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THE SAND AND GRAVEL RESOURCES OF AYR BAY AND IRVINE BAY

COMMERCIAL IN CONFIDENCE

FIRTH OF CLYDE IGS (CSU II)

by

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Introduction

This report contains the account of a detailed sand and gravel assessment carried out in Irvine Bay and Ayr Bay for the Hunterston Development Company. The mandate of the present project was to locate 15-20 million cubic meters of arenaceous sediment in the sand to gravel range. A complication however is that this quantity should be outside the 9 fathom line and in the top meter of sediment. Previous reports (C E Deegan April 1972, August 1973, et.al. 1973) had indicated that the sand deposit is roughly in the form of a seaward tapering wedge with no arenaceous sediments found outside the 20 fathom line. Later enquiries were made concerning the advantages of dredging to the 8 fathom line and removing a thicker layer of sediment; these points are also considered in the following text.

A geophysical and sampling survey was carried out in the area aboard M.V. Steelfish during October 1973. Navigation throughout was by main chain Decca (North British chain, 3B). The Decca Navigation Company claim their positioning in this area during October to be accurate to within 185 m at 68% probability after allowing for fixed errors. There are also fixed errors in the area, the error for a point in the centre of the working area being 250 m in a N.N.W. direction and an E.S.E. error of only 20 m. Fixed errors have not been corrected for in plotting the sample positions and geophysical traverses.

Geolphysical Data

Geophysical data were collected along the traverses shown in Figure 2 using a high resolution O.R.E. pinger. The quality of the records was normally sufficiently good to follow the surficial sediment to bedrock interface to a depth of 40 m, bedrock being here defined as either rock or boulder clay. The depths of the surficial sediments were plotted and an isopachyte map of sediment thickness drawn (see Figure 3). Unfortunately only the depth of total surficial sediment could be mapped and not the depth of sand alone, for the thickness of sand was not usually sufficiently great to be resolved on the pinger records. Due to problems of resolution the areas marked on Figure 3 as outcrop may be covered by some 1-2 m of sediment, with perhaps slightly deeper localised pockets.

In Irvine Bay the isopachyte map indicates areas of boulder clay or rock outcrop in the extreme north off Ardrossan, off Irvine, around the Lappock Rock and forming a pronounced spur extending from Troon to beyond Lady Island. The thickest sediments occur in a roughly north-south belt running south from Ardrossan. In this belt there are fairly large areas where 30 m or more of sediment are found but only in one restricted locality does the thickness exceed 40 m. The boulder clay surface is generally relatively gently sloping with only minor undulations, except in the north-west and extreme south where it is markedly irregular.

Sampling

(i) Grab Sampling (G S)

All grab samples were recovered using a shipek grab, the sample stations, 89 in all, being on a 1 km gird. The location of the stations is given in Figure 1. Due to the limitations imposed concerning the position of the required sand the sampling programme was concentrated around the 9 fathom line and seaward of it.

During recovery of the sample some of the very fine material in suspension may have been lost, but the ammount is not thought to be significant. Before being dispatched for analysis the larger samples were sub-sampled where necessary, while those samples from which only a limited return was obtained were dispatched complete.

(ii) Core Sampling (V E)

Vibrocore samples were taken with the Institute's 10 ft electric vibrocorer on the same sites as the shipek grab samples, although no coring was undertaken at site H89. The corer was allowed to vibrate for an average of 10 minutes at each site. The cores obtained were stored in sealed plastic tubes, and the shoe sample where available was bottled. The cores are then split into more convenient meter lengths which are each labelled A,B,C etc from the upper part of the core downwards (for more detail see Deegan April 1972, p.3).

In the laboratory the cores were examined, initially at each end, as a result of which over half the cores were split to allow closer observation and sub-sampling for grain size analysis. The cores were generally split longitudinally although some were cross-sectioned.

Most of the core samples were taken from the sand immediately above the sand/mud boundary which was found in most of the cores containing sand. Where sand was found it's thickness, as estimated visually, was measured. For certain selected cores sub-samples were also taken at intervals down the sand sequence, so as to ascertain the nature of any changes down the sand column.

It was also noticed from visual inspection that well defined shellhorizons were often found above and usually close to the sand/mud boundary (see Frontispiece). Indeed there is a general trend for the shells to be concentrated in bands rather than dispersed throughout the sand column, although this may not influence the carbonate content of the sand fraction.

After the cores are recovered there is considerable water within the plastic tube, and although all efforts were made to remove it some water was unavoidably retained in the tube, particularly in the muddy parts of the cores. During subsequent transportation and storing this water tends to contaminate the outer layer of the core, mud being the most important contaminant. Also there is considerable disturbance in the outer core during the coring operation. Consequently an effort was made to sample only from the centre of the core, but as the cores are narrow this is a difficult process if a large enough sub-sample is to be taken. It seems probable therefore that mud contents in the cores may be slightly higher than they should be, particularly close to the mud/sand boundary.

(iii) Grain Size Analysis

The grain size analysis of the samples and sub-samples was carried out for the Institute by Messers Sandberg Limited of London. The analysis proceedure was to wet sieve the sample to divide it into gravel (which is retained in the 0.063 mm sieve) and the mud fraction which passes through the 0.063 mm sieve. The sand fraction was subsequently dried and shaken in a nest of sieves, so that the following divisions were made.

	Sieve Mesh	Size in m.m.	
		V	gravel
	16	1.0	
SEE APPENDIX I	30	0.5	
The grain size	60	0.25	sand
results	120	0.125	
	240	0.063	
		V	mud

Carbonate analysis was then carried out on the sand fraction, where enough (40 gms) was available, using sodium Hexametaphosphate and sodium carbonate as dispersing agents (see appropriate sections in Appendix I). Pipette analyses were also carried out on the mud fraction of some specified samples.

The full results of these analyses are presented in Appendix I.

Interpretation

Sand under the Folk (1968) classification contains less than 10% mud, and in this work useful aggregate will be considered as sand or gravel with 10% or less mud. It is with regard to this percentage that the 0 cm contour line in Figure 4 has been drawn, the data being taken from the grab sample analyses only.

The other depth contours in the same figure have been drawn from the core analyses. As stated above the core sub-samples were normally taken from immediately above the sand/mud boundary as visually established; a contact which was usually sharp. Because of the unavoidable problems of mud contamination, particularly near the mud/sand boundary (see core data section), the acceptable mud percentage is here increased to 15%. This change is considered fully justified under these particular circumstances. Where the mud level in the sand is unacceptably high the depth of sand has been calculated assuming a regular upward decrease in the mud content. This assumption was clearly necessary, although those cores sub-sampled throughout the vertical section (24,27,49 and 72) do not show a regular change in the mud content with depth. Indeed the changes are unpredictable as far as can be seen from this limited sample.

The calculations presented in the following section are based wholly on the contours shown in Figure 4, the main limits to accuracy being the size of the grid sampled and any assumptions made in the estimation of mud content. Also quoted in the calculations are the 8 and 9 fathom contours, these being shown in Figure 5. Some extrapolation was neccessary in drawing these contours from the relevant Admiralty Chart (No. 2494).

Calculations

For purposes of calculation the survey area has been divided into 3 divisions, based on sand depth: (i) those with thickness greater than 100 cms. (ii) between 50 and 100 cms. (iii) from 25 to 50 cms.

Firstly the division with thicknesses greater than 100 cms will be considered. This division has been sub-divided into five geographical areas, which are marked on Figure 4 (A-E). The calculations made are shown in Table 1. In the first column are shown the volumes of sand/gravel available if only the sea depths greater than 9 fathoms are dredged, and only the top meter of sand is removed. The total aggregate available here is 7,437,500 cu.m. This volume would be increased by 372,000 cu.m. if the sand were dredged to a depth of 105 cms, for such a sand thickness is available over a large percentage of the areas A-E. In the second column are shown the additional sand available if the 100 cms of sand were dredged to a water depth of 8 fathoms, the total being 1,562, 500 cu.m. The areal difference between the 8 and 9 fathom lines is illustrated in Figure 5. Should the portion between the 8 and 9 fathom lines be dredged to 105 cms. an additional 78,000 cu.m. would be obtained.

Table II also considers the first division, that is the areas with sand thickness greater than 100 cms, and concerns the additional volumes available from these areas should dredging deeper than 100 cms or 105 cms be carried out. As can be seen the additional volumes are not large (187,000 cu.m.) if a sand depth of 125 cms is removed (i.e. allowing an extra 20 cms on top of the Table I calculations to 105 cms) . Similarly the additional volume to be gained from dredging to 150 cms is only 109, 500 cu.m. It should however be noted that minimum sand depths have been used in these particular calculations.

Table III considers the second sand division in the 50-100 cms thickness range. The calculations are presented showing the volume available if a water depth greater than 9 fathoms is dredged (column 1), and the additional volume if the 8-9 fathom regions are dredged (column 2). The third column shows the thickness of sand used in the volume calculations for the individual areas (V-Z).- these values are low estimates taken from Figure 4. The total sand volume available in this division is 10,330,000 cu.m.

In addition Table III also shows the voalume of sand available in the 25-50 cms depth areas, the volume being calculated ot a mumimum sand thickness of 25 cms to produce a total of 2,999,500 cu.m. to the 8 fathom line.

The total sand/gravel aggregate available from the survey area if dredged in water of 9 fathoms and deeper, removing the 25-105 cms sand as available, would be 19,349,000 cu.m. This total becomes 22,789,000 if the 8-9 fathom area is dredged to the same depths - an additional 3,440,000 cu.m. This total would be increased to over 23,000,000 cu.m. if deeper dredging were carried out (see Summary Table IV), although this additional volume does not provide much extra sand. It is doubted therefore whether application for dredging much deeper than 105 cms, and certainly no deeper than 125 cms, would be worthwhile. Clearly the most important sand areas are those with the greatest thickness of sand, and the cumulative grain size curves (from the grab samples) for the areas A-E and immediate surrounds are presented in Appendix II.

TABLE I

Sand Areas thicker than 100 cms dredged to 100 cms only. (Division I).

Areas (See Figure 4)	to 9 f	to 8 f		
A	3,562,500	875,000		
B	1,062,500	125,000		
C	1,750,000	437,000		
D	1,062,500	-		
E	-	125,000		
TOTALS	7,437,500	1,562,500	=	9,000,000 cu. m.

If an average depth of 105 cms is taken in these calculations, then an additional 4,500,000 cu.m. is available (i.e. 371,875 + 78,250 from the 9 f and 8 f areas respectively).

TABLE II

Division I, sand areas thicker than 100 cms dredged to 125 cms where available, allowing 20 cms extra on top of previous calculations. These volumes are additional to those given in Table I.

Areas	to 9 f		to 8 f		
A	37,500		-		
B	37,500		-		
C	62,500		50,000		
D	-		-		
E	-		-		
TOTAL	137,500	+	50,000	=	187,000 cu.m.

If the one area (C) deeper than 150 cms were dredged to that depth then an additional 109,500 cu.m. would be available.

∴ Maximum total from areas with sand thickness greater than 100 cms = 9,746,500 cu.m.

TABLE III

Division II. Areas of sand thickness 50-100 cms.

Areas	to 9 f	to 8 f		Average thickness (cms) used in calculations
V	2,625,000			70
		450,000		60
W	2,318,500			70
		43,500		70
X	309,500	-		55
Y	2,843,500	612,500		70
Z	787,500	350,000		75
TOTALS	8,884,000	1,456,000	=	10,330,000 cu.m.

Division III. Areas 25-50 cms.

If these areas are dredged to the 9 fathom line, at a minimum depth of 25 cms, then a total of 2,656,000 cu.m. of aggregate are available. If dredged to the 8 f then an additional 343,500 cu.m. may be obtained.

TABLE IV

INDIVIDUAL DIVISION TOTALS

Division and dredging depth	to 9 fathoms	to 8 fathoms
> 100 cms to 105 cms	7,809,500	1,640,500
> 100 cms to 125 cms (i.e. 105-125 cms)	137,500	50,000
> 100 cms to 150 cms (i.e. 125-150)	109,500	-
50-100 cms	8,884,000	1,456,000
25-50 cms	2,656,000	343,500

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