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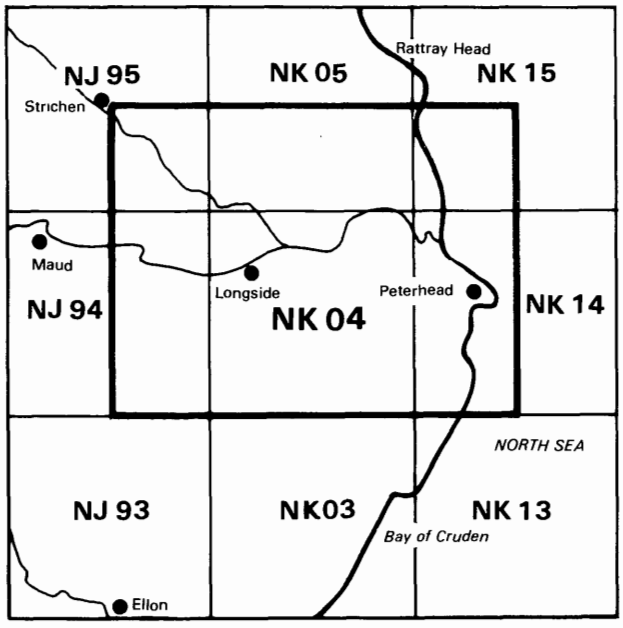

The sand and gravel resources of the country west of Peterhead, Grampian Region

Description of 1:25 000 sheet NK 04 and parts of NJ 94 and 95, NK 05, 14 and 15

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

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

PREFACE

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

Sand and gravel, considered together as naturally occurring aggregate, was selected as the bulk mineral demanding the most urgent attention, initially in the south-east of England, where about half the national output is won and very few resources of alternative aggregates are available. Following a short feasibility project, initiated in 1966 by the Ministry of Land and Natural Resources, the Industrial Minerals Assessment Unit (formerly the Mineral Assessment Unit) began systematic surveys in 1968, 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 257.7 km^2 of country west of Peterhead, Grampian Region, shown on the accompanying resource map. The survey was conducted by A. A. McMillan under the supervision of A. M. Aitken and the work was controlled from the sub-unit in Edinburgh (E. F. P. Nickless, Officer-in-Charge). The geological lines, now presented at the 1:25 000 scale are based on the one-inch geological survey of Sheet 87, published in 1885 and a re-appraisal of the drift by D. L. Ross, resulting from field survey during 1977.

The section of the report on the geology of the area was prepared by D. L. Ross and A. A. McMillan. J. W. Gardner, CBE, FRICS and C. L. Reeves, ISO, ARICS (Land Agents) have been responsible for negotiating access to land for drilling. The ready cooperation of land owners, tenants and gravel companies and the assistance of officials of Banff and Buchan District is gratefully acknowledged.

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A. A. McMillan and A. M. Aitken

SUMMARY

The geological maps of the Institute of Geological Sciences, pre-existing borehole information, sixty-seven boreholes drilled for the Industrial Minerals Assessment Unit, together with data from eleven sand and gravel pits and nineteen shallow trenches, form the basis of the assessment of sand and gravel resources in the Peterhead area, Grampian Region.

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

The 1:25000 map is divided into four resource blocks. Statistical assessments are offered for valley-floor deposits of Block A and valley-side deposits of blocks B and C which contain 7.6, 6.1 and 5.0 km^2 respectively of potentially workable sand and gravel. Inferred assessments are offered for a total of 7.5 km^2 of scattered sand and gravel deposits in blocks B and C and coastal deposits in Block D. For all blocks, the geology of the deposits is described and the mineral-bearing area, the mean thickness of overburden and mineral and the mean grading of the various types of deposit are stated. Detailed borehole, section and shallow-trench data are given. The geology, the outlines of the resource blocks and the position of sample points considered in the assessment are shown on the accompanying 1:25000 scale resource map.

Note

National Grid references are given in square brackets. In this publication all lie within 100-km squares NJ and NK.

Bibliographic reference

McMillan, A. A. and Aitken, A. M. 1981 The sand and gravel resources of the country west of Peterhead, Grampian Region. Description of 1:25000 Sheet NK 04 and parts of NJ 94, 95 and NK 05, 14 and 15. *Miner. Assess. Rep. Inst. Geol. Sci.*, No. 58.

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INTRODUCTION

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

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

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

a The deposit should average at least 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 should lie within 25 m of the surface, this being taken as the likely maximum working depth under most circumstances. It follows from the second criterion that boreholes are drilled no deeper than 18 m if no sand and gravel has been proved.

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

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

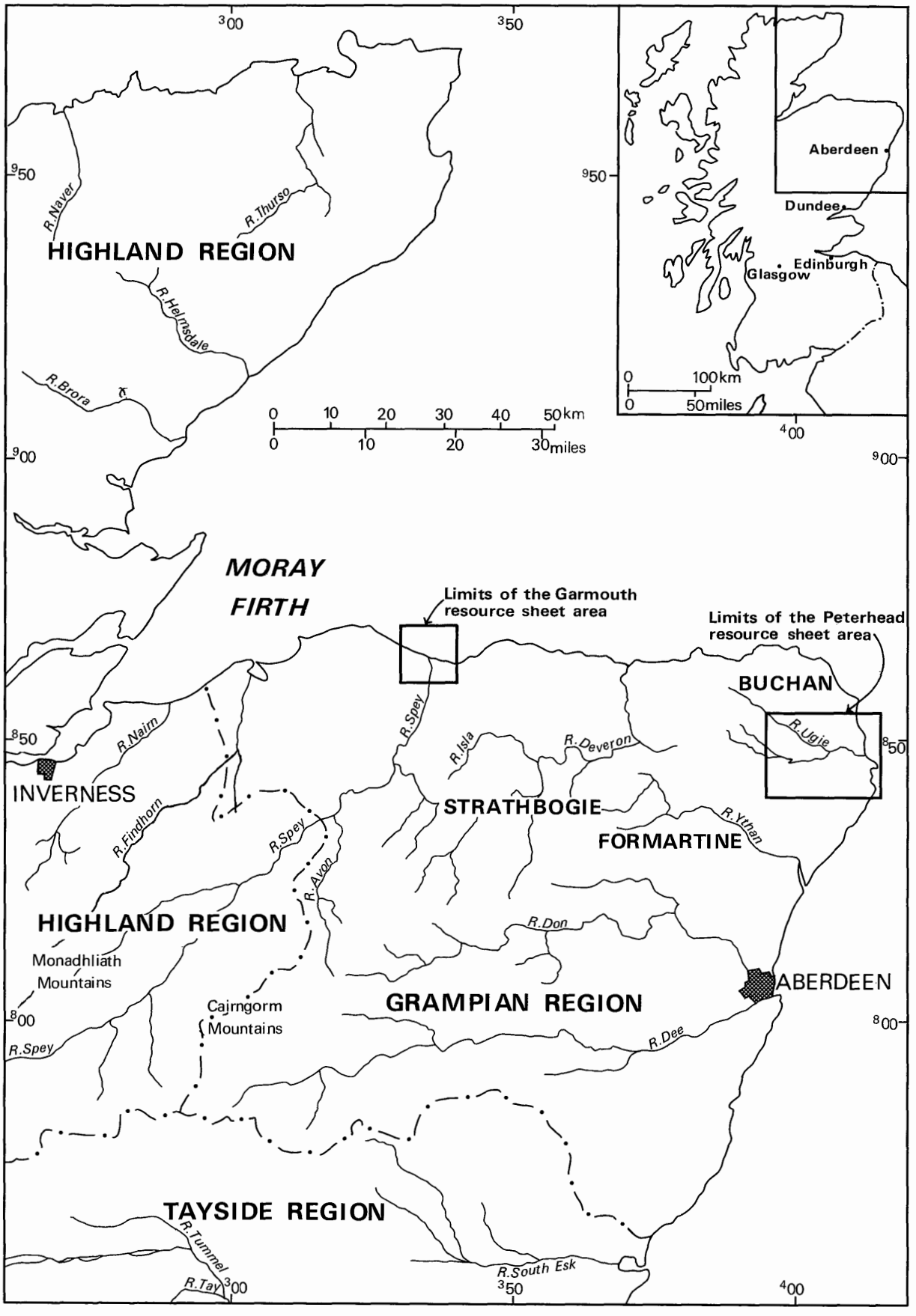

Figure 1 Sketch-map showing the location of the resource sheet

grade material, are placed at $\frac{1}{16}$ mm and 4 mm respectively (see Appendix C).

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

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

DESCRIPTION OF THE RESOURCE SHEET

GENERAL

The sand and gravel resources of north-east Scotland were described by Anderson (1943), and more recently Peacock and others (1977) have summarised published and unpublished data for the Grampian Region as a whole. An assessment of resources in the Garmouth area is published in Mineral Assessment Report 42 (Aitken, Merritt and Shaw, 1979).

This report presents a detailed account of indicated resources in the vicinity of Peterhead.

The area assessed forms part of the district known as Buchan (Figure 1) and covers 257.7 km² (about 99.5 miles²) of country west of Peterhead, of which 26.2 km² (or 10 per cent) are mineral-bearing. By road, Peterhead is situated 55 km north of Aberdeen and 29 km south of Fraserburgh. Inverness lies about 160 km to the west.

Small workings for sand and gravel to supply local markets have operated in the area for many years. Recent major construction work including, for example, the building of the North Sea Gas Terminal at St Fergus has increased demand for aggregate in the area and over north-east Scotland in general.

TOPOGRAPHY

In all likelihood the topography of the Peterhead area results from the dissection of a series of erosion surfaces developed over much of north-east Scotland in pre-Quaternary times, probably during the Tertiary period, as a consequence of intermittent uplift. The lowest of these surfaces, known locally as the Buchan Plateau, now lying between about 100 and 150 m above Ordnance Datum, forms the high ground of the Peterhead area. Other pre-Quaternary erosional features have been largely modified and obliterated by repeated glaciation, resulting in a relatively featureless terrain mainly covered by glacial drift.

The drainage pattern of the area is dominated by the easterly flowing North and South Ugie waters which converge east of Longside [037 474] and reach the sea north of Peterhead. The major valleys contain terraces of fluvioglacial sand and gravel and alluvium, the latter often forming flat poorly drained floodplains. Either side of the valleys the gently undulating land rises steadily westwards from the coast, culminating in the high ground of Skelmuir Hill [986 414] at 149 m and Hill of Dens [953 456] at 168 m above Ordnance Datum. Mormond Hill [963 572], which lies to the north of the area covered by the resource sheet, is visible over a wide area; at 234 m, it is the highest hill in Buchan. Particularly, but not exclusively, in the west, the bedrock surface tends to mirror the present topography and rock crops out on many summits, for example the aforementioned hills, White Cow Wood [953 517] and Hill of Longhaven [080 420].

On the coast, north of Peterhead dune ridges of blown sand locally at least 15 m above Ordnance Datum (Ritchie and others, 1978) form an extensive belt. To the south, in contrast, a spectacular cliff coastline has developed in the Peterhead granite.

GEOLOGY

The resource sheet area, which is included in the hand-coloured one-inch geological Peterhead (87) Sheet, published in 1885, was originally geologically surveyed at a scale of six inches to one mile by J. S. Grant Wilson. The explanation of Sheet 87, edited by Grant Wilson, was published in 1886. In connexion with the present survey the drift geology was re-appraised by D. L. Ross during 1977.

The geological sequence is summarised in Table 1, where deposits are listed as far as possible in order of increasing age.

Table 1 Geological classification of deposits

DRIFT	
Recent and Pleistocene	Peat
	Alluvium (undifferentiated)
	Blown sand
	Present-day beach deposits
	Post-Glacial beach deposits
	Lake alluvium
	Glaciolacustrine deposits
	Fluvioglacial sand and gravel (usually flat or terraced at surface)
	Glacial sand and gravel (usually moundy at surface)
	Till
SOLID	
?Pliocene	Buchan Ridge gravels
Permo-Carboniferous	Igneous (intrusive) rocks
Caledonian (mainly pre-Lower Old Red Sandstone)	'Newer Igneous Intrusions': late-tectonic to post-tectonic basic, granitic or complex plutons and hypabyssal rocks
Dalradian (?Late Precambrian to Cambrian)	Metamorphic rocks of the Grampian Caledonides

SOLID

Except for the ?Pliocene deposits, bedrock is not differentiated on the resource map accompanying this report. The distribution and classification of older solid rocks, which range in age from ? late Precambrian to Permo-Carboniferous are summarised in Figure 2. Because of the general lack of exposure inland, the solid geological boundaries are frequently highly generalised.

The oldest exposed rocks belong to the Dalradian Supergroup and comprise mainly metasediments including gneiss, mica-schist, psammite and quartzite, together with slate and metagreywacke. They are disposed about a broad structure known as the Buchan anticline, the axis of which is aligned to the north-east. Dips in general are shallow, between 20° and 30°, although steepening occurs locally, particularly north-west of the anticlinal axis.

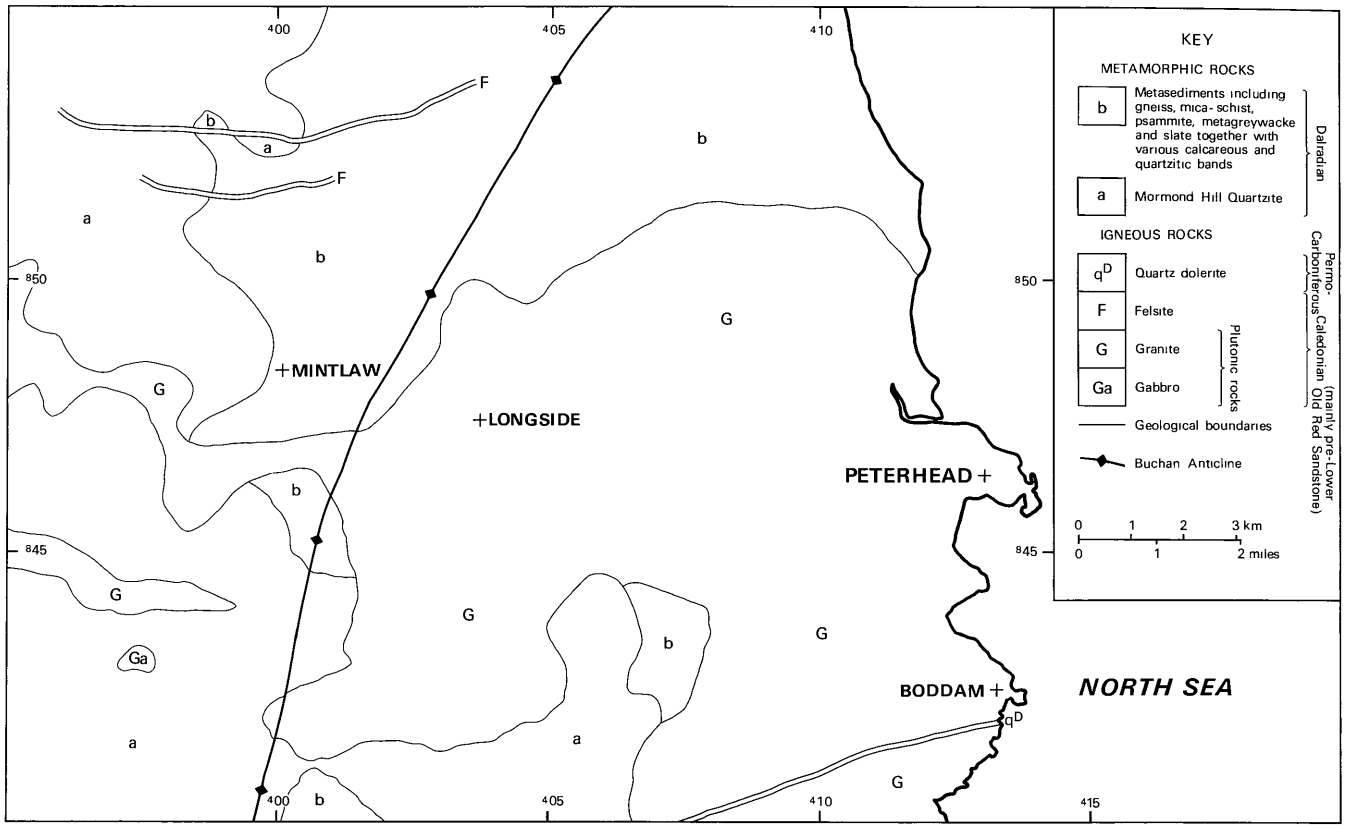

Figure 2 Sketch-map showing the solid geology of the Peterhead area (excluding the Buchan Ridge gravels)

The gneissose, schistose and psammitic metasediments, which are often highly weathered, are banded, fairly massive, quartz-rich rocks. Locally they become strongly micaceous and foliated and, near their contact with the overlying Mormond Hill Quartzite (Read, 1952) contain some pebbly quartz beds and more rarely thin calcareous bands. The Mormond Hill Quartzite, which forms the higher ground in the west and south of the assessment area is a gritty, bedded, often highly jointed rock, which varies greatly in lithology (Read and Farquhar, 1956). The bedding in general dips west-north-west at up to 65°.

The metasediments are cut by several igneous intrusions, the largest of which, the Peterhead granite, emplaced late in the Caledonian Orogeny, occupies an extensive area west and south of Peterhead. In general, the granite, understood to belong to a post-tectonic suite of pre-Lower Old Red Sandstone age (Pankhurst and Pidgeon, 1973), is a coarsely crystalline red rock, although towards the north and west finer grained grey varieties are found. Decomposition, possibly due to deep Tertiary subaerial weathering, locally extends to depths of tens of metres (Peacock and Michie, 1975) as, for example, on the Hill of Longhaven.

Small intrusions cut both the granite and metasediments. The largest are two felsite dykes of probable Caledonian age, which trend east–west across the north-west of the area, and a quartz-dolerite dyke, probably of Permo-Carboniferous age, which can be traced over a considerable distance near Boddam [133 425].

The Buchan Ridge gravels, possibly Tertiary in age, occupy much of the high ground of the Moss of Cruden [040 410] and Hill of Aldie [056 416], which form part of the Buchan Ridge of Flett and Read (1921). The deposit, which has been considered in the assessment of resources, is thought to have been derived from Cretaceous strata and to be of marine origin (Flett and Read, 1921). It is composed of clay-bound gravel interbedded with fine-grained to medium-grained sand. The fines fraction is composed dominantly of kaolinitic clay and silt (McMillan and Merritt, 1980): the gravel fraction comprises fine to coarse, rounded to well rounded flint and quartzite. Many of the flints, which bear chatter marks similar to beach cobbles, contain fossils of Cretaceous age (Jukes Browne and Milne, 1897). The deposit predates the last occasion when ice overrode Buchan, being locally overlain by a thin layer of till, as shown for example by borehole 04 SE 6*sited on the Hill of Aldie. Clasts from the gravel are incorporated in till and concentrated in the topsoil over a wide area especially around the Moss of Cruden.

DRIFT

Most of the Peterhead area is mantled by glacial drift of Pleistocene age, comprising till, fluvioglacial and glacial sand and gravel and glaciolacustrine deposits, which are generally considered to date from the time of the last (Devensian) glaciation (Clapperton and Sugden, 1977). Recent drift deposits include basin peat, fluviatile alluvium and coastal deposits of lake alluvium, post-Glacial beach deposits and blown sand. Drift cover varies greatly but in general appears to increase in thickness towards the north and east where the inferred form of the bedrock surface is highly irregular. In the west the bedrock surface is thought to mirror the present topography.

*Boreholes fall in 100-km square NK, except where marked NJ.

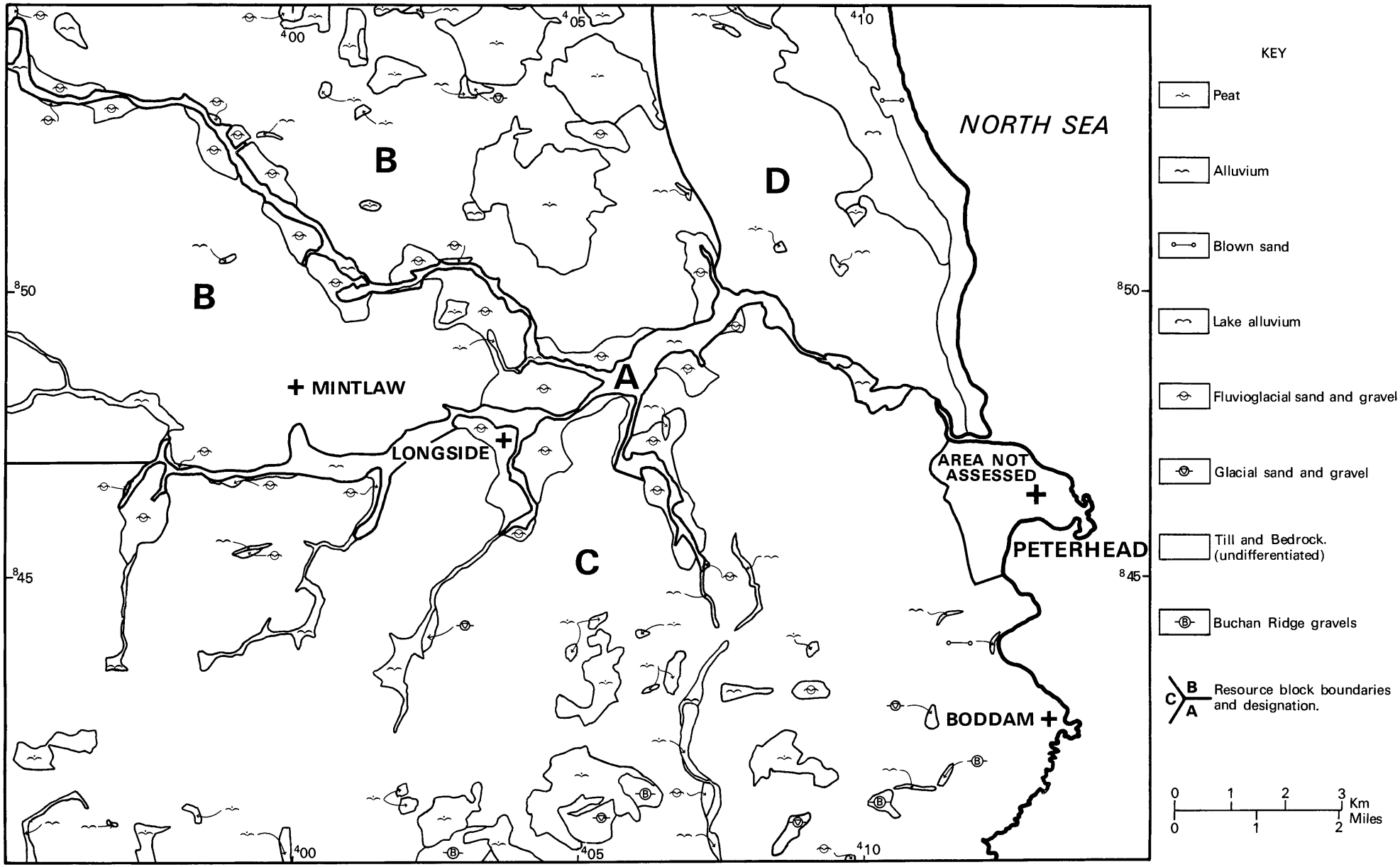

Figure 3 Sketch-map showing the drift geology (including the **Buchan Ridge gravels**) of the Peterhead area and the position of resource block boundaries

Till: Till of very variable thickness, composition and colour is the most widespread glacial deposit. Examination of temporary exposures, including recent pipeline trenches and samples recovered by drilling suggests that three distinct tills, similar to those described by Murdoch (1975) for the area around Aberdeen, may be recognised on the basis of colour. The first is a basal, olive-green to grey clay-rich till, probably of local origin and limited extent. Constituent clasts include schist, psammite, quartzite, granite and gabbro. The second and characteristic till of the central and eastern parts of Buchan is a reddish brown or greyish brown, stony clay, locally sandy, containing angular to subangular clasts, similar in composition to those found in the basal till. The deposit, which rarely includes thin bands of sand and gravel, is shown by boreholes to rest on the basal till or directly on bedrock.

Near the coast the reddish brown or greyish brown till, thought to have been deposited by ice moving from the east, generally passes below a third bright reddish brown, clayey till. The latter seldom extends more than 6 km inland and is considered on the basis of its clast content to have been derived offshore from the south or south-east. Clasts include not only metamorphic and igneous rocks of local origin but also sedimentary rocks derived from beds of Devonian, Permo-Triassic, Jurassic and Cretaceous age (Clapperton and Sugden, 1977). The relationship between the two last-mentioned tills is complex, one often interdigitating with the other.

Jamieson (1906) recorded another till near Annachie [105 529], which he described as a dark grey to black, shelly clay. This deposit, which has possibly also been derived offshore, underlies lacustrine clays east of the St Fergus Gas Terminal [098 537] (Peacock, *personal communication*) and near South Blackwater [099 532] (borehole 15 SW 1).

Clapperton and Sugden (1977) suggest that the three most extensive tills in Buchan are contemporaneous and that their deposition can be referred to one glaciation, during which fluctuations in flow and direction of three principle ice streams moving from the Grampian Highlands, the Moray Firth and northwards along the North Sea coast caused the observed interrelationships of the deposits.

Fluvioglacial sand and gravel: Fluvioglacial sand and gravel, which constitutes the second most widespread drift deposit around Peterhead is confined largely to the major river valleys of the North and South Ugie Waters and River Ugie. The deposits are thought to have been laid down in pre-existing valleys by braided streams fed by the meltwaters of a westward retreating ice sheet. The pattern of deposition was influenced by subaerial meltwater channels, as at New Leeds [996 545], where the inferred drainage is from ice lying to the north and west. Along the valley sides the deposits at surface locally grade laterally and vertically into fine glaciolacustrine sediments and display fairly well defined, often flat-topped terraces, which have been considerably dissected as the present river system matured. Ice wedge casts, observed in several small gravel pits and stone polygons detectable on aerial photographs of fluvioglacial terraces, demonstrate a phase of permafrost following the last glaciation (Clapperton and Sugden, 1977). In the valley floors boreholes 04 NW 3 and 8 prove sand and gravel of fluvioglacial origin concealed by more recent alluvium. These buried deposits may have been laid down adjacent to one of a series of glacial lakes which from time to time occupied the overdeepened valley of the River Ugie and lower South Ugie Water (see section on glaciolacustrine deposits). Scattered patches of fluvioglacial outwash lie outwith the major river valleys, for example, at Blackhills [049 528] and north of Redleas [091 428], where a deposit of local derivation occurs.

The fluvioglacial deposits are variable in composition, constituent rock types in the gravel fraction including schist, psammite, quartzite, quartz, granite with basic igneous rocks, sandstone, metagreywacke, slate, siltstone and flint. Pebble shape varies from subrounded to well rounded with some subangular. The sand fraction is composed mainly of medium to coarse, subangular to subrounded quartz and rock.

Glacial sand and gravel: Glacial sand and gravel, an ice-contact deposit of similar composition to fluvioglacial sand and gravel but usually displaying a moundy topography, occurs at a few scattered localities. At Oldmill [025 443] a poor 'terrace-like' feature delimits a deposit of glacial sand and gravel, which is overlain locally by soliflucted brown pebbly till. In places a black brecciated shaley clay separates the till from the underlying sand and gravel. North of Moreseat [053 404] borehole 04 SE 2 proves 7 m of sand, clayey and pebbly towards the base, resting on a black silty clay similar to that found at Oldmill. Glacial gravels also occur within till, especially in the reddish brown or greyish brown variety, and beneath this deposit and the underlying greenish grey basal till, as shown by boreholes 04 NE 10 and 14 NW 3. These gravels, possibly deposited by meltwater within stagnant ice, may have been buried subsequently by flow till.

Glaciolacustrine deposits: Much of the overdeepened lower valley of the South Ugie Water and River Ugie west of Cairnhill [094 491] is filled with thick deposits of laminated silts, clays and fine sands, which underlie alluvium and fluvioglacial sand and gravel. These deposits are glaciolacustrine in origin, having been laid down in a series of temporary lakes, which occupied the valley at times when coastal glacier ice impeded drainage to the east. On the valley floors boreholes 04 NW 3 and 04 NE 2 and 6 prove alluvial gravel on glaciolacustrine deposits, which comprise grey silt, greenish grey to reddish brown silty clay with laminae of silt and fine sand.

On the valley sides boreholes 04 NW 5 and 9 and 04 NE 3 penetrated fluvioglacial sand and gravel overlying glaciolacustrine deposits of 'very clayey' fine sand grading downwards into silts and clays: borehole 04 NW 10 proves fluvioglacial deposits on glaciolacustrine clay resting on 'clayey' sand. At higher elevations, along the valley sides of the North Ugie Water deposits fine with depth, fluvioglacial sand, and gravel generally passing into glaciolacustrine 'clayey' fine sand and laminated silt and clay, as shown by section NJ 95 SE 16 and boreholes NJ 95 SE13, 05 SW 1 and 5.

Near the coast, several assessment boreholes sited outwith the major river valleys show glaciolacustrine silt and clay either interbedded with or underlying till. Boreholes 04 NE 5 and 05 SE 5 prove grey and olive-green silts interbedded with grey and reddish brown till. Elsewhere red silt and clay is associated with bright reddish brown

× *Alluvium (Undifferentiated)*
○ *Fluvioglacial Sand and Gravel*
● *Glacial Sand and Gravel*
⊙ *Glaciolacustrine Deposits*
■ *Till*
\+ *Blown Sand and Lake Alluvium*
□ *Post-Glacial Beach Deposits*
△ *Buchan Ridge Gravels*

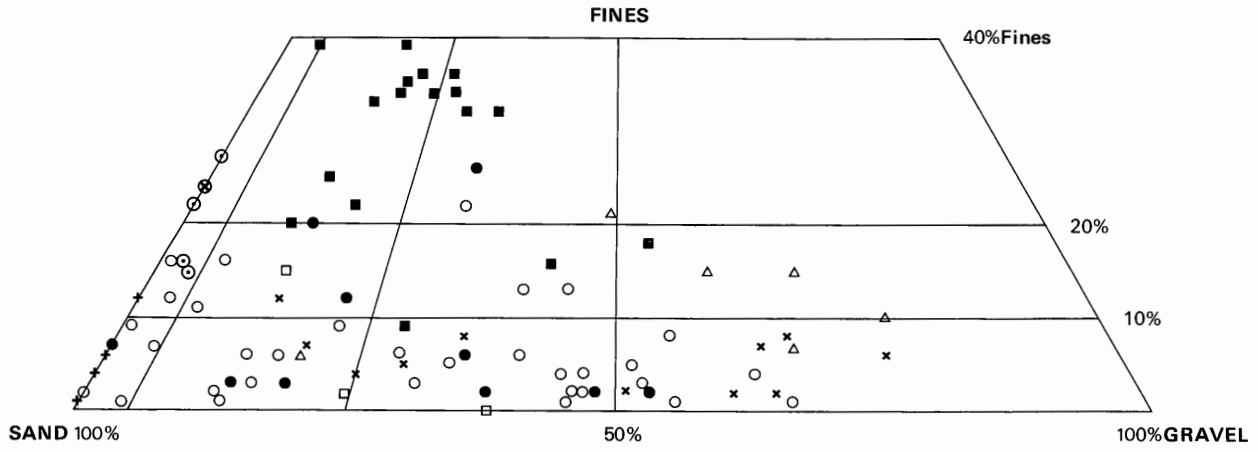

Figure 4 Comparison of the mean particle-size of mineral deposits proved at 52 sample points (not including data from IMAU trenches)

coastal till, as for example in boreholes 05 SE 9, 14 NW 4 and 5 and 15 SW 3. Laminated silt encountered in borehole 05 SE 9 may occupy a former channel of the River Ugie.

Coastal deposits: Coastal deposits include lake alluvium, post-Glacial beach deposits, blown sand and present-day beach deposits (the last-mentioned deposit is not assessed).

Lake alluvium, which forms undifferentiated raised surfaces usually less than 8 m above Ordnance Datum (Ritchie and others, 1978) occupies an area aligned with the coast between South Kirkton Farm [110 504] and Northmoss Farm [088 544]. The deposit, which mainly comprises faintly laminated grey to black plastic clay with silt and thin sand laminae, is thought to be post-Glacial in age and to have formed in a brackish lagoonal environment. Along the coast between Kirkton Head [121 505] and Pittenheath [097 546] the deposit forms the backslope of a post-Glacial cliff, the line of which has been locally obscured by blown sand. Boreholes 05 SE 8, 15 SW 1 and 4 sited to the west of the cliff line show blown sand, usually less than 1.5 m thick, and rarely peat, to overlie 14.0 m+, 16.7 m and 9.5 m respectively of lacustrine silt and clay. At the two last-mentioned sites the clay overlies till.

North of Scotstown Head [120 519] in section 15 SW 5 post-Glacial raised beach deposits, comprising sandy gravel, underlie blown sand. Although borehole 15 SW 2, south-east of Annachie, proves 2.6 m of sandy gravel considered to be exposed post-Glacial raised beach, the surface extent is unknown and the deposit is not delimited on the resource sheet.

Present-day beach sand fringes much of the coast north of Peterhead as does blown sand, composed of yellow quartz and shell, which forms a series of sub-parallel dune ridges, the largest occurring east of the main post-Glacial cliff line.

Alluvium (undifferentiated): Spreads of fluviatile alluvium, composed mainly of reworked fluvioglacial sand and gravel and till, are generally restricted to the valley floors, where they form low-lying terraces and floodplains. As no obvious compositional or grading differences are observed between alluvium occupying the surface of the valley floors and fluvioglacial sand and gravel exposed on the valley sides, a distinction based on morphology has been made, namely, that generally only the lowest, most recent, terrace is mapped as fluvial. Locally, however, as at Baluss Bridge [002 469] a higher terrace is mapped as alluvium and at Longside the upper 3.0 m of clay and 'very clayey' sand in borehole 04 NW 5, sited on a supposed terrace of fluvioglacial sand and gravel, may also be alluvial in origin. On the valley floor alluvium may directly overlie bedrock, till, glaciolacustrine deposits or rarely, as in borehole 04 NW 8, fluvioglacial sand and gravel.

The many scattered patches of alluvium present outwith the river valleys mainly comprise sandy silt and clay derived locally from till.

Peat: Basin peat occurs principally north of the valley of the North Ugie Water. The accumulations, which have long been used as a local source of domestic fuel, probably occupy rock basins gouged out by glacial action. Thin, impersistent deposits of hill peat are common.

COMPOSITION OF THE MINERAL DEPOSITS

Particle-size distribution

As there is no readily apparent method for distinguishing sand and gravel of different origin in borehole samples, for example, alluvial and fluvioglacial material, for this assessment differences of origin have been ignored and deposits within two broad geographical divisions have

been considered as a whole. All potentially workable alluvium and fluvioglacial sand and gravel occurring beneath the valley floor forms one category: and potentially workable fluvioglacial and glaciolacustrine deposits on the valley sides constitutes the other. Scattered deposits of fluvioglacial and glacial sand and gravel, together with blown sand, post-Glacial beach deposits and Buchan Ridge gravels, are also considered to be potentially workable. Locally till grades as mineral but is not generally considered to constitute a resource. Detailed mean grading data for all mineral from assessment boreholes and exposures are presented in Tables 7 to 14. The mean grading of individual mineral deposits for fifty-two sample points (excluding shallow trench data) are plotted on a triangular diagram (Figure 4) and grading data for groups of deposits, which have been assessed in each resource block are given in Figures 5 to 8.

Valley-floor and valley-side deposits: Potentially workable alluvium, fluvioglacial sand and gravel and glaciolacustrine deposits occupy the valleys of the North and South Ugie Waters and River Ugie. Figure 4 illustrates that a distinction cannot be made between alluvium and fluvioglacial sand and gravel on the basis of grading alone, but differences in morphology allow both deposits to be recognised where they occur at the surface and to be shown separately on the resource map.

Table 7 and Figure 5 show the mean grading for valley-floor deposits of the Ugie and its major tributaries (Block A), to be sandy gravel in the IMAU classification (see Figure 12). In the upper part of the valley of the North Ugie Water boreholes NJ 95 SE 10, 11 and 12 prove coarse cobble gravels in the alluvium, which account for the wide grading 'envelope' over the coarse gravel grades shown in Figure 5. Downstream, borehole and section data show that both the alluvial and fluvioglacial deposits become generally less gravelly and more sandy. The mean fines (silt and clay) content for the block is 6 per cent. Mineral was not proved in the thick glaciolacustrine deposits below the floors of the River Ugie and South Ugie Water.

The mean gradings for the fluvioglacial sand and gravel and glaciolacustrine deposits of the valley sides of the Ugie and major tributaries, contained in blocks B and C, are given in Tables 8 and 10, Figures 6 and 7. For Block B the deposits grade as sandy gravel. The gravel content ranges from 1 per cent in section NJ 95 SE 16 to 61 per cent in borehole 04 NW 9: the mean fines content is 5 per cent. The valley-side deposits of Block C classify as 'clayey' pebbly sand and the mean grading (Figure 7) shows a unimodal distribution peaking in the medium sand grade. The high fines content (mean, 16 per cent) is caused mainly by the inclusion of data from section 95 SE 16 and boreholes 04 NW 5 and 10, 04 NE 3 and 05 SW 1, which prove glaciolacustrine 'clayey' and 'very clayey' fine sand. These deposits, which grade laterally and vertically into coarser and more fines-free fluvioglacial sand and gravel, are arbitrarily defined as generally comprising at least 60 per cent by weight of particles less than $\frac{1}{4}$ mm, that is, fine sand, silt and clay.

Deposits outwith the major river valleys: Scattered deposits of fluvioglacial and glacial sand and gravel lie outwith the valley of the Ugie and major tributaries in blocks B and C. Mean gradings for individual sample points, proving potentially workable material, are given in Tables 9 and 11 and plotted on Figure 4. The gravel content ranges from 3 per cent in borehole 04 SE 2 to 47 per cent in borehole 04 NE 10: fines from 2 per cent in borehole 04 NE 10 and section 04 SE 5 to 26 per cent in borehole 04 SE 3.

A deposit of possible Pliocene age, the Buchan Ridge gravels, occurs in Block C where boreholes 04 SW 3 and 04 SE 6 show up to 25 m of mainly clay-bound cobble gravels with a mean grading of fines 14 per cent, sand 36 per cent and gravel 50 per cent (Table 12, Figures 4 and 7).

Coastal deposits: Potentially workable coastal deposits, comprising blown sand and post-Glacial beach deposits are present in Block D. The blown sand, which is a generally fines-free medium-grained deposit, locally overlies lake alluvium. In borehole 15 SW 1, where only the upper 0.7 m of lake alluvium is mineral, this deposit has been included in the calculation of mean grading for coastal resources. In general, however, lake alluvium that is exposed in the St Fergus area is considered not to be potentially workable, as it is composed mainly of laminated, grey silt and clay. Post-Glacial beach deposits are proved at surface in borehole 15 SW 2, where they grade as sandy gravel with a high proportion of well rounded cobble material. Section 15 SW 5 proves pebbly sand of post-Glacial origin, overlain by blown sand.

Grading data for the coastal deposits are given in Table 13, Figures 4 and 8. The mean grading is pebbly sand and shows a strong unimodal distribution peaking in the medium sand grade (Figure 8). The narrow grading envelope about the mean reflects the high degree of sorting that might be expected of coastal deposits that have undergone repeated reworking by marine and wind action. No data are available for coastal deposits of Block C, which contains a small area of blown sand. Present-day beach deposits are not assessed.

Till: Over the resource sheet seventeen assessment boreholes show that locally till is potentially workable. However, most of the material grading as mineral is poorly sorted and 'very clayey', the mean fines content being 28 per cent. Because of difficulties in limiting the extent of till classifying as mineral no volumetric assessment is offered, but grading data for potentially workable till are given in Table 14, and individual deposit gradings are plotted on Figure 4. The gravel content in mineral till ranges from 10 per cent in boreholes 05 SW 5 and 14 NW 3 to 44 per cent in borehole 04 SE 6.

PETROGRAPHY AND MECHANICAL AND PHYSICAL PROPERTIES OF THE AGGREGATES

Compositional analysis – method

Pebble counts were undertaken on the 10 to 14 mm fraction of seven samples of fluvioglacial and glacial sand and gravel samples, (PX 89 to 95). Samples PX 89, 91, 93 and 94 comprise material collected from working faces and stockpiles of sand and gravel pits in the valley of the North Ugie Water: samples PX 90, 92 and 95 are from pits in scattered sand and gravel deposits lying outwith the major valley. All material for testing was sieved by hand in the field and later resieved in the laboratory. In one sample PX 93, the 10 to 14 mm fraction contained crushed oversize material. To compare the composition of these fluvioglacial and glacial deposits with Buchan

Table 2 Classification and characteristics of rock types† in the Peterhead area adopted for composition analyses of 10 to 14mm gravel based upon British Standard trade group classification scheme (BS 812.1:1975)

Trade Group	*Subgroup rock types and pebble characteristics*
Flint	**a** Flint, brown, crypto-crystalline, mainly irregular **b** Chert, crypto-crystalline, mainly subrounded
Gabbro	**a** Gabbro, coarsely crystalline, subrounded **b** Basic gneiss, coarsely crystalline, strongly foliated, subrounded, often weathered
Granite	Undivided: including granite, coarsely crystalline, subangular to subrounded, often weathered; acid gneiss, coarsely crystalline, subangular to subrounded
Gritstone	Undivided: including sandstone, medium- to coarse-grained, friable, poorly cemented, often weathered. Subrounded to rounded
Porphyry	**a** Felsite, finely crystalline, rounded **b** Acid lavas, finely crystalline, rarely porphyritic, rounded
Quartzite	**a** Fine quartzite, hard, finely crystalline quartz with generally <15% feldspar, subrounded to well rounded **b** Coarse quartzite, (including quartzose grits), medium- to coarse-grained, quartz, mica and generally <15% feldspar. Subrounded. **c** Psammite, (including metagreywacke and a small proportion of acid igneous rocks), mainly equigranular, fine- and medium-grained, quartzo-feldspathic (generally >15% feldspar). Subangular to subrounded **d** Vein-quartz, vitreous lustre, usually well rounded
Schist	**a** Mica-schist, medium-grained, foliated, micaceous, flaky **b** Slate, (including cleaved and indurated siltstone) fine-grained, flaky
Others	Highly decomposed clasts, probably metasediments (only in Buchan Ridge gravels)

† All rocks listed have been identified in the gravel samples analysed

Ridge gravels, the +4mm fraction of twenty-five bulk samples from borehole 04 SW 3 were retained after sieve-grading by commercial laboratories and the 10 to 14mm fraction amalgamated to form sample PX 100.

Each rock type has been assigned to its trade group as defined in BS 812.1: 1975, but modified to accommodate vein-quartz and certain metasediments together with deleterious and weathered materials (Table 2). The glacial and fluvioglacial gravels of the Peterhead area are composed predominantly of Dalradian quartzose metasediments and in this report, within the quartzite trade group, a vein-quartz subgroup and three metamorphic subgroups, namely, fine quartzite, coarse quartzite and psammite have been distinguished. Fine quartzites form hard, rounded pebbles composed of finely crystalline quartz with generally up to 15 per cent feldspar; the coarse quartzite subgroup encompasses a wider variety of softer rock types including medium to coarsely crystalline muscovite-rich quartzites and quartzose grits with generally less than 15 per cent feldspar; the psammite subgroup embraces mainly equigranular, fine-grained and medium-grained quartzo-feldspathic metasediments (feldspar >15 per cent). Because of difficulties in distinguishing igneous and metamorphic textures in fine gravel-grade clasts, a small proportion of finely crystalline acid igneous rocks is also included in the psammite subgroup. Acidic and coarsely crystalline gneissose metasediments have been assigned to the granite trade group which is undivided: basic gneisses comprise a subgroup in the gabbro trade group. The schist trade group is divided into two subgroups of flaky rocks, namely mica-schist and slate, the latter including cleaved and indurated siltstone. The gritstone group comprises friable medium-grained to coarse-grained sandstones.

Other rock types present in the Peterhead area but not recognised by British Standard trade groups include highly decomposed clasts, probably of metasedimentary origin, observed only in the distinctive Buchan Ridge gravels. Composition analyses are shown in Table 3.

Mechanical and physical properties – method

Aggregate impact value (AIV), 10 per cent fines, relative density and water absorption were determined in accordance with BS 812.3: 1975 for the 10 to 14mm fraction of the seven samples of fluvioglacial and glacial gravel. Only the first two tests mentioned were conducted on the composite sample of Buchan Ridge gravels, there being insufficient material for other determinations.

AIV is a measure of the resistance of aggregate to sudden impact. In the 10 per cent fines test a steadily increasing compressive load is applied for a fixed period of time. It follows that an aggregate may display different strength properties when subjected to these two tests. Relative density (specific gravity) is given for both oven-dried and surface-dried samples: water absorption is expressed as a percentage of the oven-dry weight of aggregate following 24 hours of immersion in distilled water. The results are shown in Table 4.

*Composition analysis– **results***

Detailed results, which are presented in Table 3, are given as the number per cent of clasts counted and their weight per cent within each rock type or trade group where rock types are not divided. The total weight per cent of quartzite trade group material for each sample is given in Table 4. In this account all results are in weight per cent.

Quartzite trade group material comprising Dalradian metasediments is generally the dominant constituent of both the fluvioglacial and glacial gravels, usually accounting for 42 to 76 per cent and averaging 56 per cent in the samples examined. Sample PX 90 is atypical, being taken from a fluvioglacial deposit close to the outcrop of the Peterhead granite and containing by trade group 65 per cent granite, 16 per cent flint and 15 per cent quartzite, together with minor quantities of other rock types. The granite trade group in samples PX 89 and 91 to 95, probably derived from the Peterhead granite, ranges from 8 to 39 per cent.

For samples PX 89 and 91 to 95 the schist trade group ranges from 4 to 13 per cent. The combined totals of the flint trade group (flint and chert), gabbro trade group (gabbro and basic gneiss), gritstone trade group (sandstone and weathered metasediments) and porphyry trade group (felsite and acid lavas) range between 7 and 20 per cent of the total. Sample PX 100, from the Buchan Ridge gravels is composed mainly of flint (53 per cent) and quartzite trade group (42 per cent), with minor quantities of other rock types including 2 per cent of decomposed clasts.

Table 3 Pebble count analyses of 10 to 14mm fractions
PX89 to 94 (Fluvioglacial sand and gravel); PX95 (Glacial sand and gravel); PX100 (Buchan Ridge gravels)

British Standard trade groups	Rock type (modified after BS812)	PX89		PX90		PX91		PX92		PX93 *		PX94		PX95		PX100	
		No%	Wt%	No%	Wt%	No%	Wt%	No%	Wt%	No%	Wt%	No%	Wt%	No%	Wt%	No%	Wt%
Flint	Flint	1	1	15	16	trace	trace	trace	trace	–	–	trace	trace	1	1	48	53
	Chert	–	–	–	–	trace	1	1	1	trace	trace	1	1	3	3	–	–
Gabbro	Gabbro	trace	trace	–	–	2	2	2	2	trace	trace	1	1	–	–	–	–
	Basic gneiss	1	1	–	–	trace	trace	1	1	1	1	1	1	5	5	–	–
Granite	Undivided	10	11	68	65	15	15	9	8	21	20	10	10	38	39	trace	trace
Gritstone	Undivided	8	9	2	2	3	3	3	4	3	3	2	2	3	3	2	2
Porphyry	Felsite	1	1	1	2	2	2	5	5	5	5	2	2	2	2	1	1
	Acid lavas	1	1	–	–	1	1	1	1	4	4	1	trace	2	1	–	–
Quartzite	Fine quartzite	8	8	5	5	12	11	19	19	21	22	20	20	13	12	24	20
	Coarse quartzite	21	20	–	–	6	7	6	6	6	6	6	6	5	6	14	13
	Psammite	29	30	4	4	39	40	37	38	27	27	42	43	20	20	–	–
	Vein-quartz	5	5	5	6	7	7	6	6	5	5	8	7	4	4	9	9
Schist	Mica-schist	10	8	trace	trace	5	5	7	7	3	3	2	2	4	4	–	–
	Slate	5	5	–	–	7	6	3	2	4	4	4	5	–	–	–	–
Others	Highly decomposed clasts	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2
Total number of pebbles		513		266		662		446		337		592		449		345	

* Includes a proportion of crushed gravel

No rocks belonging to the basalt, hornfels and limestone trade groups were identified in any samples examined.

*Mechanical and physical properties– **results***

The aggregate impact value for a sample of natural aggregate depends largely on the petrography, grain-size, shape, flakiness and degree of weathering of the constituent pebbles. Except for petrography these factors are also functions of depositional environment. Subrounded to well rounded pebbles of finely crystalline metasediments and fine-grained, well cemented sediments might be expected to show better resistance to suddenly applied loads than less well rounded, coarsely crystalline granitic material or elongate micaceous schistose metasediments. This predicted behaviour is borne out for crushed rock aggregates and in particular by the work of Ramsay (1965), who attributes the weakening effect on the strength of granite aggregates to coarse feldspars. He also notes a relationship between increasing flakiness and AIV.

Although test data for the lithologically diverse glacial and fluvioglacial gravels of the Peterhead area vary, the results are in line with expectations, and some broad trends are discernible. Samples PX91 and PX94 with 65 per cent and 76 per cent respectively of material in the quartzite trade group give AIVs of 18 and 16 respectively, lower than the average of 19 for worked gravels cited by Edwards (1970) and although an inverse relationship of increasing AIV with decreasing proportion of quartzite trade group material is not followed precisely, this trend is generally recognisable. The relatively low AIV (19) for sample PX93, which contains 20 per cent granite trade group, may be due to a substantially higher proportion of less weathered material produced by the crushing of oversize aggregate at the particular location from which the sample was obtained. The highest AIV (38) for sample PX90, exceeds the normally recommended maximum test value (30) in BS812.3: 1975, and could be expected from a gravel containing 65 per cent by weight of weathered granite. The weathered nature of both the granites and the minor constituents in the gabbro, gritstone, porphyry and schist trade groups has probably influenced the AIVs obtained.

Ten per cent fines values generally correspond to those of AIV tests suggesting that similar lithological control applies.

The relative densities of samples tested (mean values 2.50 and 2.56 for oven-dried and surface-dried respectively) are generally lower than the mean of 2.58 for worked gravels given by Edwards (1970) and are possibly due to the paucity of basic metamorphic and igneous constituents.

Water absorption ranges from 1.7 to 2.4 per cent, higher than the average for worked gravels (1.48 per cent) quoted by Edwards (1970). The weathered nature of much of the granite, together with the appreciable proportion of coarse quartzite, schist and gritstone pebbles may explain the high absorption values. Referring these results to Edward's (1970) graph plotting water absorption against concrete drying shrinkage indicates that shrinkage values between 0.064 and 0.080 per cent might

Table 4 Results of mechanical and physical tests*

Sample	Deposit type	Wt% quartzite group material	AIV	10% fines	Relative Density (oven dried)	Relative Density (surface dried)	Apparent Relative Density	Water Absorption %
PX 89	Fluvioglacial sand and gravel	63	26	130	2.49	2.55	2.65	2.4
PX 90	Fluvioglacial sand and gravel	15	38	95	2.45	2.51	2.60	2.2
PX 91	Fluvioglacial sand and gravel	65	18	250	2.53	2.58	2.67	2.0
PX 92	Fluvioglacial sand and gravel	69	22	210	2.46	2.57	2.76	n.a.
PX 93	Fluvioglacial sand and gravel	60	19	200	2.54	2.58	2.66	1.9
PX 94	Fluvioglacial sand and gravel	76	16	270	2.54	2.59	2.66	1.7
PX 95	Glacial sand and gravel	42	26	170	2.50	2.55	2.64	2.2
PX 100	Buchan Ridge gravels (?Pliocene)	42	20	220	n.a.†	n.a.	n.a.	n.a.
Mean for PX 89 to 95		56	24	190	2.50	2.56	2.66	2.1
Mean for PX 89 to 95 and 100		54	23	190	n.a.	n.a.	n.a.	n.a.

* Tests conducted in accordance with BS 812; 2 and 3: 1975 † n.a. = not available

be expected. Although this range lies within the limits set out in Building Research Station Digest 35 (1968), defining aggregate suitable for all general structural purposes, it must be emphasised that inferred shrinkage values derived in this way should be interpreted cautiously, particularly in view of the relatively small number of samples tested.

For sample PX 100, composed predominantly of rounded flint and fine quartzite, the AIV and 10 per cent fines results are predictably more favourable than the values obtained from typical glacial and fluvioglacial gravels. However, the small proportion (2 per cent) of decomposed pebbles may have lowered the strength characteristics of the gravel, though whether this effect has operated and by how much is not known.

THE MAP

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

Geological data: The geological boundary lines and symbols are taken from the geological maps of the area, which was last surveyed on the scale of 1:10 000 or 1:10 560 by staff of the Institute's Highlands and Islands Unit during 1977. The boundaries are the best interpretation of information available at the time of the survey. However it is inevitable, particularly with variable superficial deposits, that locally the accuracy of the map will be improved as new evidence from boreholes and excavations becomes available.

Mineral assessment information: The map is divided into resource blocks (see Appendix A), within which the extent of mineral is shown in red. A further subdivision of the mineral into areas where it is exposed (where the overburden averages less than 1.0 m in thickness) and areas where it is present in relatively continuous spreads beneath overburden, averaging more than 1.0 m in thickness, are represented by progressively lighter shading. Within these areas, however, there may be small patches where sand and gravel is absent or not potentially workable, as for example, around borehole 05 SW 2. Areas where sand and gravel is considered to be generally not potentially workable, where the superficial deposits do not contain mineral or where bedrock crops out are uncoloured. Excepting coastal deposits seaward of high-water mark, small patches of unassessed sand and gravel, although they may be potentially workable, are indicated by red stipple.

For the most part the distribution of resource categories is based on mapped geological boundaries. Where transitions between categories cannot be related to the geological map inferred boundaries have been inserted. Such boundaries, drawn primarily for the purpose of volume estimation, are shown by a distinctive zig-zag symbol, which is intended to convey an approximate location within a likely zone of occurrence, rather than to represent the breadth of the zone; its width is dictated by cartographic considerations. For the purpose of measuring areas the centre-line of the symbol is used.

Table 5 Sand and gravel resources: summary of statistical assessments

Resource block	Area		Mean thickness				Volume*				Mean grading percentage		
	Block	Mineral	Over-burden		Mineral				Limits at 95% probability level		Fines	Sand	Gravel
	km^2	km^2	m	ft	m	ft	$m^3 \times 10^6$	$yd^3 \times 10^6$	±%	$\pm m^3 \times 10^6$	$-\frac{1}{16}$mm	$+\frac{1}{16}-4$mm	+4mm
A Valley floor deposits (alluvium and fluvioglacial sand and gravel)	7.7	7.6	0.7	2.3	3.1	10.2	23.7	28.3	51	12.1	6	58	36
B Valley side deposits (fluvioglacial sand and gravel and glaciolacustrine deposits)	86.1	6.1	0.4	1.3	4.0	13.1	24.4	29.2	29	7.1	5	64	31
C Valley side deposits (fluvioglacial sand and gravel and glaciolacustrine deposits)	133.2	5.0	0.7	2.3	4.2	13.8	20.8	24.9	57	11.9	16	76	8
D	26.9	no statistical assessment offered											
Built-up area (Peterhead)	3.8												
Total	257.7	18.7					68.9	82.4					

* Figures for volume may not equal the products of area and mean thickness because of independent rounding

RESULTS

The results are summarised in Tables 5 and 6. Detailed grading and thickness data for all mineral deposits are given in Tables 7 to 14. The cumulative frequency, grading 'envelope' and frequency distribution for deposits which have been assessed are given in Figures 5 to 8.

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 29 to 57 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 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 be emphasised that the quoted volume of sand and gravel has no simple relationship with the amount that could be extracted in practice, as no allowance has been made in the calculations for any restraints (such as existing buildings and roads) on the use of land for mineral working.

RESOURCE BLOCK DESCRIPTIONS

The area assessed is divided into four resource blocks. In general the block boundaries reflect the distribution of different mineral-bearing deposits within the area. Statistical assessments are offered in Table 5. Block A contains the valley-floor deposits (alluvium and fluvioglacial sand and gravel); valley-side deposits (fluvioglacial sand and gravel and glaciolacustrine deposits) fall within blocks B and C. Inferred assessments are presented in Table 6 for scattered spreads of fluvioglacial and glacial sand and gravel of blocks B and C, the Buchan Ridge gravels of Block C and coastal deposits comprising blown sand and post-Glacial beach deposits of Block D. Although till may be locally potentially workable a volumetric assessment is not given because of difficulties in defining the extent of mineral-bearing ground. As till occurs in all blocks, a comment on the deposit in the Peterhead area follows the description of Block D. No assessment is offered for pockets of alluvium which occur outwith the major river valleys and are generally considered not to be potentially workable. The burgh of Peterhead is not assessed.

Block A – valley floor deposits

Block A encompasses the valley floors of the easterly flowing North and South Ugie Waters, the River Ugie and its major tributaries, which together constitute the

Table 6 Sand and gravel resources: summary of inferred assessments

Resource block	Area		Mean thickness				Volume*				Mean grading percentage		
	Block	Mineral	Over-burden		Mineral				Limits at 95% probability level		Fines	Sand	Gravel
	km^2	km^2	m	ft	m	ft	$m^3 \times 10^6$	$yd^3 \times 10^6$	$\pm$%	$\pm m^3 \times 10^6$	$-\frac{1}{16}$ mm	$+\frac{1}{16} - 4$ mm	+4 mm
B Scattered deposits and fluvioglacial sand and gravel:													
Blackhills	86.1	0.3	0.2†	0.7	5.7†	18.7	1.8	2.2	speculative		6	56	38
C Scattered deposits of fluvioglacial sand and gravel:													
Redleas	133.2	0.1	0.2†	0.7	2.4	7.9	0.3	0.4	speculative		4	74	22
Scattered deposits of glacial sand and gravel:													
Moreseat	133.2	0.6	insufficient data		9.5†	31.2	5.2	6.2	speculative		10	87	3
Howe o' Buchan	133.2	0.6	6.4	21.0	2.7	8.9	1.6	1.9	speculative		3	54	43
Oldmill	133.2	0.1	insufficient data		10.4†	34.1	0.9	1.1	speculative		3	75	22
Hillhead of Gask	133.2	0.2	0.3†	1.0	2.0†	6.6	0.4	0.5	speculative		26	50	24
Scattered deposits of Buchan Ridge gravels	133.2	2.1	insufficient data		11.4‡	37.4	24.3	29.1	speculative		14	36	50
D Coastal deposits (blown sand and post-Glacial beach deposits)	26.9	3.5	0.2	0.7	2.4	7.9	8.4	10.0	speculative		3	87	10
Total	246.2	7.5					42.9	51.3					

* Figures for volume may not equal the products of area and mean thickness because of independent rounding † Based only on one sample point ‡ It is assumed that the form of the Buchan Ridge gravels at the Moss of Cruden and the Hill of Aldie approximates to a triangular prism. The mean is derived from thicknesses proved at two sample points weighted by the inferred area of the deposit on which the boreholes are sited (see block description)

principal drainage of the area. Valley-floor deposits comprising alluvium, fluvioglacial sand and gravel and glaciolacustrine silts and clays are usually found at or below the water table and rest directly on either bedrock or till. With the exception of small outcrops of bedrock, alluvium, which constitutes the principal potentially workable deposit, covers the block.

North Ugie Water: Generally the alluvium in the valley of the North Ugie Water is considered to be potentially workable, but locally, for example in borehole 05 SW 2 near Milltown of Gaval [000 508], the alluvial deposits comprise mainly silts resting on a thin sequence of till and fluvioglacial sand and gravel. In the far north-west of the block boreheole NJ 95 SE 10 failed to penetrate a cobble gravel in which 46 per cent of the material was greater than 64 mm. Adjacent boreholes NJ95 SE 11 and 12, sited on alluvium, proved 2.2 and 2.3 m respectively of coarse gravels resting directly on bedrock. Downstream of Nether Hythie [012 505], the river is incised into bedrock in places, for example at Dumpstown [022 501] and west of Mill of Rora [042 497]. Farther east, boreholes 05 SW 9 and 04 NW 8 drilled on the alluvial floodplain proved 1.0 m and 3.0 m of gravel respectively, the former deposit resting on 4.5 m of till, of which the upper 1.5 m grades as mineral: at the latter site the alluvial gravel rests on 4.0 m of fluvioglacial sand and gravel, which in turn overlies a basal till.

South Ugie Water: The South Ugie Water meanders through a wide strip of flat, poorly drained ground. A higher terrace of older alluvium at about 35 m above Ordnance Datum occurs north of Baluss Bridge, where borehole 04 NW 2 proved 4.0 m of silty, pebbly sand interbedded with 1.1 m of laminated clay, overlying 3.1 m of till, (the lower 2.1 m is mineral) resting directly on bedrock comprising weathered psammite. Sited on the present alluvial floodplain, borehole 04 NW 3 proved 4.5 m of alluvium (the lower 4.0 m is mineral), on 2.0 m of glaciolacustrine silt. The base of a lower mineral deposit, fluvioglacial in origin and at least 4.4 m thick, was not proved. Inferred boundaries south of Old Deer [978 476], at Fordmouth [012 457] and at the Bridge of Ludquharn [036 457] separate potentially workable deposits from alluvium either too thin or too silty to be considered in the assessment.

River Ugie: Downstream of the confluence of the North and South Ugie Waters, the River Ugie flows over a wide

Table 7 Block A: data from assessment boreholes – resources in valley-floor deposits of the Ugie and major tributaries (alluvium and fluvioglacial sand and gravel)

Borehole	Recorded thickness			Mean grading percentage						
	Mineral	Overburden to first mineral	Intervening waste	Fines	Fine sand	Medium sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles and boulders
	m	m	m	$-\frac{1}{16}$ mm	$+\frac{1}{16}-\frac{1}{4}$ mm	$+\frac{1}{4}-1$ mm	+1–4 mm	+4–16 mm	+16–64 mm	+64 mm
95 SE 10	1.2	0.3	0	6	4	9	9	11	15	46
95 SE 11	2.2	0.8	0	2	5	14	15	17	38	9
95 SE 12	2.3	0.5	0	8	4	13	13	21	32	9
04 NW 2	4.0	0.3	1.1	13	18	37	20	9	3	0
04 NW 3	7.7	1.0	2.7	7	18	38	22	9	6	0
04 NW 8	7.0	0.5	0	4	6	16	20	19	31	4
04 NE 2	2.7	0.3	0	8	8	27	25	17	12	3
04 NE 4	3.7	2.0	0	2	4	20	24	14	22	14
04 NE 6	1.0	0.4	0	5	4	22	41	15	13	0
05 SW 2	1.0	–	–	–	–	–	–	–	–	–
05 SW 9	1.0	1.5	0	7	6	14	13	11	44	5
14 NW 1	4.8	0.2	0	4	15	38	19	13	10	1
Mean	3.1	0.7		6	11	26	21	14	17	5

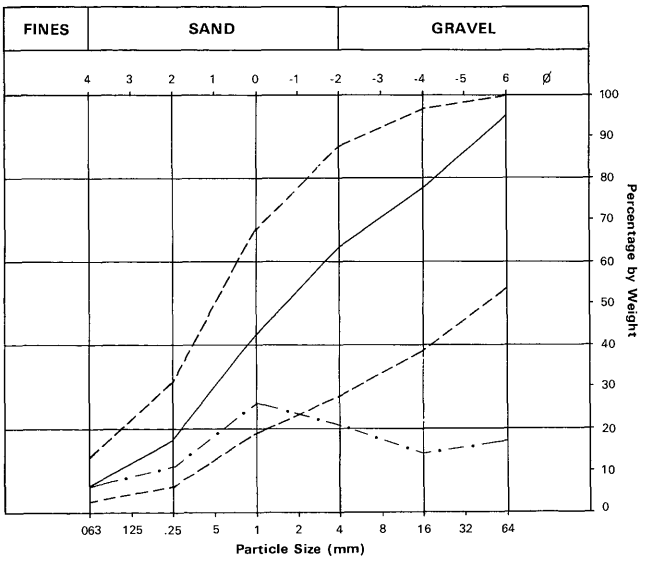

Figure 5 Grading characteristics of resources in valley-floor deposits (Block A): the continuous line is the cumulative weighted mean; the broken lines define the envelope within which the cumulative mean grading of individual mineral deposits fall; the frequency distribution of the mean grading is shown by a dashed and dotted line

alluvial plain underlain by thick sequences of glaciolacustrine deposits. Boreholes 04 NE 2 and 04 NE 6, sited on alluvium, proved 2.7 m and 1.0 m of sandy gravel overlying 17.2 m+ and 17.8 m+ respectively of glaciolacustrine laminated silts and clays, and indicate overdeepening of the valley hereabouts. A constriction in the valley south-west of Cairnhill [094 491] coincides with a shallowing of the drift deposits and bedrock is exposed 200 m due south of the farm. Downstream, as far east as Balmoor Bridge [109 483] terraced alluvium occupies the floor of a deeply incised valley. Borehole 14 NW 1 sited on an upper terrace proved 4.8 m of sandy gravel on 1.4 m of basal till. East of Balmoor Bridge, [at 114 477] a small alluvial deposit is mapped. In the absence of qualitative and thickness data for the deposit no assessment is offered.

Potentially workable alluvium is found in the valleys of the Crooko Burn and Burn of Faichfield. At the Bridge of Faichfield [066 463] borehole 04 NE 4 proved 3.7 m of cobble gravel resting on till. Upstream of the Bridge an inferred boundary [at 072 451] separates potentially workable alluvium from that regarded as too thin to be assessed.

Assessment of resources: On the basis of eleven assessment boreholes, the mean grading of potentially workable valley-floor deposits is fines 6 per cent, sand 58 per cent and gravel 36 per cent (sandy gravel),(Table 7; Figure 5). The mineral, which is generally at or near surface, has a mean thickness of 3.1 m and, based on the area of exposed alluvium upstream of Balmoor Bridge, is estimated to have a volume of about 24 million $m^3 \pm 51$ per cent (Table 5).

Block B

Block B includes valley-side deposits (fluvioglacial sand and gravel, glaciolacustrine deposits and till) of the North Ugie Water, together with drift deposits of the northern part of the resource sheet lying outwith the main river valley. The principal potentially workable deposits, which generally occur above the water table are found in the fluvioglacial and glacial sand and gravel, and in glaciolacustrine deposits.

Table 8 Block B: data from assessment boreholes and exposures – resources in valley-side deposits of the North Ugie Water (fluvioglacial sand and gravel and glaciolacustrine deposits)

Sample point	Recorded thickness			Mean grading percentage						
	Mineral	Overburden to first mineral	Intervening waste	Fines	Fine sand	Medium sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles and boulders
	m	m	m	$-\frac{1}{16}$ mm	$+\frac{1}{16}-\frac{1}{4}$ mm	$+\frac{1}{4}-1$ mm	+1–4 mm	+4–16 mm	+16–64 mm	+64 mm
95 SE 13	4.2	0.1	4.5	4	5	21	28	16	26	trace
95 SE 14	1.0	0.6	0	9	22	34	15	16	4	0
95 SE 15†	4.3	0	0	1	10	51	25	7	5	1
95 SE 16†	4.1	0	0	16	47	32	4	1	0	0
04 NW 4	4.5	0.4	0	6	10	51	17	4	9	3
04 NW 9	3.0	0.5	0	4	6	16	13	17	40	4
04 NW 11†	7.7	0	0	1	2	32	24	15	22	4
04 NW 12†	6.2	0	0	2	8	59	19	7	4	1
04 NW 13†	2.5	0	0	1	1	24	19	18	33	4
04 NW 14†	3.5	0	0	4	9	21	18	15	30	3
04 NE 1	1.7	0.6	0	13	14	16	18	16	23	0
05 SW 1	4.7	0.3	0	15	62	18	2	trace	2	1
05 SW 3	8.8	0.3	1.0	3	3	20	25	19	27	3
05 SW 5	2.8	0	2.8	7	20	37	23	4	3	6
05 SW 13†	2.8	0	0	2	17	17	18	15	27	4
05 SE 6	2.8	0.4	0	4	6	31	16	18	21	4
Mean	4.0	0.4*		5	14	31	19	12	17	2

† Indicates pit section; all other sample points are boreholes * Based on borehole data only

Valley sides between Newton [951 541] and Mill of Hythie [022 505]: Fluvioglacial sand and gravel, locally grading laterally and vertically into glaciolacustrine deposits, forms well defined, fragmented terraces, flanking both sides of the valley. Terrace-surface levels descend from about 53 m near Newton to about 30 m above Ordnance Datum at Mill of Hythie. Near Hillhead [960 538] north of the river, a large area of gravel has been worked both above and below the water table. Unworked deposits occur south of the river [at 958 533 and 968 532], trenches NJ 95 SE P2 and P3 at the latter site proving a coarse cobble gravel. A complex drift sequence occurs north-east of Gaval [982 517] where borehole NJ 95 SE 13 sited on a terrace at about 46 m above Ordnance Datum proved, in downward succession, 1.0 m of fluvioglacial sand and gravel, 3.5 m of glaciolacustrine silt, 3.4 m of grey till (grading as 'very clayey' sandy gravel) 1.0 m of red 'non-mineral' till and 3.2 m of fluvioglacial sand and gravel on bedrock. To the east, workings in higher terraces at 52 m above Ordnance Datum, near Brownhill [at 994 523] (section NJ 95 SE 15) and near Sandhole [at 998 521] (section NJ 95 SE 16) reveal respectively 4.3 m of fluvioglacial sand and gravel and 2.0 m of fluvioglacial sand

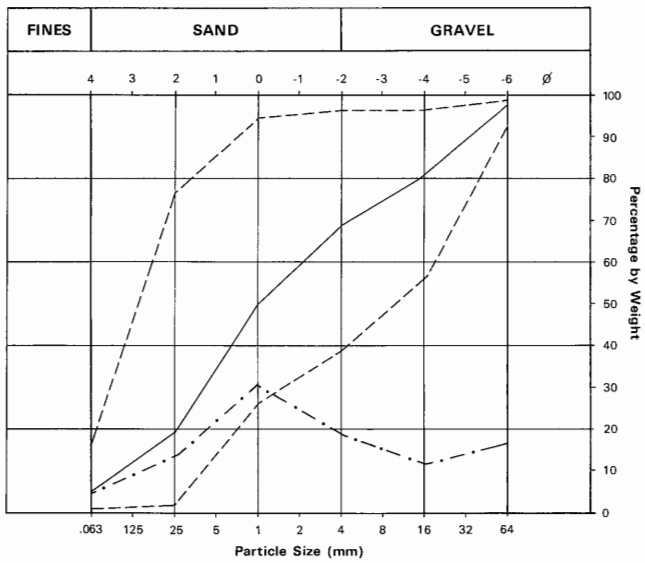

Figure 6 Grading characteristics of resources in valley-side deposits (Block B). For explanation see Figure 5

Table 9 Block B: data from assessment boreholes and exposures – resources in scattered deposits (fluvioglacial and glacial sand and gravel)

Sample point	Locality	Recorded thickness		Mean grading percentage						
		Mineral	Overburden	Fines	Fine sand	Medium sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles and boulders
		m	m	$-\frac{1}{16}$ mm	$+\frac{1}{16}-\frac{1}{4}$ mm	$+\frac{1}{4}-1$ mm	+1–4 mm	+4–16 mm	+16–64 mm	+64 mm
05 SW 10	Longhill	1.2	2.8	12	19	26	24	12	7	0
05 SW 14†	Blackhills	5.7	0.2	6	3	26	27	16	17	5

† Indicates pit section; all other sample points are boreholes

and gravel, fining downwards into 'very clayey' glaciolacustrine sand. Some 240 metres to the south of Sandhole pit, borehole NJ 95 SE 14 sited on a lower terrace proved a complex sequence: 1.0 m of fluvioglacial sand and gravel overlies 7.0 m of till (the upper 2.4 m is mineral), which rests on a thin gravel and basal till on quartzite bedrock.

East of the A92 trunk road at Milltown of Gaval, borehole 05 SW 1 sited on fluvioglacial sand and gravel showed 0.7 m of 'clayey' pebbly sand at surface on 4.0 m of 'clayey' glaciolacustrine sand, which fines downwards into laminated silt and clay. Near Dumbmill [005 503] borehole 05 SW 3, on a low terrace at about 33 m above Ordnance Datum south of the North Ugie Water proved 6.4 m of fluvioglacial sand and gravel on 3.5 m of till, of which the upper 2.5 m is mineral. A lower 2.4 m of fluvioglacial sand and gravel rests on a thin basal till on bedrock. North of the river near Mill of Hythie, borehole 05 SW 5, sited in a partially worked-out pit, proved an interbedded sequence of fluvioglacial sand and gravel and glaciolacustrine clay overlying 3.5 m+ of till: 1.2 m and 1.6 m of mineral (both fluvioglacial sand and gravel) and 1.0 m (till) are separated by 2.8 m and 1.4 m of waste respectively. About 110 m west of the borehole, section 05 SW 13 shows 2.8 m of fluvioglacial sand and gravel on silt.

Till, which forms considerable stretches of the valley sides, for example north of Little Skillymarno [953 531] and south of Kindrought [976 535] and Hythie [007 514], is generally considered to be barren. Elsewhere bedrock crops out through till near Croft of Bogieneuk [995 526], Mains of Gaval [992 515], Nether Hythie and at Dumpstown.

Valley sides between Dumpstown [022 501], Strawberry Bank [046 479] and West Ednie [075 509]: Between the North and South Ugie Waters, fluvioglacial sand and gravel, overlain by peat at Moss of Dumpstown [028 497] and east of Ardlaw Hill [033 489], forms terraces which descend from about 38 m above Ordance Datum east of Dumpstown to 23 m north of Strawberry Bank.

Sections 04 NW 11, 13 and 14 in partially worked out pits near Knaps of Auchlee [at 036 494], Loch of Auchlee [at 042 487] and Auchlee [at 045 484] respectively, and borehole 04 NW 4, failed to prove the full thickness of the fluvioglacial deposits. However, borehole 04 NW 9 proved 3.0 m of fluvioglacial gravel overlying thick glaciolacustrine silts and clays and section 04 NW 12 in a partially worked-out pit north of Woodside Farm [040 492] shows 6.2 m of fluvioglacial sand and gravel to rest on grey till.

North of the North Ugie Water, till, which covers the valley side as far east as Millbank [043 491] and a small area south of the river at Knaps of Auchlee [040 495], is presumed to be mainly unworkable, although borehole 05 SW 8 proved 3.5 m of the deposit to grade as 'very clayey' pebbly sand. East of Millbank, trench 04 NE P1 and borehole 04 NE 1 sited on terraced fluvioglacial deposits, proved sandy gravels: in the borehole 1.7 m of 'clayey' sandy gravel rests on 4.1 m of till, the lower 2.1 m of which grades as mineral. Further east a terraced deposit of fluvioglacial sand and gravel flanks the Crooko Burn near West Ednie and borehole 05 SE 6 sited next to an area of worked ground proved 2.8 m of fluvioglacial sand and gravel on 6.6 m of till, which rests in turn on decomposed bedrock.

Other areas – north of the North Ugie Water: Parts of the parishes of Strichen, Lonmay and Crimond are included in a generally featureless area north of the river valley, which attains a maximum height of 100 m above Ordnance Datum at Smiddyhill [976 549] in the north-west of the resource sheet: a series of southerly flowing drainage channels are present in the west. Till, judged not to be potentially workable on the basis of boreholes 04 NW 7 and 05 SW 4 and 7, crops out over much of the area and directly overlies bedrock, the more indurated varieties of which have been used as a local source of building stone.

Several extensive thin spreads of peat occur towards the eastern boundary of the block, the largest being the St Fergus Moss [035 545 and 054 537] and Rora Moss [044 514]. Boreholes 05 SW 12 and 05 SE 3 sited on the Rora Moss proved 1.2 m and 1.5 m of peat respectively, overlying thin basal tills. On the St Fergus Moss boreholes 05 SW 6, 11 and 05 SE 1 proved 1.1 m, 1.2 m and 4.2 m respectively of peat overlying till. At the last-mentioned site the underlying till is interbedded with 2.5 m of glacial sand and gravel, which is regarded as not potentially workable on the basis of excessive overburden.

Alluvium, found associated with the peat mosses and in small basins and narrow valleys, as at Banks of Strichen [963 546] and Croft of Bogieneuk, is generally considered to be either too thin or too silty to be potentially workable. Pockets of alluvial gravel may occur locally, but as no data are available, alluvium outwith the major river valleys has not been considered in the assessment.

Small spreads of fluvioglacial sand and gravel occur north of New Leeds and at Blackhills where section 05 SW 14, situated in a partially worked out pit, proves 5.7 m of sandy gravel overlying grey till. Glacial sand and gravel is exposed at Burnside [033 535] and a buried deposit 1.2 m thick is shown by borehole 05 SW 10 to separate an upper 2.5 m and lower 5.3 m of till. Although 2.8 m of the till grades as mineral, the material was comminuted as the result of drilling action and it is regarded as unrepresentative of the deposit as a whole, which is generally considered not potentially workable. Potentially workable glacial sand and gravel at this locality is thought not to be extensive, and has not been delimited on the resource sheet.

Other areas – around Mintlaw [000 483] and Fetterangus [987 508]: West of Mintlaw and Fetterangus the land surface rises steadily towards the western limit of the district at White Cow Wood, 142 m above Ordnance Datum, where bedrock crops out over a wide area.

The most extensive drift deposit is till, which occupies much of the land between the North and South Ugie Waters. Although borehole 04 NW 1, sited near Boghead [008 497] showed 3.3 m of till grading as a 'very clayey' pebbly sand resting on decomposed granite bedrock, generally till is not considered potentially workable. With the exception of a small patch of fluvioglacial sand and gravel west of Milladen Mill [984 469] till flanks most of the northern valley side of the South Ugie Water, and in the absence of qualitative and thickness data no assessment is offered. Alluvium, which occupies the upper stretch of the South Ugie Water north of Old Deer is generally considered to be either too silty or too thin to be potentially workable.

Assessment of resources: Potentially workable deposits occur in valley-side deposits and in scattered patches of fluvioglacial and glacial sand and gravel.

In the valley-side deposits, worked ground above the water table includes areas south of Hillhead [at 960 535], Nether Denend [at 990 529], Brownhill, Sandhole, Mill of Hythie, Moss of Dumpstown, Knaps of Auchlee, Woodside Farm, Loch of Auchlee, Auchlee, and near Burnthillock [at 071 506]. Although the deposit at several localities has only been partially extracted, it is estimated that existing and disused workings cover an area of 1 km^2, or approximately 15 per cent of the remaining mineral-bearing area of the valley sides.

Based on data from nine assessment boreholes and seven sections, the mean grading of the deposits is fines 5 per cent, sand 64 per cent and gravel 31 per cent (sandy gravel), (Table 8; Figure 6). The mineral, which is generally at or near surface, has a mean thickness of 4.0 m and an estimated volume of 24 million m^3 ± 29 per cent (Table 5).

Outwith the river valley, an isolated patch (0.3 km^2) of fluvioglacial sand and gravel is exposed at Blackhills, where section 05 SW 14 proved 5.7 m mineral. If this data point is representative of the deposit, then a volume of 1.8 million m^3 may be inferred, (Tables 6 and 9). Lack of data precludes inferred assessments of other small pockets of fluvioglacial or glacial sand and gravel in the block.

Block C

The block includes valley-side deposits (fluvioglacial sand and gravel, glaciolacustrine deposits and till) on the south side of the South Ugie Water and River Ugie, and scattered deposits of fluvioglacial and glacial sand and gravel, Buchan Ridge gravels, together with till, alluvium and blown sand of the southern part of the resource sheet. The main potentially workable deposits occur in fluvioglacial and glacial sand and gravel, glaciolacustrine deposits and Buchan Ridge gravels.

Valley sides between Stuartfield [973 459] and Peterhead: Fluvioglacial sand and gravel occurs mainly as terraces around Stuartfield and Longside. At Stuartfield, borehole NJ 94 NE 1 proved 1 m of gravel overlying 2.9 m of till, the upper 1 m of which grades as 'very clayey' pebbly sand. The till rests on decomposed bedrock, probably a gneissose metasediment. North of Easter Knock [996 465] and east of Yokieshill [010 462] two small patches of fluvioglacial sand and gravel for which no data are available flank the valley of the South Ugie Water. At Longside, borehole 04 NW 6 proved 2.0 m of 'very clayey' sandy gravel resting directly on bedrock. A complex and thicker sequence of drift deposits is shown by borehole 04 NW 10, where the downward succession is 1.9 m of fluvioglacial sand, 4.2 m of glaciolacustrine deposits, (the lower 2.7 m is mineral), 2.4 m of till (the upper 2.0 m is mineral), 1.0 m of fluvioglacial sand and gravel on decomposed gneissose bedrock. West of Longside, borehole 04 NW 5, sited on a valley-side terrace mapped as fluvioglacial sand and gravel, proved 1.6 m of silty clay on 1.0 m of 'very clayey' sand (both deposits are possibly of alluvial origin) overlying 5.0 m of 'very clayey' fine sand which, because in excess of 60 per cent by weight of the material passes the 0.25 mm sieve, is considered to be glaciolacustrine. The mineral overlies at least 13.5 m of glaciolacustrine laminated silt and clay, demonstrating that the body of water in which the sediments formed extended beyond the confines of the present valley floor.

East of Longside, fluvioglacial sand and gravel forms scattered terraces flanking the Burn of Faichfield and the southern side of the River Ugie, near Mains of Buthlaw [065 484] and north-west of Roundhillock [081 493]. Sited on a terrace east of the Burn of Faichfield borehole 04 NE 7 proved 5.2 m of fluvioglacial deposits (the upper 4.6 m is mineral), overlying granite bedrock, and borehole 04 NE 3, proved 1.9 m of fluvioglacial sand on 7.2 m of glaciolacustrine deposits of which the upper 4.1 m is mineral. The glaciolacustrine deposits rest on till. Ground over which fluvioglacial deposits have been worked includes an area west of Faichfield House [065 467].

Deposits of clayey till, which are locally exposed on the south side of the floodplain of the South Ugie Water and River Ugie may interdigitate with thin glaciolacustrine silts, as demonstrated by borehole 04 NE 5. The till is generally considered to be not potentially workable. Elsewhere, for example at Monyruy [055 471], around Mains of Buthlaw and at Inverugie, bedrock crops out.

Other areas: South of the valley of the River Ugie and South Ugie Water elevations increase westwards and southwards, culminating in the high ground of the Hill of Dens, 168 m, Skelmuir Hill, 149 m, Smallburn Hill [016 405] 143 m and the Moss of Cruden, 139 m above Ordnance Datum. The Moss forms part of the so-called Buchan Ridge (Flett and Read, 1921).

In the west of the block bedrock crops out over a wide area of high ground including Hill of Dens and Skelmuir Hill. Eastwards, bedrock is overlain by a thin till cover as demonstrated by borehole 04 SW 1. Nearer Longside, bedrock crops out on the summits of the smaller hills in the district.

Patches of peat overlying till are commonplace and include the Moss of Savock [058 422] and Moss of Kinmundy [055 432], where borehole 04 SE 1 showed 0.7 m of peat overlying 1.3 m of till, grading as a 'very clayey' pebbly sand, on rock. East of these mosses, granite bedrock, in places highly weathered, is exposed over the Hill of Longhaven and surrounding land. In the neighbourhood of Peterhead, boreholes 04 NE 8 and 14 NW 6 proved varying thicknesses of till on bedrock. The latter borehole, together with borehole 14 SW 4, showed the till to be mainly red or reddish brown stony clay with silt and sand partings.

The coastline south of Peterhead is cut in Peterhead granite, which forms impressive cliffs especially south of Boddam. Around Stirlinghill [125 413] the granite was, until 1939, extensively quarried as an ornamental and building stone but more recently, in response to changing demand, the material has been used mainly for roadstone. Locally the granite may be highly weathered and crumble in the hand to a gruss of coarse feldspar-rich sand as, for example, near Blackhill [083 424], where the material has been worked for use as bedding in gas-pipe trenches. It is possible therefore that locally the Peterhead granite may be potentially workable as a 'natural' aggregate but as the extent, depth and variation in the weathering of the rock is not known, no assessment of this resource is offered. No assessment is offered for a small area of blown sand at Sandford Bay [123 438].

Glacial sand and gravel forms isolated pockets mainly south and east of Longside. South of Oldmill, glacial sand and gravel, which forms a poorly defined terrace-like feature is exposed in a partially worked-out pit. Section 04 SW 5 showed 10.4 m of pebbly sand, the base of which was not exposed in May 1978. At the east side of the pit a similar thickness of sand is overlain by a soliflucted brown pebbly till. The glacial sand and gravel

Table 10 Block C: data from assessment boreholes – resources in valley-side deposits south of the South Ugie Water and River Ugie (fluvioglacial sand and gravel and glaciolacustrine deposits)

Borehole	Recorded thickness			Mean grading percentage						
	Mineral	Overburden to first mineral	Intervening waste	Fines	Fine sand	Medium sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles and boulders
	m	m	m	$-\frac{1}{16}$ mm	$+\frac{1}{16}-\frac{1}{4}$ mm	$+\frac{1}{4}-1$ mm	+1–4 mm	+4–16 mm	+16–64 mm	+64 mm
94 NE 1	1.0	0.3	0	8	10	20	11	19	27	5
04 NW 5	6.0*	2.0	0	26	56	17	1	0	0	0
04 NW 6	2.0	0.3	0	22	15	23	15	17	8	0
04 NW 10	5.6	0.4	1.9	11	33	41	7	3	3	2
04 NE 3	6.0	0.7	0	18	58	22	2	0	0	0
04 NE 7	4.6	0.4	0	6	16	43	22	10	3	0
Mean	4.2	0.7		16	39	29	8	4	3	1

* Includes potentially workable alluvium

is however of limited extent as borehole 04 SW 2, some 300 m to the south proved till overlying bedrock. Patches of glacial sand and gravel at the surface are also found near South Newfield [109 428], at Hillhead of Gask [087 407], where borehole 04 SE 3 proved 2.0 m of 'very clayey' pebbly sand overlying till, and at Moreseat, where borehole 04 SE 2 sited in a small sand working demonstrated 9.5 m of 'clayey' sand with pebbles at the base overlying a greyish black till.

An area of buried glacial sand and gravel occurs at the Howe o' Buchan [103 465], west of Peterhead. IMAU boreholes 04 NE 10 and 14 NW 3, together with boreholes at the Forehill Water Works [096 463] on IGS Site Exploration File 1059 have been used to draw an inferred boundary limiting the extent of potentially workable deposits. The site exploration data show that locally the deposit is too thin to be classified as mineral, or is absent. However, consideration of this data with the IMAU records indicates that as a generalisation the deposit may be regarded as 'almost continuous' and is classified accordingly. Borehole 04 NE 10 proves 3.8 m of sandy gravel between an upper 4.7 m of reddish brown till and a lower

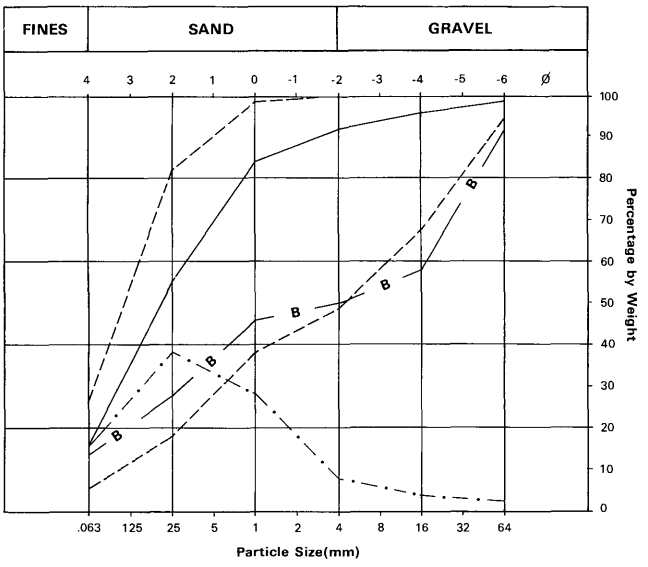

Figure 7 Grading characteristics of resources in valley-side deposits and Buchan Ridge gravels (Block C): the cumulative weighted mean (continuous line), envelope (broken lines) and frequency distribution (dashed and dotted line) are shown for valley-side deposits; the cumulative weighted mean (indicated by ——B——) is given for Buchan Ridge gravels

Table 11 Block C: data from assessment boreholes and exposures – resources in scattered deposits (fluvioglacial and glacial sand and gravel)

Sample point	Locality	Recorded thickness		Mean grading percentage						
		Mineral	Depth below surface	Fines	Fine sand	Medium sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles and boulders
		m	m	$-\frac{1}{16}$ mm	$+\frac{1}{16}-\frac{1}{4}$ mm	$+\frac{1}{4}-1$ mm	+1–4 mm	+4–16 mm	+16–64 mm	+64 mm
04 NE 10	Howe o' Buchan	3.8	5.7	2	5	19	27	18	28	1
04 SW 5†	Oldmill	10.4	0	3	6	40	29	8	8	6
04 SE 2	Moreseat	9.5	0	10	52	34	1	1	2	0
04 SE 3	Hillhead of Gask	2.0	0.3	26	23	16	11	12	12	0
04 SE 4	Redleas	1.0	0.2	13	12	16	24	26	9	0
04 SE 5†	Redleas	3.7	0	2	15	44	22	9	7	1
14 NW 3	Howe o' Buchan	1.9*	7.2	6	8	24	29	21	12	trace

† Indicates pit section; all other sample points are boreholes * Includes 0.2 m intervening waste

Table 12 Block C: data from assessment boreholes – resources in scattered deposits (Buchan Ridge gravels)

Borehole	Locality	Recorded thickness		Mean grading percentage						
		Mineral	Depth below surface	Fines	Fine sand	Medium sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles and boulders
		m	m	$-\frac{1}{16}$ mm	$+\frac{1}{16}-\frac{1}{4}$ mm	$+\frac{1}{4}-1$ mm	+1–4 mm	+4–16 mm	+16–64 mm	+64 mm
04 SW 3	Moss of Cruden	25.0	0	15	16	18	4	7	32	8
04 SE 6	Hill of Aldie	17.8	2.6	11	7	16	6	12	41	7
Mean		11.4†	insuf-ficient data	14	14	18	4	8	34	8

† It is assumed that the form of the Buchan Ridge gravels at the Moss of Cruden and the Hill of Aldie approximates to a triangular prism. The mean is derived from thicknesses proved at two sample points weighted by the inferred area of the deposit on which the boreholes are sited.

0.9 m of greenish grey till. The latter till grades as a 'very clayey' pebbly sand. Borehole 14 NW 3 proved 1.9 m of glacial sand and gravel, of which 1.7 m is mineral, between an upper 6.8 m of reddish brown till (the lower 0.8 m is a 'very clayey' sand) and lower 3.3 m of greenish grey till grading as 'clayey' pebbly sand.

Fluvioglacial sand and gravel is of very limited extent. Small deposits are mapped at Derran Howe [992 455] south-east of Stuartfield and at North Aldie [072 409]. Near Redleas, south-west of Peterhead, where a terraced deposit has been worked, section 04 SE 5 shows 3.7 m of pebbly sand composed dominantly of weathered granite fragments. About 200 m to the south-west of the section, borehole 04 SE 4 proved 1 m of mineral of similar composition overlying weathered granite bedrock, demonstrating the limited extent and variable thickness of the mineral deposits.

Ribbons of alluvium, which occupy the floors of several small valleys throughout the block are generally thought not to be potentially workable.

Claybound flint and quartzite gravels (the Buchan Ridge gravels), overlain in parts by peat and till, underlie the Moss of Cruden, where borehole 04 SW 3 proved at least 25 m of 'clayey' sandy gravel with a kaolinitic clay matrix, and the Hill of Aldie where borehole 04 SE 6 proved at least 17.8 m of similar material, grading as 'clayey' gravel overlain by 1.3 m of till, the latter also grading as mineral. Lying between these two sites borehole 04 SW 4, sited at the Corse of Balloch, proves 9.2 m of grey and yellowish brown kaolinitic clayey till on 3.0 m of clay-bound Buchan Ridge gravels, which do not grade as mineral, overlying decomposed bedrock. Data from this borehole and from IMAU trenches 04 SW P1, P2, P3, P5 and 04 SE P1 and P3 are used to define two areas of mineral, shown on the resource map. Both areas are thought to contain exposed and concealed potentially workable deposits. No data are available for the Buchan Ridge gravels at Den Muir [105 406] and Sandfordhill [115 416].

Assessment of resources: Potentially workable deposits occur in valley-side deposits and in scattered spreads of fluvioglacial and glacial sand and gravel and Buchan Ridge gravels.

On the basis of six boreholes the mean grading for the valley-side deposits is fines 16 per cent, sand 76 per cent and gravel 8 per cent ('clayey' pebbly sand),(Table 10; Figure 7). The mineral, which is generally at or near surface, has a mean thickness of 4.2 m. A volume, based on the areal extent of exposed fluvioglacial sand and gravel, is estimated at 21 million $m^3 \pm 57$ per cent (Table 5).

The following inferred assessments are offered for scattered deposits of fluvioglacial and glacial sand and gravel on the assumption that the available data are representative: Redleas, fluvioglacial sand and gravel, exposed, 0.3 million m^3; Moreseat, glacial sand and gravel, exposed, 5.2 million m^3; Howe o' Buchan, glacial sand and gravel, concealed, 1.6 million m^3; Oldmill, glacial sand and gravel, exposed, 0.9 million m^3; Hillhead of Gask, glacial sand and gravel, exposed, 0.4 million m^3. (Tables 6 and 11). No data are available for the other smaller pockets of sand and gravel in the block.

Based on two assessment boreholes, the mean grading for the Buchan Ridge gravels is fines 14 per cent, sand 36 per cent and gravel 50 per cent (Table 12; Figure 7), and at first sight a mean mineral thickness of 21.4 m might be inferred. This figure is not thought to be representative, however, as the boreholes were sited respectively on the highest parts of the ridges on the Moss of Cruden and the Hill of Aldie. A mean of 11.4 m has been calculated by considering the thickness of mineral proved at the two sample points weighted by the inferred areas of the deposit on which the boreholes are sited. On this basis an assumption has been made that the form of the mineral body at both localities approximates to a triangular prism with a base area defined by the inferred boundary shown on the resource map and a height which corresponds to proved material. The volume of exposed and concealed mineral is estimated at 24 million m^3 (Table 6). No assessment is offered for the two small patches of Buchan Ridge gravels at Den Muir and Sandfordhill.

Block D

Block D, bounded to the west by Block B and to the south by Block A, covers the coastal land around St Fergus [098 520]. West and south of that village the drift is composed predominantly of bright red and reddish brown clayey till locally interbedded with, or overlying, beds of silt, clay or fine sand mainly of glaciolacustrine origin, proved for example by boreholes 05 SE 4, 5 and 9, 14 NW 4 and 5 and 15 SW 3. None of these deposits is considered to be potentially workable.

Table 13 Block D: data from assessment boreholes and exposures – resources in coastal deposits (blown sand and post-Glacial beach deposits)

Sample point	Recorded thickness		Mean grading percentage						
	Mineral	Overburden to first mineral	Fines	Fine sand	Medium sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles and boulders
	m	m	$-\frac{1}{16}$ mm	$+\frac{1}{16}-\frac{1}{4}$ mm	$+\frac{1}{4}-1$ mm	+1–4 mm	+4–16 mm	+16–64 mm	+64 mm
05 SE 8	1.1	0.2	6	32	61	1	0	0	0
15 SW 1	1.7	0.2	12	26	61	1	trace	0	0
15 SW 2	2.6	0.2	trace	4	37	21	10	16	12
15 SW 4	1.3	0.2	4	39	56	1	0	0	0
15 SW 5†	5.3	0.3	1	10	84	trace	trace	2	3
Mean	2.4	0.2	3	16	66	5	2	4	4

† Indicates pit section; all other sample points are boreholes

Coastal deposits: East of St Fergus a flat strip of lake alluvium composed mainly of silt and clay is overlain in parts along the coast by blown sand, boreholes 05 SE 8 and 15 SW 1 and 4 showing the cover to be 1.1 m, 1.0 m and 1.3 m thick respectively. In borehole 15 SW 1 an upper 0.7 m of lake alluvium which grades as a 'clayey' sand has been considered in the assessment together with blown sand, but generally the former deposit is considered not potentially workable.

Elsewhere, section 15 SW 5 shows 4.3 m of blown sand resting on 1.0 m+ of post-Glacial beach deposits and although the latter are found at the surface in borehole 15 SW 2, which proved 2.6 m of sandy gravel overlying 9.3 m of till (of which 3.4 m grades as mineral), the extent of the outcrop is unknown and the deposit is not delimited on the resource sheet. Present-day beach deposits, below high-water mark, are not assessed.

Blown sand has been worked on St Fergus Links at [113 521]. Although land north of South Blackwater Farm [099 532] has been included in the assessment, it should be noted that the area is now occupied by the St Fergus Gas Terminal.

Assessment of resources: On the basis of four assessment boreholes and one section the mean grading of blown sand and post-Glacial beach deposits is fines 3 per cent, sand 87 per cent and gravel 10 per cent(Table 13; Figure 8).

Data from assessment sample points, which were all located towards the western margin of blown sand outcrop, give a mean mineral thickness (blown sand and post-Glacial beach deposits) of 2.4 m. This figure is considered to be unrepresentative, as dune ridges of blown sand are observed locally to exceed 10 m in height. Based on the areal extent of blown sand and on available data the inferred volume of mineral of about 8 million m^3 is probably an underestimate (Table 6).

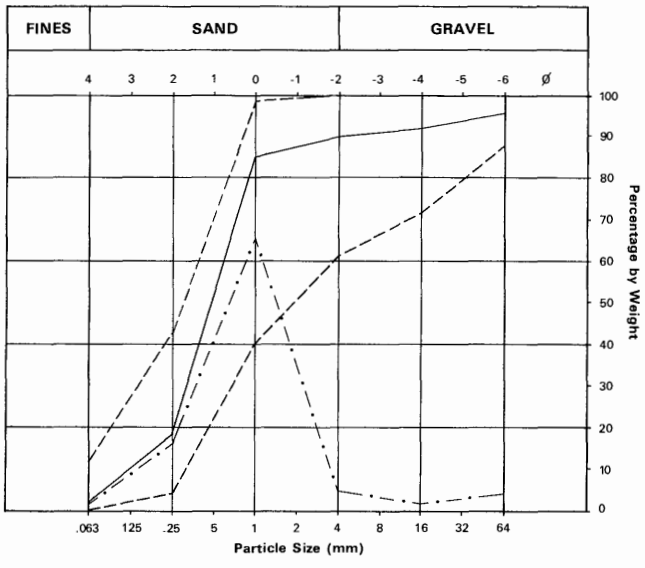

Figure 8 Grading characteristics of resources in coastal deposits (Block D). For explanation see Figure 5

Till (blocks A to D): Of a total of 294.1 m of till proved in assessment boreholes throughout the resource sheet 38.6 m or 13 per cent is judged to be potentially workable. However, no volumetric assessment for the deposit is offered, as boreholes show potentially workable material, which is found mainly in blocks B and C to occur sporadically. Based on data from seventeen boreholes, potentially workable till has a mean thickness of 2.3 m and a mean grading of fines 28 per cent, sand 54 per cent and gravel 18 per cent (Table 14). The mineral is generally concealed by overlying deposits which, at twelve of the seventeen sample points, include potentially workable sand and gravel.

Table 14 Blocks A to D: data from assessment boreholes – resources in till

Borehole	Resource block	Recorded thickness		Mean grading percentage						
		Mineral	Depth below surface	Fines	Fine sand	Medium sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles and boulders
		m	m	$-\frac{1}{16}$ mm	$+\frac{1}{16}-\frac{1}{4}$ mm	$+\frac{1}{4}-1$ mm	+1–4 mm	+4–16 mm	+16–64 mm	+64 mm
94 NE 1	C	1.0	1.3†	35	19	22	11	6	7	0
95 SE 13	B	3.4	4.6†	32	22	18	8	7	6	7
95 SE 14	B	2.4	1.6†	34	20	19	9	8	10	trace
04 NW 1	B	3.3	0.5	34	19	22	9	7	9	0
04 NW 2	A	2.1	6.4†	36	17	21	9	7	10	0
04 NW 10	C	2.0	6.5†	33	22	24	10	6	5	0
04 NE 1	B	2.1	4.3†	25	25	27	12	6	3	2
04 NE 10	C	0.9	9.5†	22	16	23	24	11	4	0
04 SE 1	C	1.3	0.7	34	23	18	12	6	7	0
04 SE 6	C	1.3	0.3	18	11	17	10	13	31	trace
05 SW 3	B	2.5	6.7†	39	21	21	8	7	4	0
05 SW 5	B	1.0	7.0†	20	22	35	13	7	3	0
05 SW 8	B	3.5	0.3	36	24	19	7	5	7	2
05 SW 9	A	1.5	2.5†	32	19	18	8	8	15	0
05 SW 10	B	2.8	5.5†	9	17	32	16	15	11	0
14 NW 3	C	4.1	6.4	20	17	27	26	7	3	0
15 SW 2	D	3.4	7.7†	16	28	14	6	10	23	3
Mean		2.3		28	21	22	11	8	9	1

† Overlying deposits include potentially workable sand and gravel

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 1:25000 sheet is divided into resource blocks. The arbitrary size selected, 10 km^2, is a compromise to meet the aims of the survey by providing sufficient sample points in each block. As far as possible the block boundaries are determined by geological boundaries so that, for example, glacial and river terrace gravels are separated. Otherwise division is by arbitrary lines, which may bear no relationship to the geology. The blocks are drawn provisionally before drilling begins.

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

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

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

A continuous series of bulk samples is taken throughout the sand and gravel. Ideally samples are composed exclusively of the whole of the material encountered in the borehole between stated depths. However, care is taken to discard, as far as possible, material which has caved or has been pumped from the bottom of the hole. A new sample is commenced whenever there is an appreciable lithological change within the sand and gravel, or ideally at every 1 m depth. The samples, each weighing between 25 and 45 kg, are despatched in heavy-duty polythene bags to a laboratory for grading. The grading procedure is based on British Standard 1377 (1975). Random checks on the accuracy of the grading are made in the laboratories of the Industrial Minerals Assessment Unit.

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

Detailed records may be consulted at the appropriate offices of the Institute, upon application.

APPENDIX B

STATISTICAL PROCEDURE

Statistical assessment

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

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

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

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

4 The above relationship may be transposed such that

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

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

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

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

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

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

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

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

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

Block calculation 1:25000 Block } Fictitious

Area
Block: 11.08 km²
Mineral: 8.32 km²

Mean thickness
Overburden: 2.5 m
Mineral: 6.5 m

Volume
Overburden: 21 million m³
Mineral: 54 million m³

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

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

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

Calculation of confidence limits

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

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

L_V is calculated as

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

Figure 9 Example of resource block assessment: calculation and results

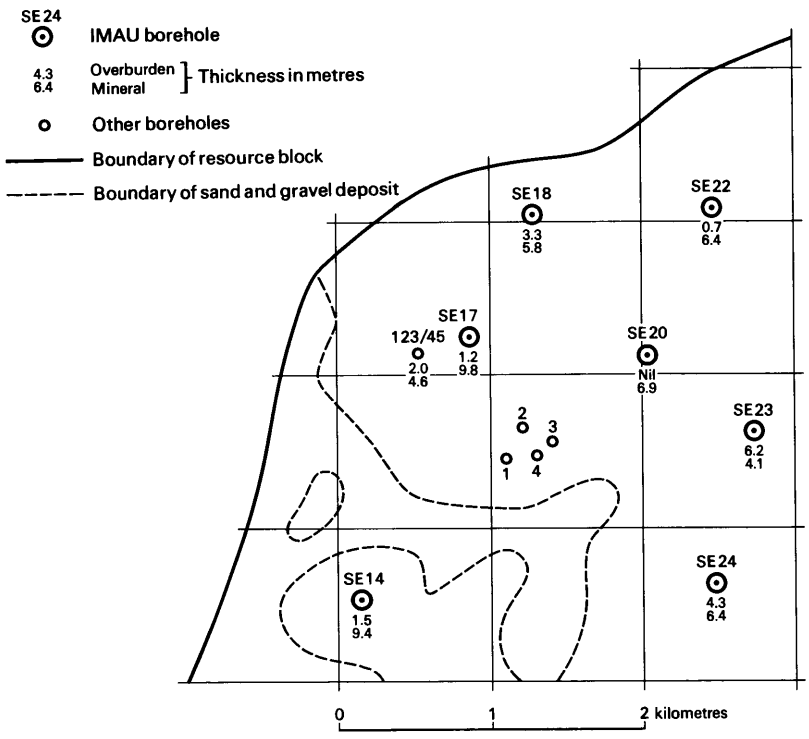

Figure 10 Example of resource block assessment: map of fictitious block

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 Figures 9 and 10.

Inferred assessment

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

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

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

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

APPENDIX C

CLASSIFICATION AND DESCRIPTION OF SAND AND GRAVEL

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

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

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

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

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

Thus it is possible to classify the mineral into one of twelve descriptive categories (see Figure 11). The procedure is as follows:

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

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

Many differing proposals exist for the classification of the grain size of sediments (Atterberg, 1905; Udden, 1914; Wentworth, 1922; Wentworth, 1935; Allen, 1936; Twenhofel, 1937; Lane and others, 1947). As Archer (1970a, b) has emphasised, there is a pressing need for a simple metric scale acceptable to both scientific and engineering interests, for which the class limit sizes correspond closely with certain marked changes in the natural properties of mineral particles. For example, there is an important change in the degree of cohesion between particles at about the $\frac{1}{16}$-mm size, which approximates to the generally accepted boundary between silt and sand. These and other requirements are met by a system based on Udden's geometric scale and a simplified form of Wentworth's terminology (Table 15), which is used in this Report.

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

The size distribution of borehole samples is determined by sieve analysis, which is presented by the laboratory as logarithmic cumulative curves (see, for example, British Standard 1377: 1975). In this report the grading is tabulated

on the borehole record sheets (Appendix F), the intercepts corresponding with the simple geometric scale $\frac{1}{16}$ mm, $\frac{1}{4}$ mm, 1 mm, 4 mm, 16 mm and so on as required. Original sample grading curves are available for reference at the appropriate office of the Institute.

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

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

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

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

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

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

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

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

Table 15 Classification of gravel, sand and fines

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

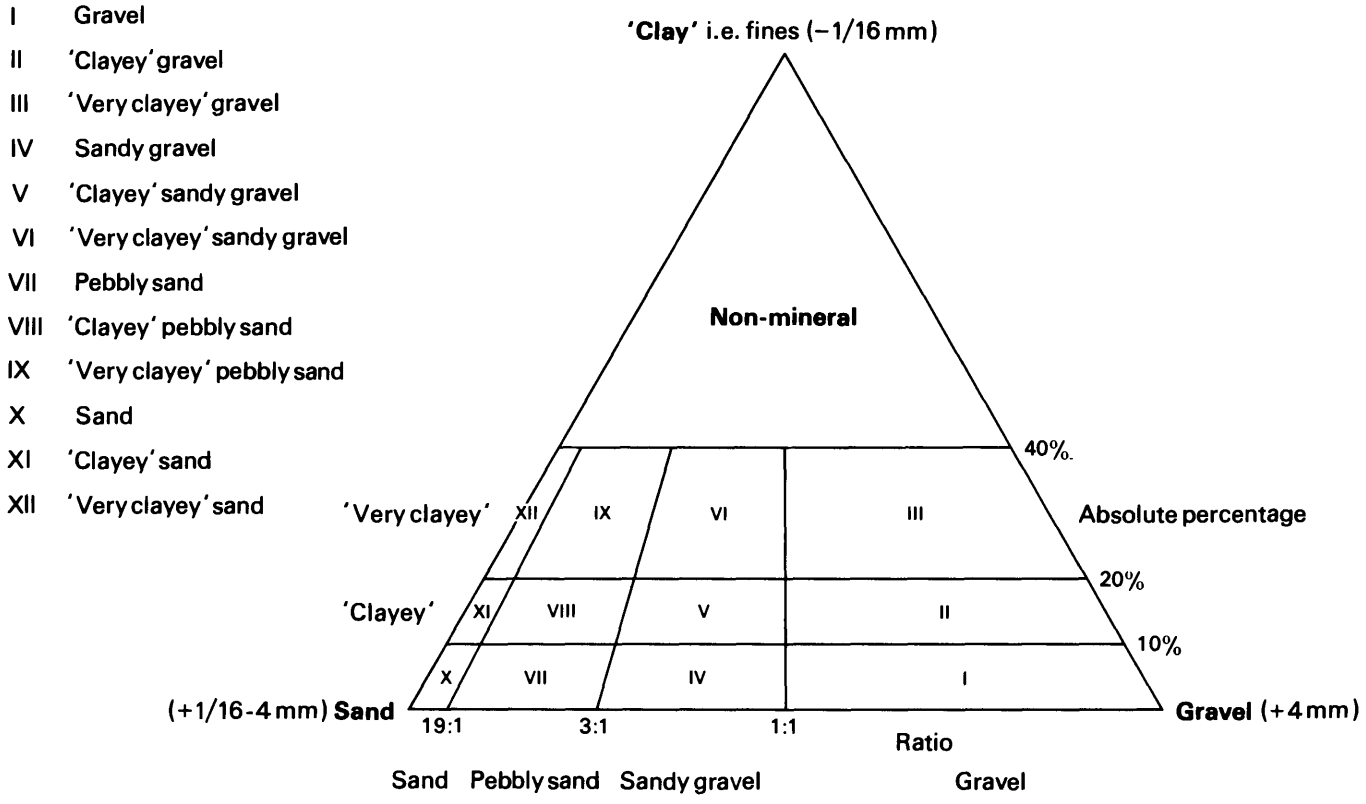

Figure 11 Diagram showing the descriptive categories used in the classification of sand and gravel

APPENDIX D

EXPLANATION OF THE ASSESSMENT RECORD

Annotated example

NK 04 NW 10[1] **0412 4698**[2] **Cairngall House, Longside**[3] **Block C**

Surface level +32.1 m[4]
Water struck at +28.3 m[5]
250 mm and 200 mm percussion[6]
February 1978

Overburden 0.4 m[7]
Mineral 1.9 m
Waste 1.5 m
Mineral 4.7 m
Waste 0.4 m
Mineral 1.0 m
Bedrock 2.0 m+[9]

LOG

Geological classification[10]	Lithology[11]	Thickness m	Depth[8] m
	Soil, dark brown, peaty	0.4	0.4
Fluvioglacial sand and gravel	**a** Sand, with thin bands of clay at top, and rare fine pebbles of granite Sand: fine to medium with coarse, subangular, quartz with feldspar and rock fragments, micaceous, orange-brown to dark brown Fines: clay, red-brown	1.9	2.3
Glaciolacustrine deposits	Clay, stiff, laminated, grey; below 3.4 m clay is red-brown with chocolate-brown laminae; both clays are unfossiliferous*	1.5	3.8
	b 'Clayey' sand with bands of stiff clay below 5.5 m and rare gravel Sand: fine to medium with coarse, subangular to subrounded, quartz with feldspar, micaceous, yellow-brown Fines: clay, red-brown and grey	2.7	6.5
?Till	**c** 'Very clayey' pebbly sand, possibly till Gravel: fine to coarse, subrounded granite and well rounded quartz Sand: fine to medium with coarse, subangular, quartz and rock fragments Fines: clay, dark brown to red-brown	2.0	8.5
Till	Clay, grey-brown, sandy with clasts of granite and quartz	0.4	8.9
Fluvioglacial sand and gravel	**d** Sandy gravel Gravel: fine to coarse with cobbles, subangular to rounded, granite, gneissose metasediments and quartz Sand: medium to coarse, subrounded quartz with feldspar and rock fragments	1.0	9.9
Dalradian	Gneiss, decomposed at top, dark grey, banded, micaceous	2.0+	11.9

* Samples PDS 17 and 18 examined by the Palaeontology Unit, Edinburgh

GRADING

	[15] Mean for deposit *percentages*			[12] Depth below surface (m)	[13] *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	9	90	1	0.4–0.8	9	35	45	8	2	1	0
				0.8–2.3	9	25	64	2	0	0	0
				Mean	9	27	60	3	1	trace	0
b	16	82	2	3.8–4.8	20	48	28	3	1	0	0†[14]
				4.8–5.5	4	60	33	2	1	0	0†
				5.5–6.5	21	39	31	7	2	0	0†
				Mean	16	48	30	4	2	0	0
c	33	56	11	6.5–7.5	29	22	28	12	6	3	0†‡[15]
				7.5–8.5	38	22	20	8	6	6	0†‡
				Mean	33	22	24	10	6	5	0
d	2	61	37	8.9–9.9	2	6	32	23	12	15	10†
a+b+c+d	17	75	8	Mean	17	30	37	8	4	3	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 section is identified by a Registration Number. This consists of two statements.

a The number of the 1:25000 sheet on which the record lies, for example NK 04

b The quarter of the 1:25000 sheet on which the record lies and its number in a series for that quarter, for example NW 10.

Thus the full Registration Number is NK 04 NW 10. Usually this is abbreviated to 04 NW 10 in the text.

Shallow trench logs not used in the assessment which are identified by quarter sheet are catalogued in a separate series prefixed by the letter P for example NJ 95 SE P3.

2 The National Grid reference
All National Grid references in this publication lie within the 100-km squares NJ and NK. 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 approximate locations, for example, for farms.)

3 Location
The position of the sample point is generally referred to the nearest named locality on the 1:25000 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 above Ordnance Datum. Measurements were made in metres.

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 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, face 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 7 and 14 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. Locally, however, the Peterhead granite, which comprises bedrock over much of the resource sheet is weathered to a degree which may render it potentially workable as a fine aggregate. An assessment of this material is not offered owing to its localised but undefined occurrence. Waste is any material other than bedrock or mineral. Where waste occurs between the surface and mineral it is classified as overburden.

8 Thickness and depth
All measurements were made in metres.

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

10 Geological classification
The geological classification is given whenever possible.

11 Lithological description
When sand and gravel 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 rocks is based on visual examination, in the field.

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

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

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

15 Mean grading
The grading of the full thickness of the mineral deposit identified in the log is the mean of the individual sample gradings weighted by the thicknesses represented, if these vary. The classification used is shown in Table 15. 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. Samples of potentially workable till with less than 40 per cent by weight passing $\frac{1}{16}$ mm, which are considered in the combined mean grading for individual logs but not in the estimate of volumes are indicated thus: ‡. These samples form a small proportion of a deposit which in the Peterhead area is regarded as generally unworkable. Data for sand and gravel sampled in shallow trenches which are not used in volume or grading calculations are similarly annotated (‡).

APPENDIX E

LIST OF BOREHOLES, SECTIONS AND SHALLOW TRENCHES USED IN THE ASSESSMENT OF RESOURCES

1 Industrial Minerals Assessment Unit Boreholes

Borehole number*	Grid reference	Page number
NJ 94 NE		
1	9759 4678	30
NJ 95 SE		
10	9526 5405	31
11	9659 5344	31
12	9815 5336	32
13	9874 5212	33
14	9972 5189	34
NK 04 NW		
1	0080 4942	37
2	0015 4716	38
3	0193 4709	39
4	0338 4973	40
5	0315 4775	41
6	0382 4620	42
7	0481 4902	42
8	0417 4900	43
9	0480 4821	44
10	0412 4698	45
NK 04 NE		
1	0581 4909	49
2	0575 4843	50
3	0596 4739	51
4	0663 4633	52
5	0799 4962	52
6	0743 4929	53
7	0702 4586	54
8	0802 4674	54
9	0952 4932	55
10	0987 4635	55
NK 04 SW		
1	0126 4040	56
2	0233 4365	56
3	0288 4020	57
4	0442 4132	58
NK 04 SE		
1	0530 4312	60
2	0529 4108	61
3	0871 4064	62
4	0906 4290	62
6	0594 4144	64
NK 05 SW		
1	0004 5087	66
2	0050 5069	67
3	0089 5023	68
4	0153 5120	69
5	0200 5034	70
6	0382 5421	71
7	0378 5212	71
8	0322 5056	72
9	0350 5015	73
10	0432 5433	74
11	0485 5327	75
12	0422 5088	75
NK 05 SE		
1	0577 5346	77
2	0592 5240	77
3	0521 5208	77
4	0774 5269	78
5	0791 5060	78
6	0702 5056	79
7	0867 5435	79
8	0999 5481	80
9	0989 5093	80
NK 14 NW		
1	1024 4811	81
2	1070 4719	81
3	1042 4652	82
4	1103 4930	83
5	1155 4816	83
6	1111 4528	84
NK 14 SW		
4	1111 4384	84
NK 15 SW		
1	1030 5344	85
2	1085 5280	86
3	1010 5159	87
4	1149 5097	87

2 Industrial Minerals Assessment Unit Sections

Section number*	Grid reference	Locality	Page number
NJ 95 SE			
15	9939 5226	Brownhill	35
16	9977 5213	Sandhole	36
NK 04 NW			
11	0358 4955	Knaps of Auchlee	46
12	0402 4920	Woodside	47
13	0419 4874	Loch of Auchlee	47
14	0435 4831	Auchlee	48
NK 04 SW			
5	0236 4405	Oldmill	59
NK 04 SE			
5	0927 4305	Redleas	63
NK 05 SW			
13	0187 5032	Mill of Hythie	76
14	0487 5282	Blackhills	76
NK 15 SW			
5	1132 5200	St Fergus Links	88

3 Industrial Minerals Assessment Unit Shallow Trenches (dug by excavator)

Trench number*	Grid reference	Page number
NJ 95 SE		
P1	9546 5354	88
P2	9642 5333	89
P3	9692 5317	89
P4	9806 5317	90
NK 04 NW		
P1	0108 4969	90
P2	0371 4824	91
P3	0460 4736	91
NK 04 NE		
P1	0522 4883	92
P2	0522 4681	92
P3	0598 4660	92
NK 04 SW		
P1	0186 4009	93
P2	0209 4077	93
P3	0407 4096	93
P4	0472 4066	94
P5	0430 4034	94
NK 04 SE		
P1	0544 4193	94
P2	0539 4048	95
P3	0623 4111	95
NK 05 SW		
P1	0251 5019	96

* By sheet quadrant

APPENDIX F

INDUSTRIAL MINERALS ASSESSMENT UNIT
BOREHOLE,SECTION AND SHALLOW TRENCH RECORDS

NJ 94 NE 1 **9759 4678** **Stonybrae, Stuartfield** **Block C**

Surface level +39.9 m
Groundwater level +37.4 m
200 mm percussion
March 1978

Overburden 0.3 m
Mineral 2.0 m
Waste 1.9 m
Bedrock 0.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	**a** Gravel Gravel: fine to coarse with cobbles, subrounded schistose and gneissose metasediments, and quartz Sand: fine to coarse, subangular, quartz, micaceous, brown	1.0	1.3
Till	**b** 'Very clayey' pebbly sand, a sandy till Gravel: fine to coarse, mainly gneissose metasediments, quartz and granite Sand: fine to coarse Fines: clay, brown with orange mottling	1.0	2.3
	Clay, sandy, brown with orange mottling, with clasts as above	1.9	4.2
Dalradian	Gneissose metasediment, decomposed, a mottled buff and white clay with weathered feldspar and quartz	0.4+	4.6

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
a	8	41	51	0.3–1.3	8	10	20	11	19	27	5
b	35	52	13	2.3–3.3	35	19	22	11	6	7	0†
a+b	22	46	32	Mean	22	14	21	11	12	17	3

NJ 95 SE 10 9526 5405 Newton Farm, Strichen **Block A**

Surface level +48.3 m
Water not struck
200 mm percussion
March 1978

Overburden 0.3 m
Mineral 1.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, brown	0.3	0.3
Alluvium	Cobble gravel Gravel: cobbles, boulders and coarse, some boulders up to 400 mm across, mainly well rounded, granite, schistose metasediments and other crystalline rocks Sand: fine to coarse, subangular, quartz and rock fragments, orange-brown Fines: clay, orange	1.2+	1.5
	Borehole abandoned due to boulder obstruction		

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
6	22	72	0.3–1.5	6	4	9	9	11	15	46

NJ 95 SE 11 9659 5344 Hillhead Farm, Strichen **Block A**

Surface level +43.2 m
Groundwater level +41.2 m
250 mm percussion
March 1978

Overburden 0.8 m
Mineral 2.2 m
Bedrock 0.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, silty at top, a mottled brown clay below 0.4 m	0.8	0.8
Alluvium	Gravel with band of orange micaceous silt from 2.0 to 2.1 m Gravel: mainly coarse with cobbles and boulders up to 250 mm, subrounded to well rounded, with subangular and angular, mainly quartz, quartzite, gneissose metasediments and granite Sand: fine to coarse, subangular, quartz with rock fragments, yellow-brown	2.2	3.0
Dalradian	Gneissose metasediments, micaceous, brownish grey, weathered	0.8+	3.8

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
2	34	64	0.8–2.0	trace	4	9	12	13	47	15
			2.0–3.0	4	7	20	19	22	28	0†
			Mean	2	5	14	15	17	38	9

NJ 95 SE 12 9815 5336 Kindrought Farm, Strichen **Block A**

Surface level +40.5 m
Water struck at +40.0 m
250 mm percussion
March 1978

Overburden 0.5 m
Mineral 2.3 m
Bedrock 0.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.5	0.5
Alluvium	Gravel Gravel: fine to coarse, with frequent cobbles up to 100 mm, subangular, pink quartzite, quartz, schistose metasediments with granite and felsite Sand: fine to coarse, subangular, quartz, orange-brown Fines: clay	2.3	2.8
Dalradian	Gneiss, coarsely crystalline, weathered, rusty green	0.7+	3.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
8	30	62	0.5–1.5	3	5	16	13	21	35	7†
			1.5–2.5	14	3	10	13	21	28	11†
			2.5–2.8	3	4	13	16	20	34	10†
			Mean	8	4	13	13	21	32	9

NJ 95 SE 13 9874 5212 Gaval Farm, Fetterangus **Block B**

Surface level +46.2 m
Groundwater level +42.0 m
200 mm percussion
March 1978

Overburden 0.1 m
Mineral 1.0 m
Waste 3.5 m
Mineral 3.4 m
Waste 1.0 m
Mineral 3.2 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, brown	0.1	0.1
Fluvioglacial sand and gravel	**a** Sandy gravel Gravel: fine to coarse, subrounded, granite with quartz and other rock fragments Sand: medium to coarse with fine, subangular, quartz with rock fragments, micaceous, brown	1.0	1.1
Glaciolacustrine deposits	Silt, light blue-grey, micaceous with bands of greyish brown clay; from 3.5 to 3.7 m, a band of very stiff red-brown till with fragments of granite and gneissose metasediments	3.5	4.6
Till	**b** 'Very clayey' sandy gravel, a sandy till Gravel: fine to coarse with cobbles, subangular to rounded, granite, quartzite, quartz and other crystalline rocks with felsite Sand: fine to medium with coarse, subangular, quartz and rock fragments Fines: clay, light grey	3.4	8.0
	Clay, sandy, light grey, mottled in parts with reddish staining, few clasts	1.0	9.0
Fluvioglacial sand and gravel	**c** Sandy gravel Gravel: fine to coarse with some cobbles, mainly crystalline rocks and quartz Sand: mainly medium to coarse, subangular, quartz and rock fragments	3.2	12.2
Dalradian	Gneiss, weathered, micaceous, brown	0.3+	12.5

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
a	5	63	32	0.1–1.1	5	6	22	35	18	14	0
b	32	48	20	4.6–5.6	39	23	20	9	7	2	0‡
				5.6–6.6	28	20	15	6	6	3	22‡
				6.6–7.6	40	25	19	8	6	2	0‡
				7.6–8.0	9	16	16	10	11	38	0‡
				Mean	32	22	18	8	7	6	7
c	4	51	45	9.0–10.0	6	7	23	26	14	24	0†
				10.0–11.0	3	3	10	21	24	37	2†
				11.0–12.2	3	5	26	29	10	27	0†
				Mean	4	5	20	26	15	29	1
a+c	4	54	42	Mean	4	5	21	28	16	26	trace
a+b+c	17	51	32	Mean	17	13	19	19	12	17	3

NJ 95 SE 14 9972 5189 Sandhole Farm, Fetterangus **Block B**

Surface level +40.6 m
Water struck at +39.6 m and +32.0 m
200 mm percussion
February 1978

Overburden 0.6 m
Mineral 3.4 m
Waste 6.4 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Fluvioglacial sand and gravel	**a** Pebbly sand Gravel: fine to coarse, subangular to subrounded, mainly pink granite with quartzite and quartz Sand: fine to coarse, subangular, quartz with feldspar and rock fragments, micaceous, brown	1.0	1.6
Till	**b** 'Very clayey' sandy gravel, a grey to yellow-brown sandy till Gravel: fine to coarse with cobbles, subangular granite, basic igneous rocks, mica-schist, and quartz Sand: fine to coarse, subangular, quartz and rock fragments Fines: clay, grey becoming yellow-brown below 2.0 m	2.4	4.0
	Clay, yellow-brown with subangular clasts as above	4.6	8.6
Fluvioglacial sand and gravel	Gravel Gravel: mainly coarse, subangular to subrounded felsite, granite, quartz and mica-schist Sand: medium to coarse, subangular, quartz and rock fragments	0.8	9.4
Till	Clay, very stiff, sandy, with fragments of mica-schist and granite	1.0	10.4
Dalradian	Quartzite, medium-grained, quartz with weathered feldspar, white	0.3+	10.7

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
a	9	71	20	0.6–1.6	9	22	34	15	16	4	0
b	34	48	18	1.6–2.0	38	19	18	8	8	9	trace‡
				2.0–4.0	33	20	20	9	8	10	trace‡
				Mean	34	20	19	9	8	10	trace
a+b	27	55	18	Mean	27	20	24	11	10	8	0

NJ 95 SE 15 9939 5226 Sand and gravel pit at Brownhill Farm, Fetterangus **Block B**

Surface level +52.2 m
Section dry
Sampling by hand
May 1978

Mineral 4.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Fluvioglacial sand and gravel	Pebbly sand, increasingly sandy at depth Gravel: fine with coarse and rare cobbles, subrounded, granite, felsite, quartzite, gneissose metasediments and quartz with flint and basic igneous rocks Sand: medium with coarse and fine, subrounded, quartz with mica and rock, yellow	4.3+	4.3

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
1	86	13	0.0–1.0	1	2	43	27	10	14	3
			1.0–2.0	1	5	49	28	10	7	0
			2.0–3.0	2	10	59	21	7	1	0
			3.0–4.3	2	18	51	24	4	1	0
			Mean	1	10	51	25	7	5	1

NJ 95 SE 16 9977 5213 Sandhole Sand Pit, Fetterangus **Block B**

Surface level +52.8 m
Section dry
Sampling by hand
May 1978

Mineral 4.1 m+

LOG

Geological classification		Lithology	Thickness m	Depth m
Fluvioglacial sand and gravel	**a**	Sand, containing thin brown clay and silt partings, finely laminated Gravel: rare, fine Sand: fine and medium with coarse, subrounded, quartz with some rock, micaceous, yellow Fines: silt and clay, brown	2.0	2.0
Glaciolacustrine deposits	**b**	'Very clayey' sand Sand: mainly fine with medium, quartz, micaceous, yellow Fines: silt and clay, brown	2.1+	4.1

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
a	9	90	1	0.0–1.0	12	51	32	4	1	0	0
				1.0–2.0	5	15	69	9	2	0	0
				Mean	9	33	51	6	1	0	0
b	24	76	0	2.0–3.0	32	51	15	2	0	0	0
				3.0–4.1	17	69	13	1	0	0	0
				Mean	24	60	14	2	0	0	0
a+b	16	83	1	Mean	16	47	32	4	1	0	0

NK 04 NW 1 0080 4942 Boghead Farm, Mintlaw **Block B**

Surface level +38.0 m
Water struck at +35.8 mm
250 mm percussion
February 1978

Overburden 0.5 m
Mineral 3.3 m
Bedrock 0.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Peat	0.5	0.5
Till	'Very clayey' pebbly sand Gravel: fine to coarse, angular to subrounded, granite and gneissose metasediments Sand: fine to medium with coarse Fines: clay, greenish grey becoming orange-brown at depth	3.3	3.8
Caledonian	Granite, very weathered, a gruss at top, with hard fragments towards base, coarsely crystalline, micaceous, orange-pink	0.8+	4.6

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
34	50	16	0.5–2.0	32	18	20	9	8	13	0‡
			2.0–3.0	38	19	23	8	6	6	0‡
			3.0–3.8	35	21	26	9	6	3	0‡
			Mean	34	19	22	9	7	9	0

NK 04 NW 2 0015 4716 Baluss Bridge, Mintlaw **Block A**

Surface level 35.5 m
Groundwater level +30.5 m
200 mm percussion
March 1978

Overburden 0.3 m
Mineral, including
1.1 m waste 5.1 m
Waste 1.0 m
Mineral 2.1 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, light brown	0.3	0.3
Alluvium	**a** 'Clayey' pebbly sand, with two bands of stiff, red-brown to brown unfossiliferous* laminated clay from 1.3 to 1.6 m and 2.7 to 3.5 m Gravel: fine with coarse, well rounded, quartz, quartzite and other rocks Sand: medium with coarse and fine, subangular, quartz with rock, brown Fines: clay and silt, increasing at depth	5.1	5.4
Till	Clay, sandy, stiff, with numerous fine gravel-sized clasts	1.0	6.4
	b 'Very clayey' sandy gravel Gravel: coarse and fine, various rock types Sand: medium and fine with coarse, quartz with rock, orange-brown Fines: silt and clay, brown	2.1	8.5
Dalradian	Psammite, flaggy, dark grey, micaceous, banded, weathered	0.2+	8.7

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
a	13	75	12	0.3–1.3	3	7	49	27	12	2	0
				1.3–1.6				Waste			
				1.6–2.7	13	12	35	26	10	4	0
				2.7–3.5				Waste			
				3.5–4.4	15	30	33	13	9	0	0
				4.4–5.4	20	24	32	14	4	6	0
				Mean	13	18	37	20	9	3	0
b	36	47	17	6.4–7.4	36	18	21	9	7	9	0‡
				7.4–8.5	35	17	20	9	8	11	0‡
				Mean	36	17	21	9	7	10	0
a+b	20	66	14	Mean	20	18	32	16	8	6	0

* Sample PES 24 (from 1.3 to 1.6 m) examined by the Palaeontology Unit, Edinburgh

NK 04 NW 3 0193 4709 Inverquhomery, Longside **Block A**

Surface level +22.7 m
Water struck at +22.2 m (artesian)
150 mm percussion
March 1978

Overburden 1.0 m
Mineral 4.0 m
Waste 2.0 m
Mineral including
0.7 m waste 4.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.5	0.5
Alluvium	Silt, micaceous, bluish grey	0.5	1.0
	a Pebbly sand, increasingly silty at depth Gravel: fine to coarse, well rounded to subrounded, quartz, quartzite, granite and other rock fragments Sand: medium to coarse, becoming fine to medium below 2.0 m, subangular, quartz and feldspar with rock fragments, micaceous, grey Fines: silt, grey	4.0	5.0
Glaciolacustrine deposits	Silt, grey, laminated, with an appreciable amount of plant and arthropod remains*, and rare brown fine sand laminae	2.0	7.0
Fluvioglacial sand and gravel	**b** Pebbly sand, with band of laminated red and dark grey clay from 10.1 to 10.8 m Gravel: mainly fine, subrounded, quartz, granite and schistose rocks with felsite Sand: mainly medium to coarse, quartz and feldspar with rock fragments, micaceous, orange-brown Fines: silt, brown, micaceous	4.4+	11.4
	Borehole abandoned due to rising sand		

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
a	7	75	18	1.0–2.0	3	7	23	39	13	15	0†
				2.0–3.0	1	22	37	23	13	4	0†
				3.0–4.0	6	37	39	9	5	4	0†
				4.0–5.0	18	34	20	8	7	13	0†
				Mean	7	25	30	20	9	9	0
b	6	83	11	7.0–8.0	6	8	39	28	16	3	0†
				8.0–8.7	4	9	38	29	12	8	0†
				8.7–10.1	8	14	53	23	2	0	0†
				10.1–10.8	clay						
				10.8–11.4	4	10	56	19	7	4	0†
				Mean	6	11	47	25	8	3	0
a+b	7	78	15	Mean	7	18	38	22	9	6	0

* Sample PDS 38 (at 6.0 m) examined by the Palaeontology Unit, Edinburgh

NK 04 NW 4 0338 4973 Knaps of Auchlee, Longside **Block B**

Surface level +36.1 m
Water not struck
250 mm percussion
February 1978

Overburden 0.4 m
Mineral 4.5 m
Waste 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	Pebbly sand Gravel: fine to coarse, subrounded, felsite, quartz, granite and yellow sandstone with basic igneous rocks Sand: medium with fine and coarse, subrounded, quartz with feldspar and rock fragments, micaceous, orange-brown	4.5	4.9
	Boulder, no recovery	0.2+	5.1
	Borehole abandoned due to rock obstruction		

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
6	78	16	0.4–1.4	7	12	63	15	2	1	0
			1.4–2.4	4	12	66	11	2	5	0
			2.4–3.4	6	11	47	19	3	14	0
			3.4–4.4	7	9	41	22	7	14	0
			4.4–4.9	3	7	28	16	5	10	31
			Mean	6	10	51	17	4	9	3

NK 04 NW 5 0315 4775 **Massiesbraes, Longside** **Block C**

Surface level +27.5 m
Groundwater level +19.5 m
200 mm percussion
February 1978

Overburden 2.0 m
Mineral 6.0 m
Waste 13.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
?Alluvium	Clay, silty, faintly laminated, mottled, orange-brown; becoming a reddish brown silt below 1.8 m	1.6	2.0
	a 'Very clayey' sand with thin bands of red-brown stiff laminated clay Sand: fine to medium, subrounded to subangular, quartz, with feldspar, yellow Fines: clay, red-brown	1.0	3.0
Glaciolacustrine deposits	**b** 'Very clayey' sand, with thin bands of chocolate-brown laminated clay Sand: fine with medium, subangular to subrounded, quartz with feldspar Fines: silt and clay	5.0	8.0
	Clay, silty, stiff, laminated, unfossiliferous*, becoming a grey-brown micaceous silt at depth with bands of chocolate-brown clay and rare laminae of fine micaceous, quartz sand	13.5+	21.5

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
a	24	76	0	2.0–3.0	24	36	36	4	0	0	0†
b	27	73	0	3.0–4.0	16	50	32	2	0	0	0†
				4.0–5.0	19	71	10	0	0	0	0†
				5.0–6.0	38	56	6	0	0	0	0†
				6.0–7.0	40	55	5	0	0	0	0†
				7.0–8.0	21	68	10	1	0	0	0†
				Mean	27	60	13	trace	0	0	0
a+b	26	74	0	Mean	26	56	17	1	0	0	0

* Sample PES 14 (at 9.0 m) examined by the Palaeontology Unit, Edinburgh

NK 04 NW 6 0382 4620 Linshart Farm, Longside **Block C**

Surface level +33.6 m
Water not struck
250 mm percussion
January 1978

Overburden 0.3 m
Mineral 2.0 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, dark brown	0.3	0.3
Fluvioglacial sand and gravel	'Very clayey' sandy gravel with thin band of greenish grey till below 1.3 m Gravel: fine to coarse, subrounded pink granite and gneissose metasediments, with well rounded quartz; increasing content of angular granite fragments at depth Sand: fine to coarse, subangular, quartz and granite Fines: clay, mainly brown	2.0	2.3
Caledonian	Granite, coarsely crystalline, leucocratic, pink, a sand at top becoming hard at depth	0.9+	3.2

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
22	53	25	0.3–1.3	22	15	23	15	17	8	0
			1.3–2.3	not available						
			Mean	22	15	23	15	17	8	0

NK 04 NW 7 0481 4902 Wester Rora Farm, Longside **Block B**

Surface level +35.9 m
Water struck at +32.1 m
200 mm percussion
February 1978

Waste 4.1 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Clay, sandy, mottled in parts, orange-brown to brown, with numerous subangular to subrounded clasts of granite and schistose metasediments, up to cobble size	3.7	4.1
Dalradian	Psammite, buff, weathered, fine- to medium-grained, micaceous	0.3+	4.4

NK 04 NW 8 0417 4900 Milbank Farm, Longside **Block A**

Surface level +22.6 m
Water struck at +22.3 m (artesian)
200 mm percussion
February 1978

Overburden 0.5 m
Mineral 7.0 m
Waste 6.0 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey, dark brown	0.5	0.5
Alluvium	**a** Gravel Gravel: fine to coarse with cobbles, subrounded to well rounded, granite, gneissose and schistose metasediments, sandstone, quartzite, felsite and quartz with basic igneous rocks Sand: medium to coarse, subangular to subrounded white quartz and rock fragments, micaceous	3.0	3.5
Fluvioglacial sand and gravel	**b** Sandy gravel, with bands of grey micaceous silt from 3.5 to 4.5 m Gravel: fine to coarse with some cobbles, subrounded to well rounded, composition as above Sand: medium to coarse, as above Fines: silt, micaceous, grey	4.0	7.5
Till	Clay, light brown at top, becoming dark grey and stiff at depth, sandy with numerous angular to well rounded clasts of mainly granite and quartz	6.0	13.5
Caledonian	Granite, coarsely crystalline, pink, leucocratic	0.2+	13.7

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
a	2	38	60	0.5–1.5	2	5	11	17	21	30	14†
				1.5–2.5	2	5	11	16	20	46	0†
				2.5–3.5	0	8	21	21	14	32	4†
				Mean	2	6	14	18	18	36	6
b	5	46	49	3.5–4.5	16	18	12	10	16	28	0†
				4.5–5.5	1	3	18	24	26	28	0†
				5.5–6.5	1	2	17	20	17	33	10†
				6.5–7.5	2	2	23	33	21	19	0†
				Mean	5	6	18	22	20	27	2
a+b	4	42	54	Mean	4	6	16	20	19	31	4

NK 04 NW 9 0480 4821 Auchlee Farm, Longside **Block B**

Surface level +23.6 m
Groundwater level +20.6 m
250 mm and 200 mm percussion
February 1978

Overburden 0.5 m
Mineral 3.0 m
Waste 16.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.5	0.5
Fluvioglacial sand and gravel	Gravel Gravel: fine to coarse, with cobbles, subrounded to well rounded, gneissose metasediments, quartzite, granite and schist with felsite and quartz Sand: fine to coarse, subrounded, quartz and rock fragments, micaceous Fines: silt, brownish grey	3.0	3.5
Glaciolacustrine deposits	Silt, laminated, micaceous, sandy in parts, red-brown becoming grey-brown to greenish grey with depth, interbedded with a laminated, stiff, unfossiliferous*, red-brown silty clay	16.5+	20.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
4	35	61	0.5–1.5	7	10	26	11	11	35	0
			1.5–2.5	1	5	10	9	14	49	12
			2.5–3.5	3	3	12	18	28	36	0
			Mean	4	6	16	13	17	40	4

* Sample PDS 20 (at 17.0 m) examined by the Palaeontology Unit, Edinburgh

NK 04 NW 10 **0412 4698** **Cairngall House, Longside** **Block C**

Surface level +32.1 m
Water struck at +28.3 m
250 mm and 200 mm percussion
February 1978

Overburden 0.4 m
Mineral 1.9 m
Waste 1.5 m
Mineral 4.7 m
Waste 0.4 m
Mineral 1.0 m
Bedrock 2.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown peaty	0.4	0.4
Fluvioglacial sand and gravel	**a** Sand, with thin bands of clay at top, and rare fine pebbles of granite Sand: fine to medium with coarse, subangular, quartz with feldspar and rock fragments, micaceous, orange-brown to dark brown Fines: clay, red-brown	1.9	2.3
Glaciolacustrine deposits	Clay, stiff, laminated, grey; below 3.4 m clay is red-brown with chocolate-brown laminae; both clays are unfossiliferous*	1.5	3.8
	b 'Clayey' sand with bands of stiff clay below 5.5 m and rare gravel Sand: fine to medium with coarse, subangular to subrounded, quartz with feldspar, micaceous, yellow-brown Fines: clay, red-brown and grey	2.7	6.5
?Till	**c** 'Very clayey' pebbly sand, possibly till Gravel: fine to coarse, subrounded granite and well rounded quartz Sand: fine to medium with coarse, subangular, quartz and rock fragments Fines: clay, dark brown to red-brown	2.0	8.5
Till	Clay, grey-brown, sandy with clasts of granite and quartz	0.4	8.9
Fluvioglacial sand and gravel	**d** Sandy gravel Gravel: fine to coarse with cobbles, subangular to rounded, granite, gneissose metasediments and quartz Sand: medium to coarse, subrounded quartz with feldspar and rock fragments	1.0	9.9
Dalradian	Gneiss, decomposed at top, dark grey, banded, micaceous	2.0+	11.9

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
a	9	90	1	0.4–0.8	9	35	45	8	2	1	0
				0.8–2.3	9	25	64	2	0	0	0
				Mean	9	27	60	3	1	trace	0
b	16	82	2	3.8–4.8	20	48	28	3	1	0	0†
				4.8–5.5	4	60	33	2	1	0	0†
				5.5–6.5	21	39	31	7	2	0	0†
				Mean	16	48	30	4	2	0	0
c	33	56	11	6.5–7.5	29	22	28	12	6	3	0†‡
				7.5–8.5	38	22	20	8	6	6	0†‡
				Mean	33	22	24	10	6	5	0
d	2	61	37	8.9–9.9	2	6	32	23	12	15	10†
a+b+d	11	81	8	Mean	11	33	41	7	3	3	2
a+b+c+d	17	75	8	Mean	17	30	37	8	4	3	1

* Samples PDS 17 and 18 examined by the Palaeontology Unit, Edinburgh

NK 04 NW 11 0358 4955 Sand and gravel pit at Knaps of Auchlee, Longside **Block B**

Surface level +35.8 m
Water struck at +28.5 m
Sampling section and trench
May 1978

Mineral 7.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Fluvioglacial sand and gravel	**a** Sand with rare fine pebbles Sand: medium to coarse with fine, subrounded, quartz with rock fragments, micaceous	1.0	1.0
	b Sandy gravel Gravel: fine to coarse with cobbles, subrounded to well rounded, granite, quartzite, psammite, schistose metasediments and quartz Sand: medium to coarse, subrounded, quartz, yellow	6.7+	7.7

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
a	1	95	4	0.0–1.0	1	5	64	26	3	1	0
b	1	54	45	1.0–2.0	1	2	31	24	17	25	0
				2.0–3.0	1	2	28	32	18	12	7
				3.0–4.0	1	2	22	29	20	26	0
				4.0–5.0	1	2	18	16	18	38	7
				5.0–6.5	1	1	49	31	15	3	0
				6.5–7.7	1	3	11	10	13	49	13†
				Mean	1	2	28	24	16	25	4
a+b	1	58	41	Mean	1	2	32	24	15	22	4

NK 04 NW 12 0402 4920 Sand and gravel pit at Woodside Farm, Longside **Block B**

Surface level +29.6 m
Water struck at +23.4 m
Sampling section
May 1978

Mineral 6.2 m
Waste 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Fluvioglacial sand and gravel	Pebbly sand Gravel: fine to coarse, well rounded, quartz, psammite, other metamorphic rocks and granite Sand: mainly medium with fine and coarse, subrounded, quartz with rock fragments, micaceous, orange	6.2	6.2
Till	Clay, stiff, grey	0.5+	6.7

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
2	86	12	0.0–1.0	1	6	65	12	9	7	0
			1.0–2.0	2	5	77	8	5	3	0
			2.0–3.0	1	9	75	11	3	1	0
			3.0–4.0	4	14	78	3	1	0	0
			4.0–5.0	1	4	28	44	20	3	0
			5.0–6.2	2	8	35	34	8	9	4
			Mean	2	8	59	19	7	4	1

NK 04 NW 13 0419 4874 Sand and gravel pit near Loch of Auchlee, Longside **Block B**

Surface level +25.2 m
Water struck at +22.7 m
Sampling section
May 1978

Mineral 2.5 m
Waste 0.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Fluvioglacial sand and gravel	Gravel Gravel: fine to coarse with cobbles, well rounded, quartz, quartzite, granite and psammite, iron-stained Sand: medium to coarse, subrounded, quartz with rock fragments	2.5	2.5
	Silt, with fine sand, micaceous, blue- grey	0.8+	3.3

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	44	55	0.0–1.0	2	2	28	15	16	37	0
			1.0–2.5	1	1	22	20	18	31	7
			Mean	1	1	24	19	18	33	4

NK 04 NW 14 0435 4831 Craigie Sand and Gravel Quarry, Auchlee Farm, Longside **Block B**

Surface level +25.3 m
Water struck at +21.8 m
Sampling section
May 1978

Mineral 3.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Fluvioglacial sand and gravel	**a** Gravel Gravel: fine to coarse with cobbles, well rounded, quartzite, psammite, granite and quartz with felsite, iron-stained Sand: medium to coarse, subrounded, quartz and rock fragments, orange-brown	2.5	2.5
	b 'Clayey' sand Sand: fine to medium with coarse, subrounded, quartz, micaceous Fines: silt, grey	1.0+	3.5

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
a	1	33	66	0.0–1.0	2	2	13	17	20	39	7
				1.0–2.5	1	trace	12	21	20	43	3
				Mean	1	1	13	19	20	42	4
b	12	85	3	2.5–3.5	12	28	42	15	3	0	0
a+b	4	48	48	Mean	4	9	21	18	15	30	3

NK 04 NE 1 0581 4909 Howe of Rora Farm, Longside **Block B**

Surface level +30.0 m
Water struck at +28.7 m
250 mm and 200 mm percussion
October 1977

Overburden 0.6 m
Mineral 1.7 m
Waste 2.0 m
Mineral 2.1 m
Bedrock 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.6	0.6
Fluvioglacial sand and gravel	**a** 'Clayey' sandy gravel Gravel: fine to coarse, well rounded to subrounded, quartzite, gneiss and quartz with felsite Sand: fine to coarse, subangular, quartz and rock fragments Fines: clay, red-brown	1.7	2.3
Till	Clay, stiff, red, becoming grey and silty at depth	2.0	4.3
	b 'Very clayey' pebbly sand with several bands of red and grey clay Gravel: fine to coarse with cobbles, subangular, mica-schist and quartz Sand: fine to medium with coarse, subangular, quartz and rock fragments, brown Fines: clay, red to grey	2.1	6.4
Dalradian	Gneissose metasediment, with granitic veining, decomposed at top, micaceous	1.1+	7.5

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
a	13	48	39	0.6–1.4	21	18	17	12	14	18	0
				1.4–2.3	6	10	15	24	18	27	0†
				Mean	13	14	16	18	16	23	0
b	25	64	11	4.3–5.3	26	25	25	9	6	4	5‡
				5.3–6.4	24	26	28	14	6	2	0‡
				Mean	25	25	27	12	6	3	2
a+b	20	57	23	Mean	20	20	22	15	10	12	1

NK 04 NE 2 0575 4843 Buthlaw Farm, Longside **Block A**

Surface level +21.3 m
Water struck at +19.3 m
250 mm and 200 m percussion
November 1977

Overburden 0.3 m
Mineral 2.7 m
Waste 17.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.3	0.3
Alluvium	Sandy gravel, sandier at depth Gravel: coarse and fine with cobbles mainly well rounded, quartzite, felsite, gneissose metasediments, granite and quartz Sand: medium and coarse with fine, subangular, rock and quartz Fines: clay	2.7	3.0
Glaciolacustrine deposits	Silty clay, laminated, micaceous, fine sand partings, red-brown, with black (?) carbonaceous material to 4.6 m; greenish grey silt laminae from 4.6 to 8.7 m	14.4	17.4
	Clay, stiff, laminated, greenish grey, with thin lenses of red-brown silt	1.4	18.8
	Clay, stiff, laminated, reddish brown with lenses of brown silt	1.4+	20.2

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
8	60	32	0.3–1.3	7	8	18	16	22	22	7
			1.3–2.3	10	10	32	22	16	10	0
			2.3–3.0	5	4	32	44	13	2	0†
			Mean	8	8	27	25	17	12	3

NK 04 NE 3 0596 4739 Bridge of Buthlaw, Longside **Block C**

Surface level +30.3 m
Groundwater level +26.9 m
200 mm percussion
November 1977

Overburden 0.7 m
Mineral 6.0 m
Waste 7.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty, dark brown	0.7	0.7
Fluvioglacial sand and gravel	**a** Sand, becoming silty at depth Sand: fine with medium, subangular, quartz, micaceous, yellow Fines: silt	1.9	2.6
Glaciolacustrine deposits	**b** 'Very clayey' sand Sand: fine with medium, subangular, quartz, micaceous, yellow Fines: silt, micaceous, grey	4.1	6.7
	Silt, sandy, micaceous, grey becoming a brownish grey stiff silty clay below 9.0 m	3.1	9.8
Till	Clay, stiff, sandy in parts, greenish grey with numerous angular to well rounded clasts of felsite, granite, quartz, basic igneous rocks and gneissose metasediments	3.9+	13.7
	Borehole abandoned due to slow progress in stony till		

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	9	90	1	0.7–2.6	9	35	50	5	1	0	0
b	22	78	0	2.6–3.6	20	55	24	1	0	0	0†
				3.6–4.7	19	74	7	0	0	0	0†
				4.7–5.7	21	73	6	0	0	0	0†
				5.7–6.7	27	70	3	0	0	0	0†
				Mean	22	68	10	trace	0	0	0
a+b	18	82	0	Mean	18	58	22	2	0	0	0

NK 04 NE 4 0663 4633 Bridge of Faichfield, Longside **Block A**

Surface level +34.0 m
Groundwater level +31.3 m
250 mm and 200 mm percussion
November 1977

Overburden 2.0 m
Mineral 3.7 m
Waste 1.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and made ground	2.0	2.0
Alluvium	Gravel, sandy at depth Gravel: fine to coarse with cobbles, subangular to subrounded, granite, felsite, gneissose metasediments and quartzite Sand: mainly coarse, subangular, feldspar and rock fragments with quartz	3.7	5.7
Till	Clay, stiff, sandy, brown, becoming grey at depth, with clasts of granite	1.2+	6.9
	No recovery below 6.7 m: borehole abandoned due to rock obstruction		

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
2	48	50	2.0–3.0	1	5	13	23	24	27	7†
			3.0–4.0	2	4	17	21	10	22	24†
			4.0–5.0	1	4	22	19	7	26	21†
			5.0–5.7	3	4	29	38	14	12	0†
			Mean	2	4	20	24	14	22	14

NK 04 NE 5 0799 4962 Roundhillock Farm, Longside **Block C**

Surface level +19.9 m
Groundwater level +15.3 m
200 mm percussion
November 1977

Waste 6.0 m
Bedrock 2.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown, peaty	0.9	0.9
Till	Clay, dense, reddish brown with pebbles	1.5	2.4
Glaciolacustrine deposits	Silt, micaceous, grey-brown, with clay bands and fine sand laminae	2.3	4.7
Till	Silt, greenish grey-brown, sandy with numerous clasts of schistose and gneissose metasediments	1.3	6.0
Dalradian	Schistose metasediment, very weathered, decomposed from 6.0 to 7.0 m, brownish grey, medium-grained	2.3+	8.3

NK 04 NE 6 0743 4929 Newseat Farm, Longside **Block A**

Surface level +20.2 m
Groundwater level +17.4 m
250 mm and 200 mm percussion
November 1977

Overburden 0.4 m
Mineral 1.0 m
Waste 17.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown, sandy	0.4	0.4
Alluvium	Sandy gravel Gravel: fine to coarse, subrounded, granite, felsite, and gneissose metasediments Sand: mainly coarse, subrounded, quartz, feldspar and rock fragments	1.0	1.4
Glaciolacustrine deposits	Clay, laminated, stiff, red-brown to greenish grey, with bands of brown to brownish grey silt, laminae of yellowish brown, fine sand and some well rounded pebbles of schistose metasediments and sandstone	17.8+	19.2

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
5	67	28	0.4–1.4	5	4	22	41	15	13	0

NK 04 NE 7 0702 4586 West Thunderton Farm, Longside **Block C**

Surface level +42.1 m
Water struck at +39.1 m
200 mm percussion
March 1978

Overburden 0.4 m
Mineral 4.6 m
Waste 0.6 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, black, peaty	0.4	0.4
Fluvioglacial sand and gravel	Pebbly sand, sandier at depth Gravel: fine with coarse, well rounded to subrounded, granite and quartz with quartzite, rare flint and felsite Sand: medium with coarse and fine, coarsening upwards, mainly subangular, quartz with rock and feldspar, orange-brown Fines: silt and clay	4.6	5.0
	Clay, red, stiff, unfossiliferous*, laminated with grey silty clay bands and rare fine sand laminae	0.6	5.6
Caledonian	Granite, pink, medium-grained, hard	0.2+	5.8

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
6	81	13	0.4–1.4	7	8	23	40	18	4	0
			1.4–2.4	3	4	34	40	18	1	0
			2.4–3.6	8	21	51	8	6	6	0
			3.6–4.6	6	26	52	12	2	2	0
			4.6–5.0	8	25	66	1	0	0	0
			Mean	6	16	43	22	10	3	0

* Sample PES 26 examined by the Palaeontology Unit, Edinburgh

NK 04 NE 8 0802 4674 Airfield (disused), Peterhead **Block C**

Surface level +44.7 m
Water struck at +42.7 m
250 mm percussion
November 1977

Waste 4.2 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Till	Clay, mottled at top, red-brown to brown, greenish grey at depth, with angular to subrounded clasts of basic igneous rocks, grey granite, gneissose and schistose metasediments	4.2	4.2
Caledonian	Granite, weathered, leucocratic, coarsely crystalline, pink	0.2+	4.4

NK 04 NE 9 0952 4932 Cairnhill Farm, Peterhead **Block D**

Surface level +36.5 m
Groundwater level +33.6 m
250 mm and 200 mm percussion
October 1977

Waste 8.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown	0.5	0.5
Till	Clay, mottled, grey at depth, with numerous subangular to well rounded clasts of granite, gneissose metasediments and basic igneous rocks	3.3	3.8
	Clay, plastic, red to red-brown, with subangular to well rounded clasts of granite, basic igneous rocks and gneissose metasediments with quartz	4.2+	8.0
	Borehole abandoned due to rock obstruction		

NK 04 NE 10 0987 4635 Berryhill Farm, Peterhead **Block C**

Surface level +28.6 m
Groundwater level +26.3 m
250 mm and 200 mm percussion
December 1977

Overburden 5.7 m
Mineral 4.7 m
Bedrock 0.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	1.0	1.0
Till	Clay, stiff, red-brown, with infrequent clasts of mainly subangular to subrounded, granite, weathered metasediments and quartz; thin bands of greenish grey to dark grey, stiff, unfossiliferous*, laminated silty clay occur from 4.3 m, 5.0 to 5.1 m and 5.6 to 5.7 m	4.7	5.7
Glacial sand and gravel	**a** Sandy gravel with thin bands of greenish grey clay below 8.5 m Gravel: fine to coarse with cobbles, of varied composition and shape, subangular granite, well rounded quartzite, sandstone, dark grey pelite, with quartz, flint and quartz-mica-schist Sand: medium to coarse, subangular, quartz and feldspar with flecks of mica, reddish yellow Fines: clay	3.8	9.5
Till	**b** 'Very clayey' pebbly sand, a greenish grey sandy till Gravel: fine to coarse, subangular, granite and feldspar Sand: medium to coarse with fine, subangular granite and feldspar fragments Fines: clay, greenish grey	0.9	10.4
Caledonian	Granite, very weathered, a gruss composed of quartz and feldspar, leucocratic, pink	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	2	51	47	5.7–6.7	2	8	25	27	19	19	0†
				6.7–7.7	1	3	12	17	17	46	4†
				7.7–8.5	0	3	17	34	18	28	0†
				8.5–9.5	4	5	22	32	17	20	0†
				Mean	2	5	19	27	18	28	1
b	22	63	15	9.5–10.4	22	16	23	24	11	4	0†‡
a+b	6	53	41	Mean	6	7	20	26	16	24	1

* Sample PES 3 (from 5.6 to 5.7 m) examined by the Palaeontology Unit, Edinburgh

NK 04 SW 1 0126 4040 Bogengarrie Farm, near Longside **Block C**

Surface level +127.3 m
Water not struck
250 mm percussion
March 1978

Waste 2.5 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty, black	0.3	0.3
Till	Clay, light brown to orange-brown, mottled, with clasts of subrounded white quartzite and subangular to angular, weathered schist with rare flint	2.2	2.5
Dalradian	Gneissose metasediment, weathered, foliated, micaceous, orange-brown	0.5+	3.0

NK 04 SW 2 0233 4365 Newton of Ludquharn, Longside **Block C**

Surface level +50.2 m
Water struck at +46.4 m
200 mm percussion
January 1978

Waste 4.5 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey, dark grey	0.2	0.2
Till	Clay, silty, sandy at depth, mottled, red-brown at top, becoming grey-brown to greenish grey, with angular clasts of granite and quartz with gneissose metasediments and flint	4.3	4.5
Caledonian	Microdiorite*, finely crystalline, hornblende, biotite and quartz with phenocrysts of plagioclase	0.2+	4.7

* Number S 65233 in the specimen and thin section collection of the Geological Survey, Edinburgh

NK 04 SW 3 **0288 4020** **Moss of Cruden, near Longside** **Block C**

Surface level +138.8 m
Water not struck
250 mm and 200 mm percussion
January 1978

Mineral 25.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Buchan Ridge gravels, ?Pliocene	**a** 'Clayey' gravel Gravel: coarse with fine, well rounded with angular, brown flint with rare white quartzite; fine flint is mainly angular Sand: fine to coarse, angular, flint and quartz, white *Fines: clay, mainly kaolinite, white, unfossiliferous	3.0	3.0
	b 'Clayey' pebbly sand Gravel: fine to coarse, well rounded, flint with quartzite Sand: fine to medium with coarse, angular, flint fragments and quartz Fines: clay, white	3.0	6.0
	c 'Clayey' gravel, with 'very clayey' sand from 14.0 to 15.0 m Gravel: coarse and cobbles with fine, well rounded and angular, brown flint with white quartzite and rare quartz Sand: fine to coarse, subrounded, quartz and weathered rock fragments, yellowish white *Fines: clay, white, becoming yellowish white to buff below 12.0 m, kaolinite with illite, unfossiliferous	19.0+	25.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
a	15	26	59	0.0–1.0	15	8	11	6	13	47	0†
				1.0–2.0	16	6	10	6	14	48	0†
				2.0–3.0	13	17	14	0	14	42	0
				Mean	15	10	12	4	14	45	0
b	18	76	6	3.0–4.0	19	22	43	16	0	0	0†
				4.0–5.0	20	69	11	0	0	0	0†
				5.0–6.0	15	34	32	2	4	13	0†
				Mean	18	42	29	6	1	4	0
c	15	34	51	6.0–7.0	14	14	20	4	10	25	13†
				7.0–8.0	8	10	17	4	15	38	8†
				8.0–9.0	12	13	23	6	10	15	21†
				9.0–10.0	7	6	11	3	5	38	30†
				10.0–11.0	24	17	14	6	6	33	0†
				11.0–12.0	14	12	15	5	9	45	0†
				12.0–13.0	12	8	11	3	4	50	12†
				13.0–14.0	21	21	17	3	7	31	0†
				14.0–15.0	31	48	20	1	0	0	0†
				15.0–16.0	14	15	13	4	8	31	15†
				16.0–17.0	17	15	20	3	10	35	0†
				17.0–18.0	12	8	16	3	7	46	8†
				18.0–19.0	17	12	26	6	4	16	19†
				19.0–20.0	8	5	11	3	6	56	11†
				20.0–21.0	18	9	20	6	8	29	10†
				21.0–22.0	9	6	13	4	8	50	10†
				22.0–23.0	10	5	10	4	12	59	0†
				23.0–24.0	19	11	20	6	5	23	16†
				24.0–25.0	21	9	16	6	7	27	14†
				Mean	15	13	17	4	7	34	10
a+b+c	15	38	47	Mean	15	16	18	4	7	32	8

• Clay matrix composition of X-ray films XE 278 (at 1.0 m), XE 281 (at 16.9 m) and XE 275 (at 24.0 m) determined by Petrology Unit, Edinburgh. Samples PES 9 to 11 at these depths also examined by Palaeontology Unit, Edinburgh

NK 04 SW 4 0442 4132 Corse of Balloch, near Longside **Block C**

Surface level +125.9 m
Water not struck
250 mm and 200 mm percussion
March 1978

Waste 13.5 m
Bedrock 3.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.5	0.5
Peat	Peat	0.8	1.3
Till	Clay*, composed of kaolinite and illite, very stiff, light blue grey, unfossiliferous, with clasts of subangular granite and some subrounded flint	1.7	3.0
	Clay, stiff in parts, sandy, light brown to yellow-brown, with numerous clasts of subrounded to well rounded quartz and flint and subangular to subrounded granite, metasediments and felsite; from 3.5 to 4.5 m clay is laminated, brown, with bands of orange-brown silt and fine, subrounded dark yellow quartz, sand, containing few pebbles	7.5	10.5
Buchan Ridge gravels	Clay, stiff at top, sandy, light grey with fine to coarse clasts of well rounded quartz and white quartzite and rounded flint; sand fraction is composed of fine with coarse, subangular, quartz	3.0	13.5
Dalradian	Decomposed metasediment, a light grey kaolinitic clay‡, with orange mottling and faint banding; below 14.0 m, clay contains weathered white feldspar and biotite	3.0+	16.5

* Sample PDS 34 (at 3.0 m) examined by Palaeontology Unit; clay matrix composition of this sample determined from X-ray film XE 287 by the Petrology Unit, Edinburgh

‡ Clay matrix composition determined from X-ray film XE 295 by the Petrology Unit, Edinburgh

NK 04 SW 5 0236 4405 Oldmill Sand Pit, Longside **Block C**

Surface level +54.7 m
Water struck at +45.2 m
Sampling section and trench
May 1978

Mineral 10.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial sand and gravel	**a** Pebbly sand Gravel: fine and coarse, subrounded to well rounded granite, quartz, quartzite, gneissose rocks and weathered felsite Sand: coarse with medium and some fine subrounded, quartz with feldspar, mica and rock, yellow Fines: little	3.0	3.0
	b Gravel Gravel: cobble with coarse and fine, subrounded to well rounded, composition as above Sand: coarse and medium with rare fine, subrounded, quartz with feldspar, mica and rock Fines: little	2.0	5.0
	c Pebbly sand Gravel: coarse and fine with rare cobbles, well rounded, granite and quartz Sand: medium with coarse and some fine, subrounded, quartz with feldspar and mica Fines: thin clay bands	5.4+	10.4

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
a	3	79	18	0.0–1.0	3	7	38	40	9	3	0
				1.0–2.0	2	6	27	45	12	8	0
				2.0–3.0	3	8	26	40	12	11	0
				Mean	3	7	30	42	11	7	0
b	2	46	52	3.0–4.0	3	2	10	23	19	20	23
				4.0–5.0	2	2	32	22	7	5	30
				Mean	2	2	21	22	13	13	27
c	3	84	13	5.0–6.0	3	5	42	30	7	13	0
				6.0–7.0	1	8	50	31	5	5	0
				7.0–8.0	3	8	53	23	5	8	0
				8.0–8.5	Not sampled						
				8.5–9.5	6	10	60	19	4	1	0
				9.5–10.4	3	3	57	21	2	5	9
				Mean	3	7	52	25	5	6	2
a+b+c	3	75	22	Mean	3	6	40	29	8	8	6

NK 04 SE 1 0530 4312 Moss of Kinmundy, Longside **Block C**

Surface level +78.5 m
Groundwater level +76.9 m
250 mm percussion
January 1978

Overburden 0.7 m
Mineral 1.3 m
Bedrock 0.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Peat	0.7	0.7
Till	'Very clayey' pebbly sand Gravel: fine to coarse, angular to well rounded, quartz, flint, dark green igneous rocks and gneissose metasediments with granite Sand: fine to medium, subangular, quartz, micaceous, grey Fines: clay, grey-brown	1.3	2.0
Dalradian	Metagreywacke*, coarse-grained, rounded quartz and feldspar, weathered	0.6+	2.6

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
34	53	13	0.7–1.7	34	24	19	12	6	5	0‡
			1.7–2.0	32	21	16	10	8	13	0†‡
			Mean	34	23	18	12	6	7	0

* Number S65234 in the specimen and thin section collection of the Geological Survey, Edinburgh

NK 04 SE 2 0529 4108 Moreseat Farm, near Peterhead **Block C**

Surface level +98.5 m
Water struck at +96.9 m
200 mm percussion
January 1978

Mineral 9.5 m
Waste 2.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial sand and gravel	**a** Sand Sand: fine to medium, subangular to subrounded, quartz, with feldspar and rare mica, orange becoming white below 4.0 m	7.0	7.0
	b 'Very clayey' pebbly sand, increase in gravel below 9.0 m Gravel: fine to coarse, mainly well rounded, quartzite, quartz and basic igneous rocks with rare gneissose metasediments Sand: fine to medium, subangular to subrounded, quartz Fines: blue-grey silt and light brown clay	2.5	9.5
Till	Clay, silty, grey-black, compact, unfossiliferous* micaceous, with rare clasts *Borehole abandoned after slow progress in compact till*	2.3+	11.8

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	7	93	0	0.0–1.0	7	52	40	1	0	0	0
				1.0–2.0	10	57	32	0	0	1	0
				2.0–3.0	8	77	15	0	0	0	0†
				3.0–4.0	5	51	44	0	0	0	0†
				4.0–5.0	6	50	44	0	0	0	0†
				5.0–6.0	6	50	44	0	0	0	0†
				6.0–7.0	4	54	41	1	0	0	0†
				Mean	7	56	37	0	0	0	0
b	20	68	12	7.0–8.0	7	42	41	4	2	4	0†
				8.0–9.0	37	50	9	1	1	2	0†
				9.0–9.5	14	22	19	5	13	27	0†
				Mean	20	41	24	3	4	8	0
a+b	10	87	3	Mean	10	52	34	1	1	2	0

* Sample PES 8 examined by the Palaeontology Unit, Edinburgh

NK 04 SE 3 0871 4064 Hillhead of Gask, Peterhead **Block C**

Surface level +75.5 m
Groundwater level +73.4 m
250 mm percussion
December 1977

Overburden 0.3 m
Mineral 2.0 m
Waste 1.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown, peaty	0.3	0.3
Glacial sand and gravel	'Very clayey' sandy gravel Gravel: fine to coarse, subangular to well rounded, quartz, quartzite and granite with flint and other rock fragments Sand: fine to coarse, subangular, yellow, quartz and rock fragments Fines: clay, brown	2.0	2.3
Till	Clay, grey-brown, sandy, with angular granite clasts; below 3.2 m chiselling on a boulder: rock fragments recovered	1.4+	3.7
	Borehole abandoned due to rock 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
26	50	24	0.3–1.3	16	22	15	13	18	16	0
			1.3–2.3	35	25	17	9	6	8	0
			Mean	26	23	16	11	12	12	0

NK 04 SE 4 0906 4290 Redleas Farm, Peterhead **Block C**

Surface level +74.0 m
Water not struck
250 mm percussion
December 1977

Overburden 0.2 m
Mineral 1.0 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.2	0.2
Fuvioglacial sand and gravel	'Clayey' sandy gravel Gravel: fine to coarse, angular to subangular, pink granite fragments Sand: fine to coarse, subangular, quartz and feldspar Fines: clay	1.0	1.2
Caledonian	Granite, weathered, coarsely crystalline, leucocratic, pink	0.2+	1.4

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
13	52	35	0.2–1.2	13	12	16	24	26	9	0

NK 04 SE 5 0927 4305 **Sand and gravel pit at Redleas Farm, Peterhead** **Block C**

Surface level +73.1 m
Water not struck
Sampling section
May 1978

Mineral 3.7 m
Waste 0.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Fluvioglacial sand and gravel	**a** Sandy gravel Gravel: fine to coarse with cobbles, subrounded to well rounded, granite, flint and quartzite with quartz Sand: medium to coarse with fine, angular, quartz and feldspar with granite fragments, yellow-brown	2.0	2.0
	b Sand with rare pebbles of flint Sand: fine to medium with coarse, feldspar and quartz	1.7	3.7
Till	Clay, green, hard and compact, with fragments of feldspar and flint	0.8+	4.5

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
a	3	67	30	0.0–1.0	3	2	14	44	16	17	4
				1.0–2.0	3	12	32	32	15	6	0
				Mean	3	6	23	38	16	12	2
b	2	98	trace	2.0–3.0	2	26	70	2	trace	0	0
				3.0–3.7	not available						
				Mean	2	26	70	2	trace	0	0
a+b	2	81	17	Mean	2	15	44	22	9	7	1

NK 04 SE 6 0594 4144 Berryley Farm, near Peterhead **Block C**

Surface level +106.6 m
Groundwater level +96.2 m
250 mm and 200 mm percussion
December 1978

Overburden 0.3 m
Mineral 19.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Peat	0.3	0.3
Till	**a** 'Clayey' gravel, a gravelly till Gravel: fine to coarse, well rounded, quartzite and flint, and a boulder of gneiss Sand: fine to coarse, quartz Fines: clay, orange-brown, mottled	1.3	1.6
Buchan Ridge gravels, ?Pliocene	**b** 'Clayey' gravel Gravel: coarse with fine and cobbles, well rounded, brown flint, some with white patena, white quartzites, some micaceous, and vein-quartz Sand: fine to coarse, subangular, flint and quartz, white Fines: clay and silt, white	6.0	7.6
	c 'Very clayey' sandy gravel, a clay-bound gravel, becoming sandy below 10.5 m Gravel: coarse with fine and cobbles, well rounded flint, quartzite and vein-quartz with decomposed pebbles Sand: fine to coarse, quartz and flint, white with orange iron-staining throughout Fines: clay and silt, white	3.7	11.3
	d Gravel, clay-bound in parts Gravel: mainly coarse and cobbles, with fine, cobbles up to 170 m, well rounded to subangular, brown flint and well rounded, white quartzite and vein-quartz, with decomposed pebbles showing relict igneous and metamorphic fabrics Sand: medium with fine and coarse, quartz and flint, white Fines: mainly clay with silt, white, homogeneous	8.1+	19.4
	Borehole abandonded due to slow progress in cobble gravel		

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	18	38	44	0.3–1.6	18	11	17	10	13	31	trace‡
b	10	20	70	1.6–2.6	14	7	9	4	4	62	0
				2.6–3.6	4	4	5	5	16	60	6†
				3.6–4.5	8	6	9	5	19	53	0†
				4.5–5.5	10	5	10	6	15	48	6†
				5.5–6.7	13	6	13	4	13	51	0†
				6.7–7.6	8	7	12	2	10	61	0†
				Mean	10	6	10	4	13	55	2
c	21	40	39	7.6–9.0	27	9	16	4	13	31	0†
				9.0–10.5	21	10	20	6	19	24	0†
				10.5–11.3	11	13	53	2	2	8	11†
				Mean	21	10	25	5	13	24	2
d	7	30	63	11.3–13.0	3	4	14	8	14	44	13†
				13.0–14.5	9	6	18	8	12	36	11†
				14.5–16.0	6	5	19	9	11	36	14†
				16.0–17.5	8	7	19	5	13	41	7†
				17.5–19.4	8	6	16	6	11	31	22†
				Mean	7	6	17	7	12	37	14
b+c+d	11	29	60	Mean	11	7	16	6	12	41	7
a+b+c+d	11	29	60	Mean	11	7	16	6	13	40	7

NK 05 SW 1 0004 5087 Milltown of Gaval, Fetterangus **Block B**

Surface level +44.9 m
Water struck at +39.9 m
250 mm and 200 mm percussion
February 1978

Overburden 0.3 m
Mineral 4.7 m
Waste 6.5 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glaciolacustrine deposits	'Clayey' sand with gravel above 1.0 m Gravel: mainly coarse, well rounded, granite, quartzite and quartz Sand: mainly fine, subangular, quartz, micaceous, yellowish brown to brown, orange-brown below 4.0 m Fines: silt, yellow-brown	4.7	5.0
	Silt, sandy, grey, micaceous with bands of grey-brown, laminated clay	4.0	9.0
	Clay, silty, laminated, unfossiliferous*, red to brown with greenish grey, micaceous silt laminae with rounded pebbles of felsite and angular fragments of granite	2.5	11.5
Dalradian	Gneissose metasediment‡, coarsely crystalline, with biotite and shimmer aggregate	0.9+	12.4

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
15	82	3	0.3–1.0	16	35	19	10	3	13	4
			1.0–2.0	7	86	6	1	0	0	0
			2.0–3.0	24	73	3	0	0	0	0
			3.0–4.0	19	76	5	0	0	0	0
			4.0–5.0	9	33	57	1	0	0	0
			Mean	15	62	18	2	trace	2	1

* Sample PDS 26 (at 11.0 m) examined by the Palaeontology Unit, Edinburgh
‡ Number S 65235 in the specimen and thin section collection of the Geological Survey, Edinburgh

NK 05 SW 2 0050 5069 Milltown of Gaval, Fetterangus **Block A**

Surface level +32.1 m
Water struck at +28.1 m (Artesian)
250 mm and 200 mm percussion
March 1978

Waste 8.0 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.7	0.7
Alluvium	Silt with some fine sand, rare fine gravel, micaceous, grey to brown	3.8	4.5
	Sandy gravel Gravel: fine with coarse and rare cobbles, subrounded, schistose metasediments, granite and quartz Sand: coarse and medium with some fine, subangular, quartz, rock and mica, yellow-brown Fines: little	1.1	5.6
Till	Clay, sandy, with clasts up to 250 mm, mainly of fine-grained grey granite, gneissose metasediments and quartz	1.4	7.0
Fluvioglacial sand and gravel	Gravel Gravel: coarse and fine with rare cobbles, subrounded to well rounded, quartz, quartzite and schistose and gneissose metasediments Sand: coarse and medium with fine, subangular, quartz with mica and rock, yellowish brown Fines: little	1.0	8.0
Dalradian	Metasediment, highly decomposed silt, rust-coloured	0.5+	8.5

NK 05 SW 3 0089 5023 Dumbmill Farm, Mintlaw **Block B**

Surface level +33.2 m
Groundwater level +31.1 m
200 mm and 150 mm percussion
March 1978

Overburden 0.3 m
Mineral 8.9 m
Waste 1.0 m
Mineral 2.4 m
Waste 0.4 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown loam	0.3	0.3
Fluvioglacial sand and gravel	**a** Gravel, dense, clean, light brown at surface Gravel: coarse and fine, with cobbles, rounded to well rounded, of varied composition, including granite, quartz, quartzite, gneissose metasediments and varied igneous rocks Sand: mainly coarse and medium, sharp, mainly angular, quartz, and rock grains, light to mid-grey, grey-brown from 1.3 to 2.3 m Fines: silt, mica	6.4	6.7
Till	**b** 'Very clayey' pebbly sand, a greenish grey to light brown sandy till Gravel: fine to coarse, mainly subrounded to rounded of varied composition Sand: fine to medium with coarse Fines: silt and clay	2.5	9.2
	Clay, firm to stiff, grey-brown, becoming dark grey at depth, with angular to subrounded clasts, commonly of grey-black gneissose metasediments	1.0	10.2
Fluvioglacial sand and gravel	**c** Sandy gravel, light brown Gravel: fine and coarse with rare granite cobbles, subangular to well rounded, of varied composition Sand: fine to coarse, mostly subangular, quartz with feldspar and rock, rare garnet	2.4	12.6
Till	Clay, sandy, silty, rust-coloured, micaceous, with few clasts of mostly weathered bedrock	0.4	13.0
Dalradian	Psammite, veined with quartz, medium-grained, quartz and feldspar, rust-coloured weathering	0.5+	13.5

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
a	3	46	51	0.3–1.3	trace	3	16	19	24	38	0
				1.3–2.3	10	2	16	16	18	30	8
				2.3–3.3	3	5	21	21	15	35	0
				3.3–4.3	1	1	11	23	18	39	7†
				4.3–5.3	1	1	23	26	16	27	6†
				5.3–6.3	2	2	26	41	19	11	0†
				6.3–6.7	2	2	25	37	15	19	0†
				Mean	3	2	19	25	18	30	3
b	39	50	11	6.7–9.2	39	21	21	8	7	4	0‡
c	2	53	45	10.2–11.2	3	7	20	21	21	28	0†
				11.2–12.6	2	5	24	26	23	18	2†
				Mean	2	6	23	24	22	22	1
a+c	3	48	49	Mean	3	3	20	25	19	27	3
a+b+c	11	48	41	Mean	11	7	20	21	17	22	2

NK 05 SW 4 0153 5120 Middle Hythie Farm, Longside **Block B**

Surface level +43.6 m
Groundwater level +42.0 m
200 mm percussion
February 1978

Waste 7.4 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.5	0.5
Till	Clay, sandy and silty in parts, dark grey, stiff, with angular to well rounded clasts of felsite, granite, gneiss and quartz, with shell fragments; below 6.0 m clay is very sandy with numerous clasts of granite and gneiss	6.9	7.4
Caledonian	Granite, coarsely crystalline, with pyrite, pink	0.3+	7.7

NK 05 SW 5 0200 5034 Mill of Hythie, Longside **Block B**

Surface level +33.9 m
Water struck at +29.9 m
250 mm and 200 mm percussion
February 1978

Mineral 1.2 m
Waste 2.8 m
Mineral 1.6 m
Waste 1.4 m
Mineral 1.0 m
Waste 2.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Fluvioglacial sand and gravel	**a** Sandy gravel: very silty sand below 1.0 m Gravel: mainly coarse with cobbles, subrounded, basalt, granite and quartz with felsite Sand: medium, subangular, quartz with rock fragments, yellow	1.2	1.2
Glaciolacustrine deposits	Clay, silty, laminated, grey	2.8	4.0
Fluvioglacial sand and gravel	**b** Sand Sand: medium with fine, subangular, quartz with rock fragments, micaceous, grey	1.6	5.6
Glaciolacustrine deposits	Clay, stiff, laminated, red-brown, becoming dark grey at depth, with rare rock fragments	1.4	7.0
Till	**c** 'Very clayey' pebbly sand Gravel: fine with coarse, subangular to subrounded, fine-grained igneous rocks, and gneissose metasediments Sand: fine to medium with coarse Fines: clay, grey	1.0	8.0
	Clay, very stiff, black with subangular to subrounded and well rounded clasts of grey granite and other crystalline rocks	2.5+	10.5
	Borehole abandoned due to rock obstruction		

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
a	6	67	27	0.0–1.0	1	10	42	15	6	8	18
				1.0–1.2	32	50	16	1	1	0	0
				Mean	6	16	38	13	5	7	15
b	7	89	4	4.0–5.0	6	23	34	33	4	0	0†
				5.0–5.6	9	23	38	27	3	0	0†
				Mean	7	23	35	31	4	0	0
c	20	70	10	7.0–8.0	20	22	35	13	7	3	0‡
a+b	7	80	13	Mean	7	20	37	23	4	3	6
a+b+c	10	77	13	Mean	10	21	36	20	5	3	5

NK 05 SW 6 0382 5421 **Longhill Plantation, Crimond** **Block B**

Surface level +54.2 m
Groundwater level +51.1 m
200 mm percussion
March 1978

Waste 7.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Peat	1.1	1.1
Till	Clay, silty, soft, becoming firm, with numerous clasts, many cobble-sized, mainly subangular to rounded, of dark grey medium-grained gneissose rocks, granites, quartzite, quartz, igneous rocks and red sandstone. Colour is dark grey	6.4+	7.5
	Borehole abandoned due to rock obstruction		

NK 05 SW 7 0378 5212 **Cairntawie Wood, St Fergus** **Block B**

Surface level +56.6 m
Water struck at +56.3 m
250 mm percussion
March 1978

Waste 3.9 m
Bedrock 0.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Peat, brown	0.3	0.3
Till	Clay, stiff, grey, with subangular to subrounded clasts of dark grey gneiss	3.6	3.9
Dalradian	Gneissose metasediment*, coarsely crystalline, quartz and feldspar, with shimmer aggregate, weathered	0.8+	4.7

* Number S 65236 in the specimen and thin section collection of the Geological Survey, Edinburgh

NK 05 SW 8 0322 5056 East Cortiecram Farm, Longside **Block B**

Surface level +37.5 m
Water not struck
200 mm percussion
February 1978

Overburden 0.3 m
Mineral 3.5 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey, brown	0.3	0.3
Till	'Very clayey' pebbly sand, a stiff sandy till Gravel: fine to coarse with cobbles, angular to well rounded clasts of granite, quartz, gneissose metasediments and felsite Sand: fine to coarse Fines: clay, yellow-brown to red-brown, mottled at top	3.5	3.8
Dalradian	Gneissose metasediment, micaceous, fine-grained, dark grey, hard	0.2+	4.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
36	50	14	0.3–1.3	34	20	21	9	4	12	0‡
			1.3–2.3	37	22	20	7	5	3	6‡
			2.3–3.8	37	27	18	5	6	7	0‡
			Mean	36	24	19	7	5	7	2

NK 05 SW 9 0350 5015 Fortry Farm, Longside **Block A**

Surface level +27.0 m
Water struck at +25.5 m and +20.0 m (Artesian)
250 mm percussion
February 1978

Overburden 1.5 m
Mineral 2.5 m
Waste 3.0 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Peat, dark brown, with grey micaceous silt at base	1.5	1.5
Alluvium	**a** Gravel Gravel: fine to coarse, with rare subrounded quartzite cobble; gravel composed mainly of subangular to subrounded gneiss and basic igneous rocks with granite and quartz Sand: fine to coarse, subangular, rock fragments, grey Fines: clay, grey	1.0	2.5
Till	**b** 'Very clayey' sandy gravel Gravel: fine to coarse, subangular to well rounded, basic igneous rocks, gneiss and pink granite Sand: fine to coarse Fines: clay, grey	1.5	4.0
	Clay, stiff, black, with few clasts; rare cobble of granite	3.0	7.0
Dalradian	Gneissose metasediment, foliated, coarse-grained	0.2+	7.2

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
a	7	33	60	1.5–2.5	7	6	14	13	11	44	5†
b	32	45	23	2.5–4.0	32	19	18	8	8	15	0†‡
a+b	22	40	38	Mean	22	14	16	10	9	27	2

NK 05 SW 10 0432 5433 Longhill Farm, Crimond **Block B**

Surface level +53.4 m
Groundwater level +51.3 m
200 mm and 150 mm percussion
March 1978

Overburden 2.8 m
Mineral 1.2 m
Waste 1.5 m
Mineral 2.8 m
Waste 1.0 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown, peaty	0.3	0.3
Till	Clay, mottled, grey-brown, firm to stiff, weathered to 1.2 m, sandy in parts, with clasts of grey-black gneissose metasediment	2.5	2.8
Glacial sand and gravel	**a** 'Clayey' pebbly sand Gravel: fine and coarse, subangular, dark grey gneissose metasediment and well rounded quartz and quartzite Sand: fine to coarse, abundant rock fragments, grey-brown Fines: silt and clay	1.2	4.0
Till	Clay, firm, gritty, reddish brown to 4.4 m, then dark greenish grey with clasts, fine to coarse gravel-size; shape varied, rounded to angular; matrix is a sandy silty clay with abundant quartz	1.5	5.5
	b Sandy gravel, a comminuted sandy till Gravel: coarse and fine, subangular to well rounded and rare angular, quartz and various igneous rocks Sand: fine to coarse, mostly subrounded, quartz with rock fragments Fines: mostly silt, light grey; increase in clay content below 7.5 m	2.8	8.3
	Clay, very stiff sandy and gritty, dark grey with clasts of varied composition	1.0	9.3
?Caledonian	Microdiorite*, medium-grained, quartz, feldspar, biotite and hornblende	0.5+	9.8

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	12	69	19	2.8–4.0	12	19	26	24	12	7	0†
b	9	65	26	5.5–6.5	5	13	36	19	15	12	0†‡
				6.5–7.5	10	16	24	13	18	19	0†‡
				7.5–8.3	12	22	37	16	11	2	0†‡
				Mean	9	17	32	16	15	11	0
a+b	10	66	24	Mean	10	17	30	19	14	10	0

* Number S 65237 in the specimen and thin section collection of the Geological Survey, Edinburgh

NK 05 SW 11 0485 5327 Blackhills Farm, St Fergus **Block B**

Surface level +44.9 m
Groundwater level +42.1 m
250 mm percussion
March 1978

Waste 5.9 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Peat with wood fragments	1.2	1.2
Till	Clay, stiff, grey, becoming greenish grey at depth, with angular to subrounded clasts of gneissose and schistose metasediments and granitic rocks; band of black silt from 5.7 to 5.8 m	4.7	5.9
Caledonian	Felsite, weathered, fine-grained, pinkish orange	0.1+	6.0

NK 05 SW 12 0422 5088 Bruxfin Wood, Rora Moss, Longside **Block B**

Surface level +51.6 m
Water not struck
200 mm percussion
February 1978

Waste 3.8 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Peat, brown	1.2	1.2
Till	Clay, greenish grey, stiff, with numerous angular to well rounded clasts of gneiss and quartz	2.6	3.8
Dalradian	Sericite-schist*, with feldspar largely replaced by fine-grained white mica; sillimanite present	0.5+	4.3

* Number S 65238 in the specimen and thin section collection of the Geological Survey, Edinburgh

NK 05 SW 13 0187 5032 Lintmill Sand and Gravel Pit, Mill of Hythie, Longside **Block B**

Surface level +35.9 m
Water struck at +33.4 m
Sampling section
May 1978

Mineral 2.8 m
Waste 1.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Fluvioglacial sand and gravel	Sandy gravel with frequent cobbles, a pebbly sand below 2.0 m Gravel: fine to coarse with cobbles, well rounded, of varied composition including granite, quartz, quartzite, psammite and gneissose metasediments Sand: fine to coarse, subangular, quartz and rock fragments, yellow-brown	2.8	2.8
	Silt, brown	1.4+	4.2

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
2	52	46	0.0–1.0	1	2	14	22	20	36	5
			1.0–2.0	1	2	7	28	21	35	6
			2.0–2.8	3	55	32	3	2	5	0
			Mean	2	17	17	18	15	27	4

NK 05 SW 14 0487 5282 Sand and gravel pit at Blackhills Farm, St Fergus **Block B**

Surface level +47.7 m
Water struck at +41.8 m
Sampling section and trench
May 1978

Overburden 0.2 m
Mineral 5.7 m
Waste 0.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	Sandy gravel Gravel: fine to coarse with cobbles, subangular to well rounded, felsite, granite, gneissose metasediments and quartz, often iron stained Sand: iron stained at top, medium to coarse with fine, subangular, quartz and rock fragments with feldspar, yellow	5.7	5.9
Till	Clay, stiff, grey, with numerous clasts	0.6+	6.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
6	56	38	0.2–1.2	3	1	22	48	20	6	0
			1.2–2.2	19	6	30	12	11	20	2
			2.2–3.2	2	2	18	21	25	28	4
			3.2–4.7	3	3	24	26	11	17	16
			4.7–5.9	4	5	36	29	13	13	0
			Mean	6	3	26	27	16	17	5

NK 05 SE 1 0577 5346 St Fergus Moss, St Fergus **Block B**

Surface level +41.6 m
Groundwater level +35.3 m
250 mm and 200 mm percussion
October 1977

Waste 15.8 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.4	0.4
Peat	Peat, dark red-brown with some well rounded pebbles of pink felsite and whitish quartzite and numerous wood fragments; light grey silt at base	4.2	4.6
Till	Clay, stiff, light grey at top, becoming red with grey micaceous silty partings at depth, faintly laminated in parts, with angular to well rounded clasts of granite, schistose metasediments, quartz, quartzite and felsite; rare molluscan fragments*; clay is greenish grey below 11.2 m	7.4	12.0
Glacial sand and gravel	Pebbly sand, with thin grey to greenish grey silty clay partings throughout Gravel: fine, subrounded with subangular, quartz, felsite, gneissose and schistose metasediments Sand: fine to coarse, subrounded, quartz with feldspar	2.5	14.5
Till	Clay, sandy, stiff, olive-green to brown with numerous clasts of weathered granite with quartz, and gneissose and schistose metasediments	1.3	15.8
Caledonian	Granite, leucocratic, coarsely crystalline, yellowish pink	0.2+	16.0

* Sample PDS 6 (at 10.0 m) examined by the Palaeontology Unit, Edinburgh

NK 05 SE 2 0592 5240 Outhill Farm, St Fergus **Block B**

Surface level +41.8 m
Water struck at +38.4 m
250 mm percussion
October 1977

Waste 3.1 m
Bedrock 0.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, dark brown	0.5	0.5
Till	Clay, sandy at top, compact at depth, red to dark red-brown, with angular to well rounded clasts of quartz, quartzite and granite	2.6	3.1
Caledonian	Granite, weathered at top, coarsely crystalline, micaceous, grey	0.6+	3.7

NK 05 SE 3 0521 5208 Rora Moss, St Fergus **Block B**

Surface level +49.3 m
Groundwater level +47.6 m
250 mm percussion
October 1977

Waste 3.5 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Peat with roots, becoming silty below 1.4 m	1.5	1.5
Till	Clay, stiff, light grey, becoming light greenish grey below 2.7 m, micaceous, with numerous weathered fragments of mainly platy schist and angular granite with quartz and dark grey porphyritic, basic igneous rocks	2.0	3.5
Dalradian	Gneissose metasediment, with granitic veining, weathered, micaceous, pale greenish grey	0.5+	4.0

NK 05 SE 4 0774 5269 **Shielhill Farm, St Fergus** **Block D**

Surface level +40.3m
Groundwater level +38.5m
250mm percussion
October 1977

Waste 18.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown	0.3	0.3
Till	Clay, orange with buff and grey mottling, silty at top, becoming stiff, compact, red-brown below 3.0m with frequent angular to subangular clasts of granite and other crystalline rocks and rare fine sand lenses; dark grey micaceous silt laminae occur below 14.4m	16.9	17.2
	Clay, sandy, stiff, olive-green with angular clasts of granite and fine-grained igneous rocks, often weathered, and quartz	0.8+	18.0

NK 05 SE 5 0791 5060 **Ednie Farm, St Fergus** **Block D**

Surface level +23.4m
Water struck at +20.2m
250mm and 200mm percussion
October 1977

Waste 18.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, silty, dark grey	0.4	0.4
Till	Clay, silty and micaceous at top, stiff, dark grey, with rare angular clasts	2.8	3.2
Glaciolacustrine deposits	Silt, sandy, micaceous, grey with band of fine, subangular, quartz sand from 4.0m to 5.0m	1.8	5.0
Till	Clay, stiff, red to red-brown, with rare clasts becoming common below 9.0m, mainly subrounded pebbles of gneiss and granite	11.2	16.2
Glaciolacustrine deposits	Clay, silty, laminated, olive-green, with light brown laminae of silt	1.8+	18.0

NK 05 SE 6 0702 5056 Burnthillock Farm, St Fergus **Block B**

Surface level +29.1 m
Groundwater level +26.3 m
250 mm and 200 mm percussion
October 1977

Overburden 0.4 m
Mineral 2.8 m
Waste 6.6 m
Bedrock 1.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	Sandy gravel Gravel: fine to coarse with cobbles, subrounded, felsite, quartzite and quartz with granite and mica-schist Sand: medium to coarse, subrounded, quartz and feldspar with rock fragments, yellow Fines: silt, micaceous, grey	2.8	3.2
Till	Clay, stiff, red, with band of grey clay from 5.3 m to 5.6 m; clasts are infrequent	2.8	6.0
	Clay, sandy in parts, stiff, greenish grey becoming brownish grey at depth, with angular to well rounded clasts, often weathered, metasediments	3.8	9.8
Dalradian	Gneissose metasediment, a decomposed green to orange mottled clay, banded	1.4+	11.2

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	53	43	0.4–1.4	not available						
			1.4–2.7	4	8	36	14	15	18	5
			2.7–3.2	5	2	19	19	27	28	0
			Mean	4	6	31	16	18	21	4

NK 05 SE 7 0867 5435 Northmoss Farm, St Fergus **Block D**

Surface level +11.1 m
Groundwater level +9.8 m
250 mm percussion
October 1977

Waste 2.4 m
Bedrock 0.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty, dark brown	0.4	0.4
Till	Clay, silty, sandy in parts, red-brown, becoming grey-brown and stiff below 2.0 m, with angular to well rounded clasts of weathered granite, schist, gneiss and quartz	2.0	2.4
Dalradian	Metasediment*, weathered, fine-grained, weakly foliated	0.7+	3.1

* Number S65239 of the specimen and thin section collection of the Geological Survey, Edinburgh

NK 05 SE 8 0999 5481 Pittenheath, St Fergus **Block D**

Surface level +12.2m
Groundwater level +3.9m
250mm and 200mm percussion
October 1977

Overburden 0.2m
Mineral 1.1m
Waste 14.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Silt with peat	0.2	0.2
Blown sand	Sand	1.1	1.3
	Sand: mainly fine, subangular, quartz and feldspar with shell fragments Fines: peaty silt		
Peat	Peat with thin blue-grey silt partings	0.4	1.7
Lake alluvium	Clay, silty, stiff, laminated in parts, blue-grey, with rare, well rounded, dark grey fine-grained igneous pebbles and thin bands of silt	14.0+	15.7

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
6	94	0	0.2–1.3	6	32	61	1	0	0	0

NK 05 SE 9 0989 5093 Kinloch Farm, St Fergus **Block D**

Surface level +22.3m
Groundwater level +10.8m
250mm and 200mm percussion
November 1977

Waste 19.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Till	Clay, mottled at top becoming stiff, grey at depth with well rounded to subrounded clasts of pink granite, quartz and schistose metasediments	5.4	6.0
	Clay, stiff, dark red-brown with subangular to subrounded pebbles of granite and gneissose metasediments and rare subrounded boulder of granite	3.2	9.2
Glaciolacustrine deposits	Silt, sandy in parts, micaceous, red to red-brown with fine yellow-brown sand laminae and bands	9.8+	19.0

NK 14 NW 1 1024 4811 Inverugie, Peterhead **Block A**

Surface level +12.6m
Groundwater level +8.2m
250mm and 200mm percussion
November 1977

Overburden 0.2m
Mineral 4.8m
Waste 1.4m
Bedrock 0.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Sandy gravel Gravel: fine to coarse with cobbles, subangular to well rounded, granite, quartzite, basic igneous rocks, gneissose metasediments and quartz with felsite Sand: fine to coarse, subangular, quartz and granite, micaceous Fines: clay	4.8	5.0
Till	Clay, brown to grey-brown, stiff at depth, sandy, with numerous well rounded to subangular clasts of granite, quartz and gneissose metasediments	1.4	6.4
Caledonian	Granite, coarsely crystalline, orange-pink, weathered	0.4+	6.8

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
4	72	24	0.2–1.2	4	12	39	13	16	16	0
			1.2–2.2	5	25	49	15	5	1	0
			2.2–3.2	2	22	61	13	2	0	0
			3.2–4.2	5	8	23	31	19	14	0
			4.2–5.0	6	5	12	22	24	24	7
			Mean	4	15	38	19	13	10	1

NK 14 NW 2 1070 4719 South Balmoor, Peterhead **Block C**

Surface level +20.8m
Groundwater level +19.2m
250mm and 200mm percussion
December 1977

Waste 11.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, silty, brown	0.4	0.4
Till	Clay, mottled at top, red-brown, stiff, with subangular to well rounded clasts of gneissose metasediments, quartzite, quartz and weathered granite	2.1	2.5
	Clay, stiff, grey, becoming greenish grey and sandy at depth, with micaceous silt and fine sand partings and subangular to subrounded clasts of sandstone, quartz, basic igneous rocks, granite, quartzite and gneiss; sparse balanid and molluscan fragments*	9.4+	11.9
	Borehole abandoned due to rock obstruction		

* Sample PES 5 (from 2.5 to 4.5 m) examined by the Palaeontology Unit, Edinburgh

NK 14 NW 3 1042 4652 Howe of Buchan, Peterhead **Block C**

Surface level +24.6m
Groundwater level +24.3m
250mm and 200mm percussion
November 1977

Overburden 6.4m
Mineral 5.8m
Waste 0.2m

Bedrock 0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.4	0.4
Till	Clay, red-brown, stiff, with few subrounded clasts, sandy at depth	6.0	6.4
	a 'Very clayey' sand with rare pebbles Sand: fine to medium with coarse, quartz and rock fragments, micaceous, red Fines: clay, red	0.8	7.2
Glacial sand and gravel	**b** Sandy gravel Gravel: fine to coarse with cobbles, predominantly subangular, gneissose metasediments with granite, quartzite, felsite and sandstone and rare flint Sand: medium to coarse with fine, subangular, quartz with rock fragments and feldspar Fines: clay, red	1.7	8.9
	Clay, silty, stiff, laminated, red-brown	0.2	9.1
Till	**c** 'Clayey' pebbly sand Gravel: mainly fine, angular to well rounded Sand: fine to coarse, angular, quartz, feldspar and granite fragments, grey Fines: clay, silty, greenish grey	3.3	12.4
Caledonian	Granite, weathered, coarsely crystalline, leucocratic, pink	0.2+	12.6

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
a	39	58	3	6.4–7.2	39	30	20	8	2	1	0†‡
b	6	61	33	7.2–8.9	6	8	24	29	21	12	trace†
c	15	73	12	9.1–9.8	13	4	19	45	19	0	0†‡
				9.8–11.0	19	18	29	19	7	8	0†‡
				11.0–12.4	13	16	34	32	5	0	0†‡
				Mean	15	14	29	30	9	3	0
a+c	20	70	10	Mean	20	17	27	26	7	3	0
a+b+c	16	68	16	Mean	16	15	26	27	11	5	0

NK 14 NW 4 1103 4930 Lunderton Farm, Peterhead **Block D**

Surface level +18.4m
Water not struck
250mm and 200mm percussion
November 1977

Waste 10.9m
Bedrock 0.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey, grey-brown	0.4	0.4
Till	Clay, mottled, red-brown, becoming stiff at depth, with subangular to subrounded clasts of granite, schist and quartz	3.8	4.2
Glaciolacustrine deposits	Silt, clayey, sandy at top, red, stiff in parts, with bands of fine sand and red-brown laminated clay	3.8	8.0
Till	Clay, sandy, greenish grey, with numerous clasts, often well rounded, of quartz, schist and weathered granite	2.9	10.9
Caledonian	Granite, weathered, coarsely crystalline, pink	0.3+	11.2

NK 14 NW 5 1155 4816 Mains of Inverugie, Peterhead **Block D**

Surface level +25.1m
Groundwater level +16.7m
200mm percussion
March 1978

Waste 18.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and peat	1.5	1.5
Till	Clay, grey-brown to dark grey unfossiliferous*, stiff, laminated at top, with plant remains and subangular clasts of granite and gneissose metasediments	2.0	3.5
	Clay, stiff in parts, red-brown, with well rounded clasts of dolerite and granite	5.1	8.6
Glaciolacustrine deposits	Clay, laminated, stiff, red-brown	2.4	11.0
Till	Clay, stiff, red-brown, with clasts up to boulder size of subrounded to well rounded pink granite; below 15.7m clay is sandy, greenish grey, with subangular to subrounded clasts of granite, basic igneous rocks, quartz; rare shell fragments*	7.3+	18.3

* Samples PES29 (at 2.0m) and PES30 (at 18.0m) examined by the Palaeontology Unit, Edinburgh

NK 14 NW 6 1111 4528 **Westerton of Clerkhill, Peterhead** **Block C**

Surface level +44.7m
Water not struck
200mm percussion
March 1978

Waste 16.2m
Bedrock 0.4+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.5	0.5
Till	Clay, mottled, grey-brown, silty becoming stiff at depth, with subangular to subrounded clasts of granite	6.5	7.0
	Clay, stiff, red-brown, silty, with rare fine sand partings and subrounded to subangular clasts of granite and quartz; below 14.6m clay is sandy, greenish grey, with numerous clasts of granite, quartz and dark green-grey weathered igneous rocks	9.2	16.2
Caledonian	Granite, weathered, crushed, medium-grained, pink	0.4+	16.6

NK 14 SW 4 1111 4384 **Wellbank Farm, Peterhead** **Block C**

Surface level +43.3m
Water not struck
250mm percussion
December 1977

Waste 10.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, dark brown	0.4	0.4
Till	Clay, mottled at top, red, becoming red-brown and stiff at depth, silty in parts, with subangular to well rounded clasts of quartzite, granite, basic igneous rocks and quartz and rare shell fragments; from 9.4 to 9.9m a band of silt, red-brown, unfossiliferous*, laminated with black micaceous laminae	9.5	9.9
	Clay, brown, sandy, with subrounded to well rounded clasts of flint, quartzite and granite	0.5+	10.4
	Borehole abandoned due to rock obstruction		

* Sample PES6 (from 9.4 to 9.9m) examined by the Palaeontology Unit, Edinburgh

NK 15 SW 1 1030 5344 South Blackwater Farm, St Fergus **Block D**

Surface level +11.7m
Groundwater level +6.7m
250mm and 200mm percussion
October 1977

Overburden 0.2m
Mineral 1.7m
Waste 18.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.2	0.2
Blown sand on lake alluvium	'Clayey' sand, clean from 0.2 to 1.2m Sand: fine to medium, quartz, yellow Fines: clay, buff	1.7	1.9
	Clay, silty, mottled, buff, with light red laminae, becoming grey to black and plastic at depth	3.3	5.2
	Silt, clayey, faintly laminated, light grey to light brown, with thin fine, yellow sand laminae	4.0	9.2
	Clay, silty, laminated, stiff, with fine sand at top, grey, becoming a laminated, micaceous, grey silt below 11.0m	8.7	17.9
Till	Clay, silty, stiff, grey to grey-brown, with angular clasts of granite	2.1+	20.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
12	88	0	0.2–1.2	2	21	76	1	0	0	0
			1.2–1.9	26	33	39	1	1	0	0
			Mean	12	26	61	1	trace	0	0

NK 15 SW 2 1085 5280 Annachie, St Fergus **Block D**

Surface level +1.7m
Groundwater level +0.9m
250mm and 200mm percussion
September 1977

Overburden 0.2m
Mineral 2.6m
Waste 4.9m
Mineral 3.4m
Waste 1.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.2	0.2
Post-Glacial beach deposits	**a**. Sandy gravel Gravel: fine to coarse, with cobbles, well rounded with subangular, pink granite, quartz, metamorphic rocks and fine-grained basic igneous rocks, with shell Sand: mainly coarse and medium, with shell and quartz, yellow	2.6	2.8
Till	Clay, silty, dark grey, stiff, with angular clasts of granite and gneissose metasediments	2.7	5.5
	Clay, silty, red to red-brown with angular clasts of granite and gneissose metasediments and subrounded quartz	2.2	7.7
	b 'Clayey' sandy gravel, a sandy grey till Gravel: fine to coarse, subrounded to subangular granite, quartz, quartzite and metasediments Sand: mainly fine with medium and coarse, angular, quartz, and rock fragments Fines: silt, grey	3.4	11.1
	Clay, silty, grey with clasts as above	1.0	12.1
Glacial sand and gravel	Sandy gravel Gravel: mainly fine, subangular to subrounded, of varied composition Sand: mainly coarse and medium, subangular, quartz	0.3+	12.4
	Borehole abandoned due to rising sand		

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	trace	62	38	0.2–1.2	1	5	53	28	9	4	0†
				1.2–2.3	0	3	26	17	11	15	28†
				2.3–3.8	1	3	28	16	10	42	0†
				Mean	trace	4	37	21	10	16	12
b	16	48	36	7.7–8.8	16	39	13	6	10	16	0†‡
				8.8–9.9	8	17	9	5	12	40	9†‡
				9.9–11.1	24	27	19	8	9	13	0†‡
				Mean	16	28	14	6	10	23	3
a+b	9	54	37	Mean	9	17	24	13	10	20	7

NK 15 SW 3 1010 5159 North Kirkton Farm, St Fergus **Block D**

Surface level +7.0m
Groundwater level +2.0m
250mm and 200mm percussion
September 1977

Waste 18.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, red to red-brown, mottled in parts, compact, with sandy laminae and clasts of well rounded granite and platy schist	6.9	7.2
Glaciolacustrine deposits	Silt, clayey, micaceous, laminated, grey-brown to red-brown, with rare well rounded pebbles of granite	10.8+	18.0

NK 15 SW 4 1149 5097 North Kirkton Farm, St Fergus **Block D**

Surface level +10.8m
Groundwater level +9.9m
250mm and 200mm percussion
September 1977

Overburden 0.2m
Mineral 1.3m
Waste 15.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, dark brown	0.2	0.2
Blown sand	Sand Sand: fine to medium, subangular to subrounded, quartz with feldspar and shell fragments, beige	1.3	1.5
Lake alluvium	Clay, mid-grey, mottled in part, with rare fine sand lenses and rare well rounded pebbles	9.5	11.0
Till	Clay, sandy, grey-brown, with angular to rounded clasts of basic igneous and metamorphic rocks and quartz	2.5	13.5
	Clay, firm, reddish brown, with common angular to subrounded clasts of pink granite and metamorphic rocks	2.3	15.8
	Clay, sandy, grey-brown, with clasts of gneiss becoming common towards base	0.7+	16.5
	Borehole abandoned due to slow progress in stony till		

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	96	0	0.2–1.5	4	39	56	1	0	0	0

NK 15 SW 5 1132 5200 St Fergus Links Sand Pit, St Fergus **Block D**

Surface level +7.2m
Water struck at +1.8m
Sampling by hand
May 1978

Overburden 0.3m
Mineral 5.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.3	0.3
Blown sand	**a** Sand: medium with some fine, subrounded, quartz, yellow	4.3	4.6
Post-Glacial beach deposits	**b** Sandy gravel, with pebble band at top Gravel: cobble and coarse with fine, well rounded gneissose rocks, felsite and shells Sand: medium with some fine and coarse, subrounded to well rounded, quartz and shell, yellow-orange	1.0+	5.6

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
a	1	99	0	0.3–2.3	0	10	90	0	0	0	0
				2.3–4.6	1	12	87	0	0	0	0
				Mean	1	11	88	0	0	0	0
b	1	74	25	4.6–5.6	2	7	65	2	2	9	13
a+b	1	94	5	Mean	1	10	84	trace	trace	2	3

NJ 95 SE P1 9546 5354 Little Skillymarno Farm, Strichen **Block A**

Surface level +44.5m
Water struck at +43.0m
Trench
May 1978

Overburden 0.8m
Mineral 1.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and brown silty clay	0.8	0.8
Alluvium	Gravel Gravel: fine to coarse, well rounded, quartzite, quartz and granite Sand: fine to coarse, subrounded, quartz and rock, grey	1.0+	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	43	54	0.8–1.8	3	4	17	22	27	27	0‡

NJ 95 SE P2 9642 5333 Skillymarno Farm, Strichen **Block B**

Surface level +44.0m
Water not struck
Trench
May 1978

Overburden 0.3m
Mineral 1.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.3	0.3
Fluvioglacial sand and gravel	Gravel Gravel: cobbles and coarse, well rounded, granite, psammite, gneissose rocks, quartzite and quartz Sand: medium to coarse, subangular quartz and rock Fines: clay, brown	1.2+	1.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
5	23	72	0.3–1.5	5	4	8	11	14	32	26‡

NJ 95 SE P3 9692 5317 Auchrynie Farm, Strichen **Block B**

Surface level +44.9m
Water not struck
Trench
May 1978

Overburden 0.4m
Mineral 1.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	Gravel Gravel: fine to coarse with cobbles, subrounded to well rounded, granite, quartzite, quartz and gneissose rocks, with basic igneous rocks Sand: medium to coarse, subrounded, quartz, micaceous, grey	1.1+	1.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
4	45	51	0.4–1.5	4	3	26	16	15	30	6‡

NJ 95 SE P4 **9806 5317** **Nether Cabra Farm, Strichen** **Block B**

Surface level c+43m
Water not struck
Trench
May 1978

Waste 1.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.8	0.8
Till	Clay, stiff, sandy at top, blue-grey, with boulders of gneissose metasediments, and smaller subangular to angular clasts of granite	0.7+	1.5

NK 04 NW P1 **0108 4969** **Boghead Farm, Mintlaw** **Block B**

Surface level +37.9m
Water not struck
Trench
May 1978

Overburden 0.2m
Mineral 1.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	Sandy gravel Gravel: fine to coarse with cobbles, subrounded to well rounded, granite, quartzite, quartz and gneissose metasediments Sand: medium to coarse, subrounded, quartz with rock, brown	1.3+	1.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
2	49	49	0.2–1.5	2	3	11	35	14	21	14‡

NK 04 NW P2 0371 4824 Bridgend Farm, Longside **Block B**

Surface level +26.2m
Water not struck
Trench
May 1978

Overburden 0.5m
Mineral 1.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown	0.5	0.5
Fluvioglacial sand and gravel	Gravel Gravel: fine to coarse with cobbles, subrounded to well rounded with some angular, granite, quartz and metasediments Sand: fine to coarse, subrounded to subangular, quartz, with rock, micaceous, grey	1.0+	1.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
6	42	52	0.5–1.5	6	7	22	13	16	24	12‡

NK 04 NW P3 0460 4736 Cairngall House, Longside **Block C**

Surface level +33.2m
Water not struck
Trench
May 1978

Overburden 0.2m
Mineral 1.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	Pebbly sand Gravel: fine to coarse, well rounded, granite, quartzite, and other metasediments Sand: mainly medium, subangular, quartz with some rock, yellow Fines: silt	1.6+	1.8

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
5	72	23	0.2–1.8	5	17	44	11	12	10	1‡

NK 04 NE P1 0522 4883 Wester Rora Farm, Longside **Block B**

Surface level +32.0 m
Water not struck
Trench
May 1978

Overburden 0.4 m
Mineral 1.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	Sandy gravel Gravel: fine to coarse with cobbles, well rounded, granite, quartz and quartzite Sand: mainly medium to coarse, subangular, quartz, iron stained	1.4+	1.8

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64
0	53	47	0.4–1.8	0	3	21	29	23	20	4‡

NK 04 NE P2 0522 4681 Flushing, Longside **Block C**

Surface level c +28 m
Water not struck
Trench
May 1978

Waste 1.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground and weathered clay	1.0	1.0
Till	Clay, stiff, blue-grey, with angular clasts of granite	0.7+	1.7

NK 04 NE P3 0598 4660 Faichfield House, Longside **Block C**

Surface level c +29 m
Water struck at c +27.8 m
Trench
May 1978

Waste 1.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and red-brown clay	0.7	0.7
	Sand, medium to coarse, subangular, quartz and feldspar, grey	0.5	1.2
Till	Clay, stiff, grey, with subangular clasts of granite	0.6+	1.8

NK 04 SW P1 0186 4009 Bogengarrie Farm, Longside **Block C**

Surface level c+130m
Water not struck
Trench
May 1978

Waste 1.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty with float of well rounded flint pebbles	0.4	0.4
Till	Clay, red-brown, mottled, with pebbles of flint and quartzite	0.3	0.7
	Clay, alternating red and light grey silty bands, micaceous	1.1+	1.8

NK 04 SW P2 0209 4077 Smallburn, near Longside **Block C**

Surface level c+107m
Water not struck
Trench
May 1978

Waste 1.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Peat with flints	0.3	0.3
Till	Clay, orange-brown, mottled, with well rounded pebbles of flint and quartzite with weathered granite	0.7	1.0
	Clay, silty, blue-grey, with numerous well rounded flints	0.6+	1.6

NK 04 SW P3 0407 4096 Moss of Cruden, near Longside **Block C**

Surface level c+123m
Water not struck
Trench
May 1978

Overburden 0.7m
Mineral 1.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Till	Clay, brown, with well rounded clasts of flint and quartzite with gneissose metasediments	0.7	0.7
	'Very clayey' pebbly sand, a till, as above, with bands of laminated brown silt and fine sand	1.8+	2.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
37	40	23	0.7–2.5	37	21	14	5	4	19	0‡

NK 04 SW P4 0472 4066 Moreseat Farm, near Peterhead **Block C**

Surface level c+102m
Water not struck
Trench
May 1978

Waste 2.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Peat	0.3	0.3
Till	Clay, silty, with sandy partings, orange-brown, grey to greenish grey below 0.7m, with pebbles of quartz, flint and gneissose metasediments	1.5	1.8
Glacial sand and gravel	'Clayey' sandy gravel Gravel: fine to coarse, subrounded to subangular, quartz, weathered granite, and gneissose metasediments Sand: medium to coarse, subangular, quartz with feldspar, light brown	0.7+	2.5

NK 04 SW P5 0430 4034 Croft of Hardslacks, near Peterhead **Block C**

Surface level c+106m
Water not struck
Trench
May 1978

Waste 0.3m
Bedrock 1.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty with flint pebbles	0.3	0.3
Caledonian	Granite, very weathered, a gruss of brown, medium sand, feldspathic and micaceous	1.2+	1.5

NK 04 SE P1 0544 4193 Muirend Farm, near Longside **Block C**

Surface level c+105m
Water not struck
Trench
May 1978

Waste 0.9m
Bedrock 0.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.2	0.2
Till	Clay, brown, with clasts	0.7	0.9
Dalradian	Psammite, weathered, flaggy, micaceous, brown	0.4+	1.3

NK 04 SE P2 0539 4048 Moreseat Farm, near Peterhead **Block C**

Surface level +92.6m
Water not struck
Trench
May 1978

Overburden 0.3m
Mineral 1.0m
Waste 1.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.3	0.3
Glacial sand and gravel	'Very clayey' pebbly sand Gravel: fine to coarse Sand: fine to medium, quartz, yellow-orange Fines: silt, buff to grey, laminated	1.0	1.3
Till	Clay, silty, light greenish grey, sandy in part with well rounded pebbles of red, micaceous sandstone, quartz, and metasediments; coarse sand and white silty clay at base	1.7+	3.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
23	71	6	0.3–1.3	23	36	31	4	3	3	0‡

NK 04 SE P3 0623 4111 Berryley Farm, near Peterhead **Block C**

Surface level +96.9 m
Water not struck
Trench
May 1978

Overburden 0.8 m
Mineral 2.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Peat on brown clay with flint pebbles	0.8	0.8
Buchan Ridge gravels, ?Pliocene	'Very clayey' sand with rare weathered pebbles Sand: fine to medium, quartz, white Fines: silt, micaceous, white	2.2+	3.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$
34	66	0	0.8–2.2	34	52	13	1	0	0	0‡

NK 05 SW P1 0251 5019 Dumpstown Farm, Longside **Block B**

Surface level c+35 m
Water not struck
Trench
May 1978

Waste 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.4	0.4
Till	Clay, sandy in parts, brown, with numerous subangular to angular clasts of weathered metasediments and quartz	1.1+	1.5
	Trench abandoned on hard ground, possibly bedrock		

APPENDIX G

LIST OF WORKINGS

In 1978 seven sand and gravel pits, listed below, were known to be operational. All areas that are known to have been worked are shown on the map accompanying the report. To date, all sand and gravel extraction has been confined to deposits lying above the water table.

Grid reference	*Site*	*Operator*	*Deposit worked*
994 523	Brownhill	J. H. Taylor	Fluvioglacial sand and gravel
022 505	Mill of Hythie (Lintmill)	Lintmill Sand and Gravel Company	Fluvioglacial sand and gravel
024 440	Oldmill	Edenview Properties Limited	Glacial sand and gravel
036 494	Knaps of Auchlee	John Paterson	Fluvioglacial sand and gravel
040 492	Woodside Farm		
042 487	Loch of Auchlee		
045 484	Auchlee (Craigie)	John Fyfe Limited	Fluvioglacial sand and gravel

Smaller workings operated intermittently include pits near Sandhole [at 998 521], at Blackhills [049 528], north of Moreseat [at 053 410], north of North Aldie [at 073 413] and on St Fergus Links [at 113 521].

APPENDIX H

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

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

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INSTITUTE OF GEOLOGICAL SCIENCES
INDUSTRIAL MINERALS ASSESSMENT UNIT

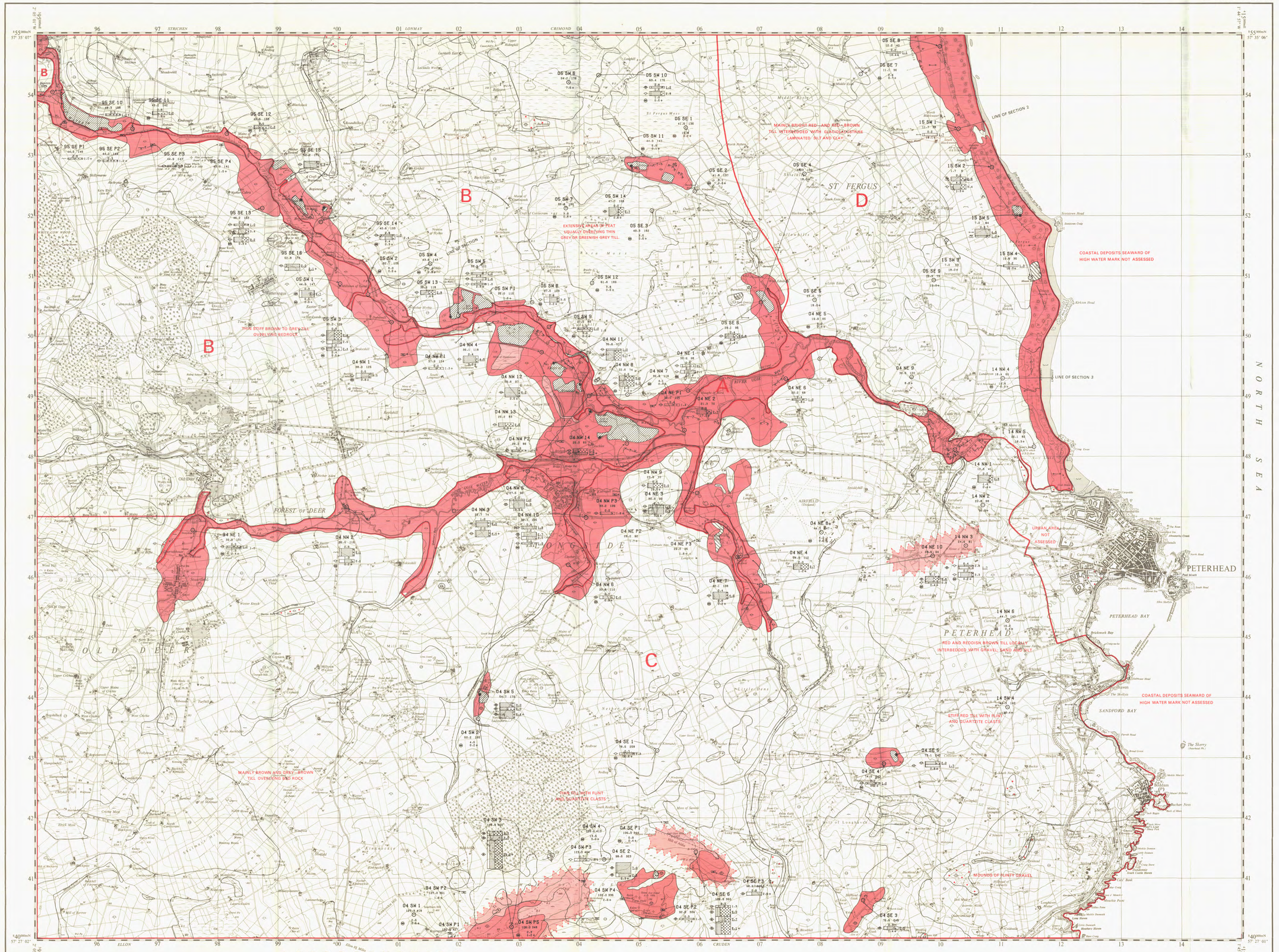
THE SAND AND GRAVEL RESOURCES OF THE PETERHEAD AREA, GRAMPIAN REGION

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

ORDNANCE SURVEY
SHEET NK04 & PARTS OF SHEETS NJ94,95 & NK05,14,15
PROVISIONAL EDITION

THE SAND AND GRAVEL RESOURCES OF
THE PETERHEAD AREA, GRAMPIAN REGION
58

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



EXPLANATION OF SYMBOLS AND ABBREVIATIONS

DRIFT
RECENT AND PLEISTOCENE

- **Blown sand** - medium with fine sand — 8S-9
- **Peat** — P-1
- **Alluvium (undifferentiated)** - mainly medium to coarse sand and fine to coarse gravel, locally with high cobble content — A-38
- **Lake alluvium** - grey silt and clay, rarely with fine sand, laminated — LK-1
- **Present day beach deposits** - mainly medium sand — PB-1
- **Post-Glacial beach deposits** - medium to coarse sand and fine to coarse gravel with cobbles — Po-2
- **Fluvioglacial sand and gravel** / **Glacial sand and gravel** - mainly medium to coarse sand and fine to coarse gravel, with cobbles, generally fines-free — FL-3
- **Glaciolacustrine deposits** - fine sand, silt and clay, grey and red, often finely laminated — G-2
- **Till** - mainly stiff red, grey-brown or greenish grey clay with clasts, locally sandy — TL-2

SOLID

- **Buchan Ridge gravels, ?Pliocene** - fine to coarse gravel and cobbles with fine to medium sand, often clay-bound
- **'Bedrock' (undifferentiated)**

In the northern and western parts of the resource sheet bedrock comprises mainly Dalradian metasediments including gneiss, mica-schist, psammite, quartzite, metagreywacke and slate. The area around Peterhead is underlain mainly by granite of Caledonian age, often highly decomposed. Small minor intrusions including felsite and quartz-dolerite cut both the granite and the metamorphic rocks.

- **Made ground** - waste and/or natural earth materials deposited either on original ground surface or in man-made workings — MG-3
- **Worked ground** - boundaries as at May 1978. — WG-1

BOUNDARY LINES

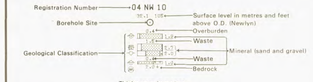
- Geological boundary
- Back feature of fluvioglacial or river terrace, downward slope in direction of arrowhead
- Feature marking former coastline
- Glacial drainage channel, arrow shows direction of water flow
- Resource Block boundary
- Inferred boundary between recognised categories of deposits at depth

BOREHOLE AND OTHER DATA

SITE LOCATIONS

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

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.

Registration Numbers

Each I.M.A.U. borehole and section is identified by a Registration Number, e.g. 04 NW10. The first numbers and letters refer to the quarter sheet and the final figures to the I.G.S. serial numbers for that quarter. The unique designation for borehole 04 NW 10 is NK 04 NW 10.

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 width of the divisions show the proportions of Fines, Sand and Gravel, but small amounts may be omitted or exaggerated.

EXPOSURE RECORDS

Information from the inspection of exposures is shown in the same way as for boreholes but they are located by an asterisk, thus ✳.

SHALLOW TRENCHES

The locations of shallow trenches providing ancillary assessment data are shown by a distinctive symbol, thus ⊐⊏. Each trench is identified by serial registration numbers indexed by the letters of the relevant standard quarter sheet, for example, 04 NW P2.

CATEGORIES OF DEPOSITS

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

RESOURCE BLOCKS

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

Generalized horizontal sections illustrating relationships of drift deposits are shown on a separate sheet.

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

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

Original geological survey on the six-inch scale by J.S.Grant Wilson 1885
Partial re-survey by D.I.Ross in 1977 . G.S.Johnstone District Geologist
Sand and Gravel Survey by A.A.McMillan in 1977 - 78, under the supervision of A.M.Aitken . R.G.Thurrell, Head, Industrial Minerals Assessment Unit
Borehole graphics drawn by computer programs written by J.L.McInnes , Computer Unit , I.G.S. Edinburgh
1: 25000 Sand and Gravel Resource Sheet published 1981
G.M.Brown, D.Sc., F.R.S., *Director, Institute of Geological Sciences*
11/81

The GRID lines on this sheet are at 1 Kilometre interval.
Heights are in feet above Mean Sea Level at Newlyn.
Contours are at 50 feet intervals.
1 square inch on this map represents 999,674 acres on the ground.

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.

Compiled from 6"sheets last fully revised 1899-1924. Other partial systematic revision 1938-55 has been incorporated.

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.

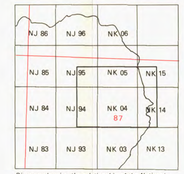


Diagram showing the relationship of the National Grid 1:25,000 sheets with the one-inch Geological Sheet 97