2.1

GRADING

Mean for deposit percentages			Depth below surface (m)		percentages						
Fines	Sand	Gravel			Fines	Sand			Gravel		
					$-1/16$	$+1/16-1/4$	$+1/4-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
11	33	56	0.2	1.2	11	7	11	15	28	28	0
			1.2	2.1	11	7	12	14	27	24	5
			Mean		11	7	11	15	28	26	2

NT 03 NE 7   0740 3953   Geldies Knowe, Skirling   BLOCK D

Surface level c + 249.0 m (c + 817 ft)
Water seepage at + 246.9 m
Pit
November 1979

Waste 2.2 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, gravelly, pale orange-brown, stiff with subrounded to well rounded clasts, mainly composed of greywacke and up to 60 mm diameter	1.3	1.6
	Clay, silty, pebbly, mottled, pale orange to pale grey, stiff	0.6+	2.2

NT 03 NE 8	0743 3935	Manse, Skirling	BLOCK D

Surface level c + 240.0 m (c + 787 ft)
Water not struck
Pit
August 1979

Waste 2.1 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, pebbly, sandy, silty, greyish orange-brown, containing fine with coarse, subrounded to well rounded pebbles of greywacke, basalt, sandstone and vein-quartz	1.9+	2.1

NT 03 NE 9	0810 3946	Whinnybrae, Skirling	BLOCK D

Surface level c + 250.0 m (c + 820 ft)
Water not struck
Pit
August, 1979

Overburden 0.2 m
Mineral 1.5 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	Gravel Gravel: coarse and fine with some cobbles, rounded to well rounded, greywacke, lava, red and yellow sandstones, felsite, porphyry, chert and vein-quartz Sand: coarse and medium with some fine, subangular to subrounded, quartz and rock fragments, medium brown Fines: silt, disseminated	1.5+	1.7

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
2	18	80	0.2	1.7	2	2	6	10	35	45	0

NT 03 SW 1 0048 3413 Mary Miller's Pool, Coulter BLOCK A

Surface level + 201.7 m (+ 662 ft)
Water struck at + 199.4 m
203 and 152 mm percussion
November 1979

Overburden 1.6 m
Mineral 4.6 m
Waste 19.8 m
Bedrock 0.3 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Alluvium	Silt, sandy, grey with orange-brown staining	1.2	1.6
	Gravel Gravel: coarse and fine with cobbles, mainly rounded to well rounded, greywacke and siltstone with lava, felsite, white quartzitic sandstone, chert and vein-quartz Sand: coarse and medium with some fine, composed of angular to subangular greywacke fragments with subrounded quartz clasts, medium grey Fines: silt, disseminated	4.6	6.2
Glaciolacustrine deposits	Silt, laminated, medium grey with medium brown seams which contain very fine, subrounded, quartzose sand	17.8	24.0
Fluvioglacial sand and gravel	Sandy gravel Gravel: coarse and fine with some cobbles, subangular to well rounded, the fine tending to be more angular than the coarse, greywacke, siltstone, lava, white quartzitic sandstone, red sandstone, chert, felsite, porphyry and vein-quartz Sand: medium with fine and coarse, angular to subrounded, quartz and rock fragments, medium grey Fines: silt, disseminated	2.0	26.0
Lower Devonian	Sandstone, fine to medium grained, composed of subangular quartz with feldspar clasts and andesite fragments (up to 5 mm in diameter), blue-grey with red tinges. Containing some thin calcite veins.	0.3+	26.3

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	
1	31	68	1.6	2.6	1	2	5	9	34	49	0	†
			2.6	3.6	1	0	7	22	24	33	13	†
			3.6	4.6	1	3	18	19	28	31	0	†
			4.6	5.6	1	2	13	17	40	27	0	†
			5.6	6.2	2	4	19	22	33	20	0	†
			Mean		1	2	12	17	32	33	3	

NT 03 SW 2 0175 3441 Coulter Maynes, Coulter BLOCK B

Surface level + 202.8 m (+ 665 ft)
Water struck at + 200.4 m
203 mm and 152 mm percussion
November 1979

Overburden 0.3 m
Mineral 11.3 m
Waste 1.1 m
Mineral 2.8 m
Bedrock 0.5 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	a 'Clayey' gravel, poorly sorted Gravel: fine and coarse with rare cobbles, angular to well rounded, greywacke, siltstone, chert, maroon mudstone and vein-quartz Sand: coarse and medium with fine, composed of angular rock fragments with subangular to subrounded quartz clasts, orangey grey-brown Fines: silt and clay, disseminated and in seams	2.0	2.3
Fluvioglacial sand and gravel	b Gravel Gravel: fine with coarse and some cobbles, subrounded to well rounded, siltstone, greywacke and lava with felsite, chert and vein-quartz Sand: coarse with medium and some fine, composed of angular rock fragments and subangular to subrounded quartz clasts, grey-brown Fines: silt and clay, disseminated	9.3	11.6
Glaciolacustrine deposits	Silt, medium brown, containing rare pebbles composed of greywacke and vein-quartz	1.1	12.7
Fluvioglacial sand and gravel	c Sandy gravel Gravel: fine with some coarse, as above in composition Sand: medium and coarse with fine, composed of subrounded quartz clasts and angular rock fragments, medium grey Fines: silt, disseminated	2.8	15.5
Lower Devonian	Sandstone, fine to medium grained, composed of subangular to subrounded quartz with feldspar, andesite and some calcite clasts, blue-grey and red. Containing some calcite veins	0.3	15.8
	Siltstone with mudstone and fine sandstone partings, calcareous, maroon with rare, ferrous green reduction spots. Containing calcite veins (up to 4 mm in thickness) which exhibit listric surfaces	0.2+	16.0

(... continued)

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	13	31	56	0.3	1.3	8	4	12	19	32	20	5	
				1.3	2.3	18	6	10	11	24	31	0	
				Mean		13	5	11	15	28	26	2	
b	3	33	64	2.3	3.3	4	3	5	14	39	35	0	†
				3.3	4.3	6	3	9	17	35	26	4	†
				4.3	5.5	3	2	9	17	36	33	0	†
				5.5	6.5	1	2	12	21	43	21	0	†
				6.5	7.5	2	2	10	23	42	21	0	†
				7.5	8.5	1	2	10	20	40	23	4	†
				8.5	9.5	1	1	8	24	40	26	0	†
				9.5	10.5	3	3	17	22	41	14	0	†
				10.5	11.6	3	4	16	23	38	16	0	†
				Mean		3	2	11	20	39	24	1	
c	7	68	25	12.7	13.7	6	13	29	23	19	10	0	†
				13.7	15.5	7	14	31	24	20	4	0	†
				Mean		7	14	30	24	19	6	0	
d	5	33	62	Mean		5	3	11	19	37	24	1	
a to c	5	40	55	Mean		5	5	15	20	34	20	1	

NT 03 SW 3 0288 3457 Culter House Avenue, Coulter BLOCK B

Surface level + 207.2 m (+ 680 ft)
Water struck at + 205.8 m
203 and 152 mm percussion
November 1979

Overburden 0.2 m
Mineral 11.2 m
Bedrock 0.1 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	Gravel Gravel: fine with coarse and rare cobbles, angular to well rounded, greywacke and siltstone with lava, yellow sandstone, chert, felsite and vein-quartz Sand: coarse and medium with some fine, composed of angular to subangular siltstone and greywacke fragments with subangular to subrounded quartz clasts, grey-brown Fines: silt and clay, disseminated	11.2	11.4
Lower Devonian	Sandstone, fine to medium grained, composed of angular to subangular rock fragments and quartz with some feldspar clasts, blue-grey with red tinges. Containing some thin calcite veins	0.1+	11.5

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	
3	40	57	0.2	1.2	9	6	10	14	30	31	0	
			1.2	2.2	5	5	9	16	33	32	0	†
			2.2	3.2	2	2	6	17	37	36	0	†
			3.2	4.2	2	1	9	18	37	30	3	†
			4.2	5.2	2	3	15	20	32	28	0	†
			5.2	6.2	1	5	32	20	32	10	0	†
			6.2	7.2	4	10	30	32	19	5	0	†
			7.2	8.2	1	2	15	38	40	4	0	†
			8.2	9.2	1	3	21	22	36	17	0	†
			9.2	10.2	2	3	7	17	43	25	3	†
			10.2	11.4	3	5	11	19	41	21	0	†
			Mean		3	4	15	21	34	22	1	

NT 03 SW 4 0025 3454 Townfoot, Symington BLOCK C

Surface level c + 209.0 m (c + 686 ft)
Water not struck
Pit
August 1979

Waste 1.6 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial meltwater deposits	Gravel, poorly sorted Gravel: coarse and fine with numerous cobbles and boulders (up to 400 mm diameter), angular to well rounded, greywacke, lava, sandstone, felsite, chert, quartzite and vein-quartz Sand: coarse and medium with some fine, subangular to well rounded, rock fragments and quartz, orange-brown Fines: silt and clay	0.6	0.9
Till	Clay, gravelly, mottled, medium grey to brown, very stiff with angular to well rounded clasts of greywacke, lava, felsite, sandstone, chert and vein-quartz	0.7+	1.6

NT 03 SW 5 0101 3454 Coulterhaugh, Culter BLOCK B

Surface level c + 205.0 m (c + 673 ft)
Water not struck
Pit
October 1979

Waste 0.6 m
Bedrock 0.5 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial meltwater deposits	Sand Sand: fine with medium and coarse, angular to subrounded, quartz with weathered basalt fragments Fines: disseminated silt	0.4	0.6
Lower Devonian	Basaltic lava, very weathered and fragmented, medium grey with orange-brown staining	0.5+	1.1

NT 03 SW 6 0353 3487 Legholmshiels, Culter BLOCK D

Surface level c + 222.0 m (c + 728 ft)
Water not struck
Pit
October 1979

Waste 2.0 m +

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, gravelly, sandy, pale brown, stiff. Containing angular sand composed of rock fragments and subangular pebbles of weathered greywacke and dark grey-black shale	1.8+	2.0
	Base of pit thought to be close to bedrock		

APPENDIX G

LIST OF WORKINGS

In December 1980 no sand and gravel was being worked in the area. All areas which are known to have been worked are shown on the resource map accompanying the report and listed below.

Location	*Grid reference*	*Deposit worked*
Thankerton	982 369	Glacial sand and gravel
Broadfield	989 333	Valley-floor deposits
Sandy's Ford	008 347	Valley-floor deposits
Rowhead	038 381	Glacial sand and gravel
Mid Toftcombs	059 392	Glacial sand and gravel

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INSTITUTE OF GEOLOGICAL SCIENCES

INDUSTRIAL MINERALS ASSESSMENT UNIT

THE SAND AND GRAVEL RESOURCES OF THE COUNTRY AROUND BIGGAR, STRATHCLYDE REGION

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

SHEETS NS 93, NT 03 & pts NS 92, NT 02

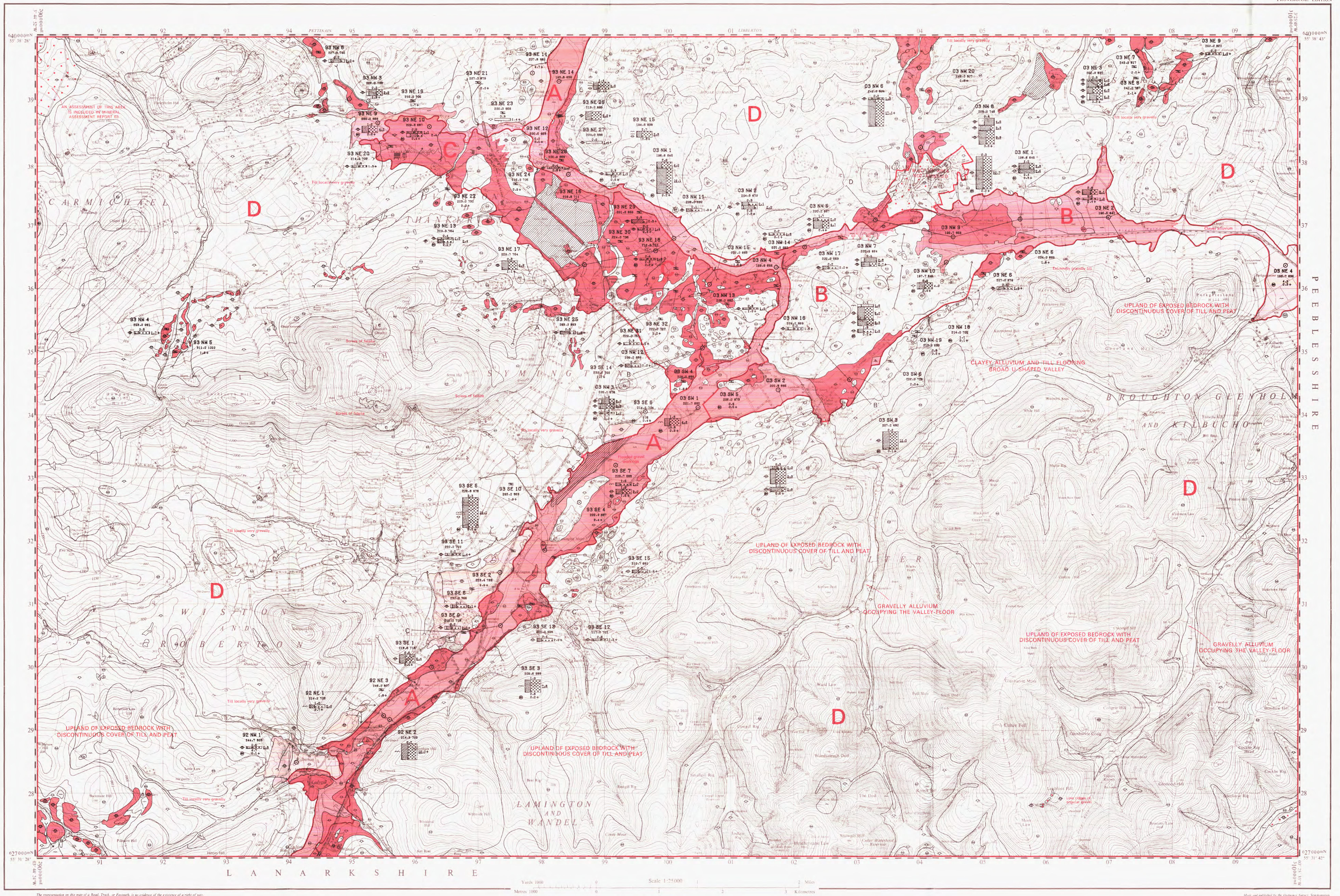
ORDNANCE SURVEY

PROVISIONAL EDITION

THE SAND AND GRAVEL RESOURCES OF
THE COUNTRY AROUND BIGGAR, STRATHCLYDE REGION

95

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



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

Yards 1000 0 Scale 1:25 000 1 Miles

Metres 1000 0 1 2 3 Kilometres

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

Made and published by the Ordnance Survey, Southampton.

Original geological survey on the six-inch scale by Sir A. Geikie, J. Geikie and B.N. Peach between 1868 and 1872.
Revised by H. H. Read and J. Phemister between 1924 and 1925.
Partial re-survey by J. W. Merritt, A. M. Bell and I. B. Cameron between 1976 and 1979. G. I. Lumsden, District Geologist.

Sand and gravel survey by A. J. Shaw and J. W. Merritt in 1979 under the supervision of E. F. P. Nickless.
R. G. Thurrell, Head, Industrial Minerals Assesment Unit.

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

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

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

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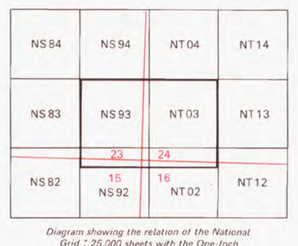


EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Made Ground -waste and/or natural earth materials deposited on the original ground surface MG-3

Made Ground -waste and/or natural earth materials filling former opencast excavations, except sand and gravel workings MG-7

DRIFT

Recent and Pleistocene

Peat P-1

Alluvium (undifferentiated) -silt, clay, sand and gravel A-51

Alluvial cone AC-1

Scree SC-1

Fluvioglacial sand and gravel -moderately well sorted sand and gravel underlying well-defined terraces FL-16

Glacial meltwater deposits (undifferentiated) - including moderately well sorted sand and gravel underlying terraces, poorly sorted sand and gravel forming hummocky terrain and fine grained glaciolacustrine deposits GM-2

Glaciolacustrine deposits -fine sand, silt and clay, often laminated G-3

Till -stony clay of variable stiffness, locally silty or sandy TL-1

SOLID

Bedrock, at or near surface -The north-easterly aligned Southern Upland Fault divides the area diagonally into regions of sharply contrasting geology (see Figure 2 in the Report). South of the fault bedrock comprises tightly folded and cleaved greywacke, siltstone, shale, conglomerate, chert and spilitic lava of Ordovician or Silurian age. North of the fault sandstone, conglomerate and volcanic rocks of the Old Red Sandstone predominate: there are also numerous intrusions of felsitic material, the most notable being a thick sill forming the Tinto Hills. A number of quartz-dolerite dykes cross the area.

Worked ground (sand and gravel) -boundaries as at 1980. Colour beneath ornament indicates that the mineral has not been exhausted. In the survey area, sand and gravel has been worked both above and below the water table WG-3

BOUNDARY LINES

Geological boundary

Back-feature of fluvioglacial terrace, downward slope in direction of arrowhead.

Form line indicating the disposition of a major mound or ridge.

Glacial drainage channel, arrow shows direction of water flow.

Inferred boundary between categories of deposit.

Resource Block boundary.

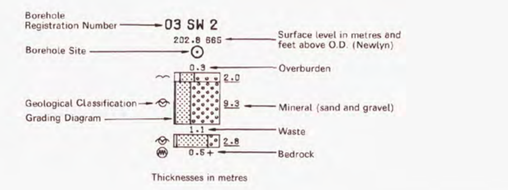
BOREHOLE AND OTHER DATA

SITE LOCATIONS

Industrial Minerals Assessment Unit (I.M.A.U.) borehole.

Shallow pit.

I.M.A.U. BOREHOLES



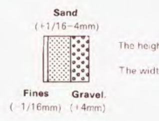
Note:
(i) Figures underlined denote thicknesses used in the assessment of resources.
(ii) The + sign indicates that the base of the deposit was not reached.
(iii) The Geological Classification is given only for mineral and bedrock.
(iv) When grading data are not sufficiently detailed or are absent the grading diagram is shown without ornament.

Borehole Registration Number

Each I.M.A.U. borehole and pit is identified by a registration number, e.g. **03 SW 2.** The first numbers and letters refer to the quarter sheet and the final figures to the I.G.S. serial number for that quarter. The unique designation for borehole **03 SW 2** is **NT 03 SW 2.**

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.**

SHALLOW PITS

The location of shallow pits providing ancillary assessment data is shown by a distinctive symbol, thus. Otherwise information is shown in the same way as for boreholes.

CATEGORIES OF DEPOSITS

Exposed, potentially workable sand and gravel (mineral). CAT-E7

Continuous or almost continuous spreads of potentially workable sand and gravel beneath overburden. CAT-C4

Discontinuous spreads of potentially workable sand and gravel exposed or beneath overburden. CAT-D2

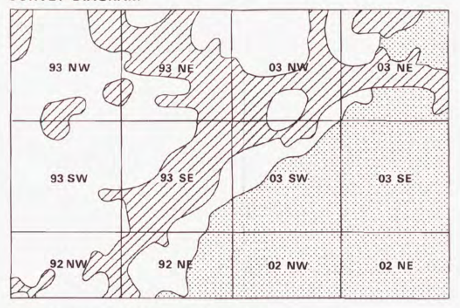
Sand and gravel not assessed. CAT-N1

Sand and gravel absent or not potentially workable. CAT-A4

RESOURCE BLOCKS

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

SURVEY DIAGRAM



The area shown hatched was resurveyed at the six-inch scale by J. W. Merritt, A. M. Bell and I. B. Cameron in 1976-79. The remainder of the sheet is compiled from older geological surveys: the unshaded area was mapped by H. H. Read and J. Phemister in 1924-25, the stippled area by Sir A. Geikie, J. Geikie and B.N. Peach between 1868 and 1872.

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.

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

GENERALISED HORIZONTAL SECTIONS SHOWING RELATIONSHIPS OF DRIFT DEPOSITS

HORIZONTAL SCALE 1:25 000 VERTICAL EXAGGERATION x 10·5

KEY TO SECTIONS

Potentially workable sand and gravel, exposed or beneath overburden.

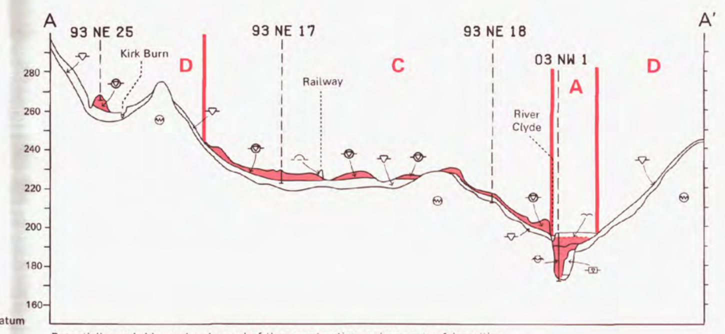
Bedrock and waste, including overburden, are uncoloured.

Geological boundary.

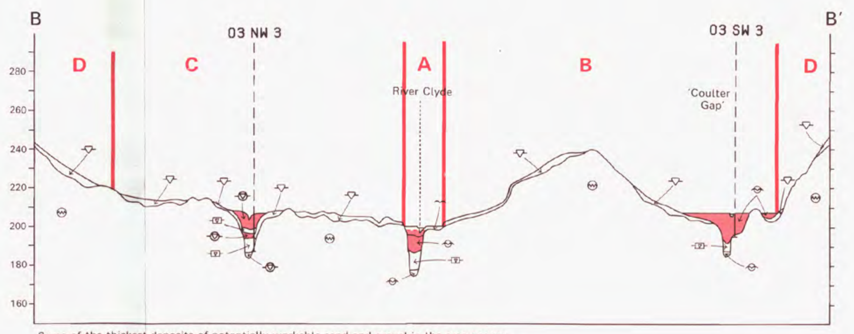
Inferred boundary limiting the extent of potentially workable material.

Otherwise symbols and abbreviations as map legend.

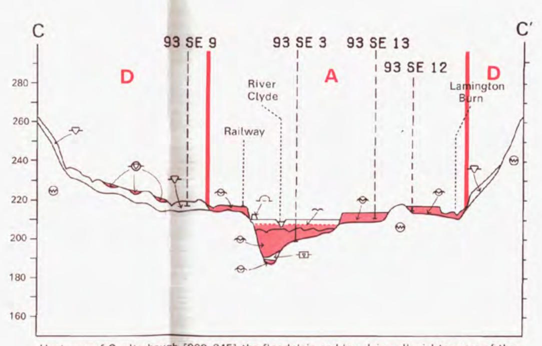
Heights in metres above Ordnance Datum



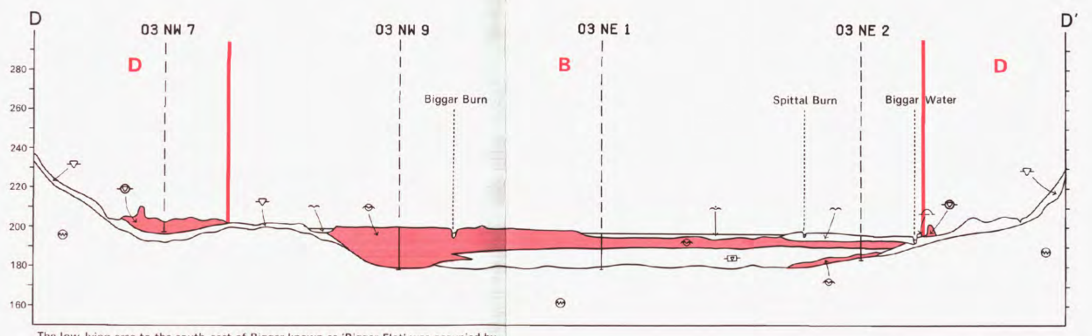
Potentially workable sand and gravel of three contrasting environments of deposition are depicted. Pit **93 NE 25** is situated on a sinuous gravel ridge (esker) which forms part of the 'Thankerton Kames'. Block C includes a spread of glacial meltwater gravels draped over hummocky till and bedrock as a result of the decay of the ice which they formerly overlay. Beneath the floodplain of the River Clyde (block A) fine-grained alluvial sediments form overburden to sand and gravel which was probably largely deposited by glacial meltwaters. These possibly channelled into glaciolacustrine silts and clays which previously occupied a steep-sided, sub-glacially eroded channel.



Some of the thickest deposits of potentially workable sand and gravel in the area occupy relatively narrow channels which were probably eroded by meltwaters flowing beneath a decaying ice-sheet. The channel proved by borehole **03 NW 3** is filled with sand and gravel, glaciolacustrine deposits and till which makes its lateral extent difficult to identify. A precursor of the River Clyde which probably flowed north-eastwards through the Coulter Gap in late-Glacial time deposited the sand and gravel proved by borehole **03 SW 3**, though the buried channel shown hereabout is speculative.



Upstream of Coulterhaugh [009 345] the floodplain and low-lying alluvial terraces of the River Clyde are bordered by discontinuous fluvioglacial terraces which stand up to 8m above the present level of the river. At Lamington terraces underlain by potentially workable sand and gravel occur on both sides of the valley and are developed at two levels. As is the case downstream, non-mineral alluvium overlies sand and gravel which occupy a buried channel. In this stretch of the valley glaciolacustrine deposits have not been recorded but nevertheless may be locally present. West of the valley of the River Clyde patchy sand and gravel overlies a very gravelly ablation till which in places may be potentially workable.



The low-lying area to the south-east of Biggar known as 'Biggar Flat' was occupied by a lake during the final stages of deglaciation and possibly for a short time afterwards. Deltas of sand and gravel which typically coarsen upwards were constructed by meltwaters entering the lake while fine-grained glaciolacustrine sediments accumulated in quiet water. Sand and gravel is thickest in the west where a precursor of the River Clyde possibly entered the lake from the Coulter Gap. Hummocky glacial meltwater gravels which bordered the lake and which were probably modified in part by wave-action occur around Biggar Flat, the most extensive deposit being situated in the vicinity of borehole **03 NW 7**.