DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

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DRILLING INVESTIGATION OF TERTIARY SAND DEPOSITS NEAR FREELING MOUNT LOFTY RANGES REVIEW

GEOLOGICAL SURVEY

by

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ABSTRACT

Tertiary sediments are the main source of construction sand and plastic brickmaking clay for the Adelaide Metropolitan area, with major deposits at Maslin Beach, Golden Grove and Gawler. A large area of similar sediments near Freeling, north of Adelaide were investigated in two stages involving:

. an 80 hole scout auger drilling program, mainly west and northeast of Freeling.

. a 15 hole program with a reverse circulation rig in thicker sediments, adjacent to the eastern margin.

Results indicated up to 12.6 m, of coarse sand and gravel occur above the basement contact and are restricted to a zone, up to 1.5 km wide and about 2.5 km long, adjacent to the Kitchener Fault. There is an upwards fining of sediments from the bottom unit which contains some pale grey, plastic clay lenses, through fine sand, silt and sandy clay, similar to Golden Grove.

Although substantial reserves of construction sand exist, overburden ratios in excess of three are considered too high for an economic mining operation and no further investigation is warranted. Large reserves of finer, filling sand occur in the northern portion of the area investigated.

INTRODUCTION

As part of the Mount Lofty Ranges Review, to delineate reserves of extractive minerals for the long term supply of Metropolitan Adelaide, Tertiary sediments in the Freeling area were investigated as a source of construction sand (Fig. 1).

The area was inspected with A.M. Pain (Principal Geologist - Extractive Minerals Section) on 29 September, 1987, prior to drilling 80 scout holes with a small, truck mounted, auger rig from 3 to 26 November, 1987. These holes were drilled by S. J. Ewen and M. W. Flintoft (Technical Assistants), mainly in the western and north-western parts of the area shown on Figure 2, to more accurately define the limits of Tertiary sedimentation and possibly locate viable sand deposits in those shallower parts of the basin.

Deeper sediments near the eastern margin were tested in a 15 hole reverse circulation drilling program, conducted between 21 March and 21 April, 1988. Samples from both programs were collected at 2 m intervals and are stored at the Department's Glenside Core Library. Cuttings were logged on site by the author. Logs of both programs are detailed in Appendices A and C respectively. Appendix B contains logs of relevant holes, obtained from the Department's Bore General File.

Selected bulk sand samples were sieved by S.J. Ewen, and results are presented graphically in Appendix D. Two samples were submitted to Dr. M.G. Farrand (Senior Geologist - Regional Geology) for identification of their heavy mineral fractions, results are detailed in Appendix E, with results of 20 gold assays by Amdel Ltd, listed in Appendix F. Five samples of lignitic clay/sand were given to Dr. N.F. Alley (Senior Geologist - Biostratigraphy) for palynological examination and results will be included in a subsequent report by him.

LOCATION

The areas investigated total about 90 km^2 and are centred about the townships of Freeling and Stockport, 56 and 67 km north-northeast of Adelaide (Fig. 1). They are within the hundreds of Nurioopta, Light and Alma, the District Councils of Light and Riverton, and the Mid North Planning Area.

Topography is undulating in the western portion, and flat to gently undulating above the deeper portion of the Tertiary Basin, adjacent to the North Mount Lofty Ranges to the east (Fig. 2). Holes were sited along road verges and reserves. These roads and tracks service grazing and cereal farmland within the area.

GEOLOGICAL SETTING

The regional geological setting is outlined on Figure 1, which has been modified from Thomson (1969). Geology of the Freeling - Stockport area is shown on Figure 2, from Dickinson and Coats (1957), and Campana (1953).

Sediments investigated comprise part of Tertiary strata laid down in the Saint Vincent Basin (Ludbrook, 1969). Deposition near Freeling was in a fluvio-lacustrine environment on Adelaidean, Burra Group meta-

sediments, in part of a sub-basin designated the Adelaide Plains basin. This includes similar deposits which are mined in the Golden Grove area (McCallum, 1988).

Deeper sedimentation is confined to a northerly trending trough, east of Freeling and bounded by the Kitchener Fault, which extends along the western flank of the adjacent hills.

The Tertiary sediments can be divided into four main units:-

1. Fine to coarse grained sand - off white with yellow-brown, iron stained zones, clayey in part with lenses of Unit 2 clay. This unit, which ranges up to 12 m thick, is confined mainly to deeper portion of the basin and generally has a layer of gravel on the basement contact.

2. Plastic clay - generally white to pale grey, often slightly silty with occasional sandy lenses and lignite zones. This unit is confined to the deeper portion of the basin east and southeast of Freeling, where it reaches a maximum thickness of 9.0 m.
3. Silt and fine sand - white to pale yellow-brown with harder indurated zones, often slightly clayey with thickness ranging up to 10 m.
4. Sandy clay and clayey sand - brown to reddish-brown. Ranging up to 15 m but generally 5 to 10 m thick. Confined mainly to the shallower, western portion of the basin where it is overlain in part by off-white to pale yellow-brown fine sand. This unit has undergone partial reworking.

Quaternary deposits are mostly confined to the plain east of Freeling and consist of mottled brown and greenish sandy clay with some calcrete zones and coarse gravel at base. Thickness ranges up to 25 m. A veneer of fine, pale yellow-brown Molineaux Sand not shown on Figure 2, mantles part of the Tertiary sediments in the northern portion of the area investigated.

PREVIOUS DRILLING

The Departmental Bore General File was examined for data on holes drilled in and adjacent to Cainozoic sediments in the Freeling area. Twelve holes with logs were found and are detailed in Appendix B, at locations shown on Figure 2. These holes are summarised in Table 1, with possible coarse sand and gravel zones indicated.

TABLE 1

SUMMARY OF BORE GENERAL FILE DATA

Hole No	Depth (m)	Sand/gravel intersection	Thickness	Overburden ratio
216	38.1	29.0-36.9	7.9	3.7
217	36.0	30.5-35.7	5.2	5.9
220	76.2	-	-	-
223	39.7	-	-	-
224	56.7	-	-	-
244	62.0	-	-	-
514	46.5	30.0-36.5	6.5	4.6
717	86.3	12.8-18.0	5.2	2.5
1291	70.0	-	-	-
1316	15.0	-	-	-
1317	15.0	10.0-14.0	4.0	2.5
12384*	23.0	13.0-21.0	8.0	1.6

Note: - no significant intersection

* on 6628 1:100 000 sheet, remainder on 6639.

Shallower gravel intersections in holes 717 and 12384 are considered to be deposited at the base of the Quaternary sediments, and the generally deeper sand/gravel intersections near the base of the Tertiary sediments. These data were useful in formulating subsequent drilling programs.

RESULTS OF DRILLING PROGRAM

Auger Drilling

Eighty holes were drilled for an aggregate depth of 527.2 m, at locations shown on Figure 2. Results are summarised in Table 2 from logs in Appendix A.

TABLE 2

SUMMARY OF AUGER HOLES

	Hole Nos. (F)	Total
Encountered basement	3, 6, 7, 11, 16, 20-22, 29, 31, 33-35, 37, 38, 43, 44, 48, 50-53, 55, 56, 62, 67-69, 73, 74, 76 ,78.	32
Possible basement	24-27, 40-42, 47, 66, 77.	10
Finished in Tertiary	1, 2, 4, 5, 8, 10, 12, 14, 15, 18, 19, 23, 28, 30, 32, 36, 45, 46, 49, 54, 57-61, 63-65, 71, 72, 75, 79, 80.	33
Finished in Quaternary	49, 70	2
Abandoned in calcrete	13, 17, 39.	3
TOTAL		80

Tertiary sediments extending northwards, from about 4 km north of Freeling, comprise mainly fine sand and clayey zones with minor coarser sand, whereas the southern area contains brown, generally sandy clay with minor sand layers. Six sand samples were submitted for sieve analysis and are discussed in RESULTS OF TESTING. Selected clay samples were supplied to J.L. Keeling (Senior Geologist, Mineral Resources Branch) for inclusion in a survey of potential clay/shale deposits in the area (Keeling and South, 1989).

Data obtained from this program and the Bore General File indicated that the area with most potential for significant coarse sand would be in the deeper, eastern portion of the basin with little potential in the western and northwestern areas.

Reverse circulation drilling

Fifteen reverse circulation holes, of 9cm diameter, were drilled with the Departmental Investigator Mark 5 rig at sites northeast and east of Freeling shown in Figure 2. Holes FR 1, 2 and 7 were abandoned before intersecting sand/gravel of Tertiary Unit 1. Also holes FR 4, 9, 11 and 14 stopped in this unit, however, they were considered to be close to the basement contact. Results are summarised in Table 3 from logs in Appendix C.

TABLE 3

SUMMARY OF REVERSE CIRCULATION DRILLING PROGRAM

Hole No (FR)	Depth(m)	Coarse sand/gravel Intersections	Thickness	Overburden Ratio
1	23.0	-	-	-
2	14.5	-	- -	
3	42.0	26.7 - 33.2	6.5	4.1
4	59.5	48.5 - 59.5+	11.0+	4.4
5	42.0	-	-	-
6	48.0	32.8 - 35.8	3.0	11.0
7	30.0	-	-	-
8	56.0	40.4 - 53.0	12.6	3.2
9	38.0	24.0 - 34.7	0.7	
		36.5 - 37.0	0.5	-
10	35.0	24.0 - 25.7	1.7	
		26.5 - 27.0	0.5	-
11	44.5	42.5 - 44.5+	2.0+	-
12	46.0	32.6 - 33.5	0.9	
		42.8 - 43.5	0.7	-
13	48.0	38.9 - 39.8	0.9	-
14	46.0	27.6 - 34.9	7.3	
		43.8 - 46.0+	2.2+	3.8
15	53.0	21.5 - 22.0	0.5	-

Intersections in holes FR 4, 8 and 14 indicate that significant thicknesses of sand/gravel are restricted to a zone up to 1.5 km wide by about 2.5 km long, adjacent to the Kitchener Fault. Closer spaced drilling would be required to accurately define this zone and establish reserves. However, this is not warranted due to excessive overburden, with ratios ranging upwards from 3.2, which preclude the establishment of a viable construction sand pit. At present ratios in excess of 1 are considered sub-economic. Similarly, gravel encountered in the southern portion of Quaternary sediments has no economic potential.

RESULTS OF TESTING

Size Analysis

Samples were sieved according to specification AS 1141 -1974, and results are presented graphically in Appendix D. Specification AS 2758.1-1985, which defines grading limits for natural fine aggregates, is shown as a broad envelope on these graphs. More rigid specifications for individual products fall within the envelope.

Size grading can also be consistently represented by two simple parameters:-

- Fineness Modulus (FM) on a 'fines-free' basis (Appendix D)
- Fines content or percentage of minus 0.075 mm material (i.e. silt and clay)

The finest sand which meets AS 2758.1-1985 specification has a FM of 1.35, and the coarsest has a FM of 4.00. Numerous specifications exist for concrete sand, but generally a FM between 2.0 and 2.5 is preferred. Maximum permissible fines content is 5 per cent. Sand with a higher content requires washing to conform to this specification. Results are summarised in Table 4 from data in Appendix D.

TABLE 4

SUMMARY OF SIZE ANALYSIS

Hole No	Depth (m)	Thickness	FM	Fines (%)
Auger holes (F)				
10	4.0 - 5.3	1.3	1.56	19.3
15	2.0 - 3.0	1.0	2.54	17.3
27	2.0 - 7.5	5.5	1.58	13.0
32	2.0 - 12.0	10.0	1.01	24.6
42	4.0 - 8.0	4.0	1.13	12.6
62	6.0 - 8.5	2.5	2.69	28.0
Reverse circulation holes (FR)				
3	26.0 - 28.0	2.0	1.06	7.7
	28.0 - 34.0	6.0	2.07	28.5
4	48.0 - 50.0	2.0	1.10	15.2
	50.0 - 54.0	4.0	1.63	3.6
	54.0 - 58.0	4.0	2.03	8.6
	58.0 - 59.5	1.5	4.44	0.0
6	32.0 - 36.0	4.0	2.12	13.1
8	40.0 - 46.0	6.0	2.59	2.8
	46.0 - 52.0	6.0	3.50	0.9
14	28.0 - 34.0	6.0	2.78	8.4

Although four of the six auger hole samples have FM'S suitable for construction sand, high fines contents and limited thicknesses indicate that potential for viable deposits is negligible.

Fines contents of some reverse circulation hole samples are unreliable, particularly for FR 4 and 8, due to removal of much of the silt by drilling fluids. Results indicate that sand from each of the major intersections, with washing and/or blending, would be suitable for use as a fine aggregate.

Mineralogy of heavy minerals

As at Golden Grove (McCallum, 1988), heavy mineral zones were encountered in coarse sand and gravel above the basement contact in most holes. Two samples submitted for microscopic examination indicated that the major constituent is probably ilmenite with some hematite. Tourmaline is common, rutile and zircon moderately abundant with trace amounts of biotite, staurolite, kyanite, andalusite and sphene present. Full results are detailed in Appendix E.

Gold Analyses

Twenty samples were submitted to Amdel Ltd for AAS gold analysis, principally to test the basal Tertiary gravel which has been mined for gold in parts of the nearby Barossa Valley. Samples of weathered basement were also tested.

Only a sample of weathered basement indicated gold, which was at the detection limit of 0.02 ppm, all other samples were under this limit. Results and sample locations are listed in Appendix F.

CONCLUSIONS

As part of a review of extractive minerals for Adelaide's future requirements, Tertiary sediments in the Freeling area were investigated in a two stage drilling program. Initially, 80 scout auger holes were drilled, mainly in the western and northwestern portion of this area, followed by a 15 hole program with a reverse circulation rig in the deeper, eastern part of the basin adjacent to the Kitchener Fault.

Intersections of up to 12.6 m of coarse sand and gravel were encountered in this deeper portion, indicating that significant reserves of suitably sized material exist. However, overburden ratios in excess of three are considered too large for an economically viable mining operation.

Substantial deposits of finer Tertiary/Quaternary sand, suitable for filling material, occur in the northern portion of the area investigated but adequate reserves of similar material exist much closer to Adelaide.

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APPENDIX A

LOGS OF AUGER HOLES

Abbreviations used in Logs:

V	Very	Brn	Brown
F	Fine	Tert.	Tertiary
M	Medium	Quat.	Quaternary
C	Coarse	EoH	End of Hole
W.S.	Weathered Shale	W.B.	Weathered Basement

Hole No.	Depth (m) From	To	Description	
F1	0.0	0.4	Soil -	Sandy clay.
	0.4	1.1	Calcrete -	Off white, clayey.
	1.1	9.0	Clay -	Brn to red brn. Sandy, silty in part. Tert. 9.0 EoH.
F2	0.0	0.6	Soil -	Brn. Sandy clay.
	0.6	9.0	Clay -	Mainly yellow-brn. Silty. Sandy in part. Tert. 9.0 EoH.
F3	0.0	0.4	Fill + soil -	White - off white. Calcareous clay.
	0.4	4.5	Clay -	Red-brn. Silty. Tert? to 2.8.
			-	Yellow-brn. Trace silt. Micaceous. Hard past 4.0. W.S. 4.5 EoH.
F4	0.0	1.0	Soil -	Dark brn.
	1.0	3.9	Clay -	Yellow brn to red brn. Silty, sandy.
	3.9	4.8	Sand -	M-F. Red. V clayey. Tert. to 4.5.
			-	F. Black-grey. V clayey. Hard. Weathered sandstone? 4.8 EoH.
F5	0.0	7.5	Clay -	Pale brn to brn. Silty, sandy. Tert.
			Note :	F, orange sandstone on bit at 7.5. No penetration. Indurated sand?? 7.5 EoH.
F6	0.0	0.2	Soil -	Brn. Sandy.
	0.2	2.3	Sand -	F. Orange-brn. Clayey to 1.1.
			-	With rounded quartz gravel. Tert.
	2.3	4.0	Silt -	White. Slightly clayey. Hard past 3.2. W.B. 4.0 EoH.
F7	0.0	0.1	Fill -	Road rubble.
	0.1	5.1	Clay -	Light brn to red-brn. Silty. Sandy. Tert.
	5.1	6.0	Sand -	VF-F. Brn-yellow. Hard past 5.5. Weathered sandstone basement? 6.0 EoH.

F8	0.0	0.2	Soil
	0.2	3.3	Clay - Light brn. Sandy, some gravel past 2.9. Tert.
	3.3	3.5	Sandstone - F. White. Hard. Indurated Tert. sand? 3.5 EoH.
F9	0.0	0.1	Soil
	0.1	1.1	Clay - Buff. Silty. Tert.
	1.1	3.0	Siltstone - Off white. Some clayey lenses. Hard past 2.6. W.B. 3.0 EoH.
F10	0.0	0.3	Soil
	0.3	1.8	Clay - Red brn. Sandy with grit and F gravel past 1.0.
	1.8	2.6	Gravel - F. Red clayey.
	2.6	4.8	Sand - VC-M. Red brn. Clayey.
	4.8	5.3	Gravel - F. Dark brn. Sandy, clayey. Hard. Tert. 5.3 EoH.
F11	0.0	0.4	Soil
	0.4	1.1	Calcrete
	1.1	3.5	Silt - White. Hard. Siltstone. W.B. 3.5 EoH.
F12	0.0	0.4	Soil
	0.4	2.1	Clay - Red brn. Sandy, with some F gravel past 1.5.
	2.1	2.5	Gravel -F. Red. Sandy, clayey.
	2.5	2.8	Sand - C-M. Red-brn. Some clay, minor gravel. Hard. Tert. 2.8 EoH.
F13	0.0	0.2	Soil
	0.2	1.9	Calcrete - Off white. Hard near bottom of hole. 1.9 EoH.
F14	0.0	0.4	Soil
	0.4	2.2	Clay - Yellow-brn. Sandy.
	2.2	2.5	Sand - Brn-yellow. Clayey. Some F gravel. Hard, Tert. 2.5 EoH.
F15	0.0	0.5	Soil
	0.5	2.0	Clay - Pale yellow-brn. Sandy. F gravel past 1.2.
	2.0	3.0	Sand - VC-F. Red with abundant F gravel. Hard, Tert. 3.0 EoH.

F16	0.0	0.5	Fill +	F sand
	0.5	1.2	Calcrete -	Off white, soft.
	1.2	2.4	Clay -	Brn. V sandy.
	2.4	9.0	Sand -	F-M. Reddish. Some C-VC grains past 5.0. Hard past 8.0. Tert.
				9.0 EoH.
F17	0.0	0.2	Fill	
	0.2	1.6	Clay -	Grey-brn. Sandy with carbonate.
	1.6	2.0	Calcrete -	Off white. Hard.
				2.0 EoH
F18	0.0	0.5	Fill + Sand -	F, old soil horizon.
	0.5	1.8	Calcrete -	Off white. Moderately hard past 1.4.
	1.8	6.8	Clay -	Brn. Slightly sandy, silty.
	6.8	12.0	Sand -	VF-M. Yellow. Some VC grains past 11.0. Brn. Clayey. Tert.
				12.0 EoH.
F19	0.0	0.5	Fill + Sand -	F, old soil horizon.
	0.5	2.4	Clay -	Brn. V sandy.
	2.4	4.2	Sand -	VF-F. Off white to pale grey. Occasional grain F gravel.
	4.2	7.0	Silt -	Pale grey. Minor clay.
	7.0	11.5	Clay -	Brn to purple-brn. Silty. Traces of sand. Tert.
				11.5 EoH.
F20	0.0	0.4	Fill + Sand	
	0.4	1.8	Calcrete -	
	1.8	10.5	Clay -	Brn. V sandy to 2.2. Tert.
			-	Grey to greenish. Silty.
				Minor sand. W.S.
				10.5 EoH.
F21	0.0	0.4	Fill + Sand	
	0.4	10.5	Clay -	Brn. sandy to 0.9 Tert.
			-	Grey brn to grey. Silty to V silty. Hard in part. W.S.
				10.5 EoH.
F22	0.0	0.4	Fill -	Sandy clay.
	0.4	4.7	Clay -	Yellow brn. Sandy with carbonate to 4.2. Tert.
			-	Grey brn. Silty. Hard W.S.
				4.7 EoH.

F23	0.0	0.4	Soil
	0.4	1.1	Clay - Dark brn. Sandy.
	1.1	2.6	Calcrete - Clayey. Moderately hard.
	2.6	3.0	Clay - Yellow brn. Sandy.
	3.0	3.5	Sandstone - VF-F. Buff with some carbonate. Indurated sand. Hard. Tert. 3.5 EoH.
F24	0.0	0.4	Soil
	0.4	1.1	Calcrete - Buff. Moderately hard.
	1.1	2.5	Clay - Red-brn. Sandy
	2.5	4.9	Sand - F-M. Reddish brn. Some C grains. Clayey. Tert.
	4.9	5.2	Clay - Pale yellow brn. Silty. Hard W.S.? 5.2 EoH.
F25	0.0	0.3	Soil
	0.3	1.2	Calcrete - Off white. Moderately hard.
	1.2	6.5	Clay - Yellow brn. Sandy to 5.7. Tert.
			- Reddish. Silty. Harder. W.S.? 6.5 EoH.
F26	0.0	0.4	Soil
	0.4	4.9	Clay - Brn. Sandy. Reddish part with VC sand.
	4.9	6.1	Sand - VC-M Red brn to brn. V clayey with some F gravel. Hard in part. Tert.
	6.1	6.2	Clay - Mottled brn and pale brn. Hard. W.S.? 6.2 EoH.
F27	0.0	0.3	Soil
	0.3	1.4	Calcrete - Buff. Clayey.
	1.4	1.9	Clay - Light brn. Some carbonate zones.
	1.9	7.4	Sand - F-M. Red to brn. Clayey with some VC. Some F gravel past 4.0.
	7.4	7.5	Clay - White, silty, hard. W.S.?? 7.5 EoH.

F28	0.0	0.9	Fill + Sand
	0.9	7.5	Clay - Pale brn to yellow brn. Sandy with some carbonate patches to 4.2
			- Red brn. V sandy with some VC grains.
	7.5	9.4	Sand - F-C. Yellow brn-red brn. V clayey. Hard past 9.1 Tert.
			9.4 EoH.
F29	0.0	1.7	Fill + soil - Dark brn sandy clay.
	1.7	3.2	Clay - Brn to yellow brn. Sandy. Tert.
	3.2	6.0	Siltstone - Buff. Clayey. Harder past 5.5. W.B.
			6.0 EoH.
F30	0.0	0.4	Soil - Dark brn. Clayey sand with some carbonate nodules.
	0.4	9.0	Clay - Yellow brn to red brn. Sandy to V sandy with some VC quartz grains past 7.4. Tert.
			9.0 EoH.
F31	0.0	0.4	Soil - Some calcrete nodules.
	0.4	7.2	Clay - Brn to red brn. Sandy, silty. Tert.
	7.2	9.0	Siltstone - Pale yellow brn to off white. Clayey. Harder with some chips past 8.5. W.B.
			9.0 EoH.
F32	0.0	0.4	Soil
	0.4	1.3	Calcrete
	1.3	2.2	Clay - Yellow brn. Sandy. Some carbonate patches.
	2.2	12.0	Sand - VF-M with some VC. Yellow brn to reddish. Clayey to 10.0.
			- F-M with minor VC and F gravel. V clayey. Tert. 12.0 EoH.
F33	0.0	0.7	Fill + soil
	0.7	7.5	Clay - Brn to grey brn. Sandy silty to 7.0. Tert.
			- Yellow brn and brn mottled. Powdery, silty. Hard W.S.
			7.5 EoH.
F34	0.0	0.6	Soil
	0.6	5.5	Clay - Yellow brn to reddish. Sandy to 4.1. Tert.
			- Brn. Silty. Hard past 5.0. W.S.
			5.5 EoH.

F35	0.0	0.5	Soil -	Sandy.
	0.5	3.8	Clay -	Brn to pale brn. Sandy. Some carbonate patches to 1.6. Tert.
	3.8	4.6	Silt -	Mottled brn and yellow brn. Clayey. Micaceous. Soft, hard past 4.5. W.B. 4.6 EoH.
F36	0.0	1.2	Soil -	Brn sandy loam.
	1.2	6.5	Clay -	Brn to reddish brn. Sandy to V sandy.
	6.5	9.5	Sand -	VF-M. Brn. Clayey. Some off white indurated chips past 8.5. Hard. Tert. 9.5 EoH.
F37	0.0	0.5	Soil	
	0.5	1.4	Clay -	Yellow brn. V sandy.
	1.4	3.8	Sand -	VF-M. Buff to off white. Clayey. Some VC.
	3.8	4.2	Gravel - F-M with F sand. Pale brn. Tert.	
	4.2	4.5	Clay -	Off white. Silty. W.S. 4.5 EoH.
F38	0.0	0.3	Fill	
	0.3	1.6	Clay -	Brn to red brn. Sandy with some carbonate patches.
	1.6	1.9	Gravel - F. Red and yellow brn. Clayey. Tert.	
	1.9	2.1	Clay -	Pale yellow brn. Silty. Hard past 2.0 W.S. 2.1 EoH.
F39	0.0	0.1	Soil	
	0.1	4.2	Clay -	Off white to brn. Sandy with carbonate patches. Quat.
	4.2	4.7	Calcrete - Off white. Hard. 4.7 EoH.	
F40	0.0	0.3	Soil	
	0.3	6.1	Clay -	Dark brn to yellow brn. Sandy. Some carbonate patches to 2.5. Silty. Tert.
	6.1	6.5	W.S.? -	Brn. Trace sand, silty. V hard. 6.5 EoH.
F41	0.0	0.3	Soil -	Brn clay.
	0.3	5.5	Clay -	Yellow brn. Sandy. Traces of carbonate to 1.6. Silty. Tert.
	5.5	7.5	W.S.? -	Brn to reddish. Trace of sand, silty. Hard past 6.0. 7.5 EoH.

F42	0.0	0.4	Soil	
	0.4	3.0	Clay -	Brn to yellow brn. Some white carbonate to 1.8. Sandy to V sandy.
	3.0	9.8	Sand -	F-VF. Brn yellow. V clayey to 4.1 - F - C. Yellow brn. Clayey with some F gravel to 5.2 - VC-F. Buff. Clayey to 6.6 - VF-M. Red. Clayey. Tert.
	9.8	11.0	Clay -	Off white to pale brn. Silty to V silty. W.S.? 11.0 EoH.
F43	0.0	0.3	Soil	
	0.3	2.2	Clay -	Brn to yellow. Sandy, silty. Some rounded F gravel past 2.0.
	2.2	2.6	Gravel - F. Yellow brn. Clayey. Tert.	
	2.6	3.0	Clay -	Grey green. Silty. Powdery. Hard past 2.8. W.S. 3.0 EoH.
F44	0.0	0.4	Soil	
	0.4	2.8	Clay -	Brn to yellow brn. Sandy. Some white calcrete to 1.3. Tert.
	2.8	4.5	Silt -	Off white to pale brn. Clayey, powdery. Hard past 3.5. W.B. 4.5 EoH.
F45	0.0	0.4	Soil	
	0.4	3.8	Clay -	Yellow brn to buff. Sandy. White carbonate patches to 2.4.
	3.8	6.0	Sand -	VF-M. Brn yellow. Clayey. Wet. Water at 4.5. Circulation lost. Tert. 6.0 EoH.
F46	0.0	0.4	Soil	
	0.4	1.0	Sand -	F. Brn. Clayey.
	1.0	1.9	Calcrete	
	1.9	7.0	Clay -	Reddish brn to brn yellow. Sandy to V sandy. Silty.
	7.0	12.0	Silt -	Buff. Clayey. Soft. Trace mica. Water hit at 10.5 Tert 12.0 EoH.
F47	0.0	1.1	Soil	
	1.1	7.5	Clay -	Red brn. Sandy to V sandy. Water at 4.2. Quat. Possible W.S. at 7.5. EoH.

F48	0.0	0.1	Soil	
	0.1	0.5	Calcrete	
	0.5	4.5	Clay -	Yellow brn. Some carbonate patches. Sandy to 2.8 Tert.
			-	Greenish brn. Silty. Minor sand. W.S.
				4.5 EoH.
F49	0.0	0.4	Soil	
	0.4	5.4	Clay -	Brn to red brn. Sandy, silty. Some carbonate nodules to 4.0. Hard past 5.2. Quat.
				5.4 EoH.
F50	0.0	0.6	Soil	
	0.6	3.0	Clay -	Greenish. Soft. V silty. W.S. to 2.0.
			-	Dark grey green. Hard.
				W.S.
				3.0 EoH.
F51	0.0	0.7	Soil	
	0.7	3.0	Clay -	Greenish. V silty. Soft. W.S. to 1.2.
			-	Yellow brn with red mottling. W.S.
				3.0 EoH.
F52	0.0	0.4	Soil	
	0.4	4.5	Clay -	Pale yellow brn to off white. Silty. Few chips past 3.5. Harder. W.S.
				4.5 EoH.
F53	0.0	0.3	Soil	
	0.3	0.9	Sand -	VF-M. Off white. Clean.
	0.9	2.6	Calcrete - Soft. Clayey.	
	2.6	6.0	Clay -	Brn. Sandy with some carbonate. Tert. to 3.8.
			-	Greenish grey. V silty.
				W.S.
				6.0 EoH.
F54	0.0	0.4	Soil	
	0.4	12.0	Sand -	F-M. Red brn. V clayey. Clayey sand in part, to 4.2.
			-	F-VC. Red brn. Some F gravel. Clayey to 8.5.
			-	VF-M. Red to yellow brn. V clayey. Tert.
				12.0 EoH.
F55	0.0	0.3	Soil	
	0.3	0.7	Calcrete	
	0.7	1.5	Silt -	Pale to dark grey. Hard past 1.2 W.B.
				1.5 EoH.

F56	0.0	0.3	Soil	
	0.3	1.3	Clay -	Yellow brn. Sandy with some calcrete.
	1.3	2.8	Sand -	VF-M. Yellow brn to brn. V clayey.
	2.8	3.4	Clay -	Brn to grey brn. Sandy, silty. Tert.
	3.4	3.7	Sandstone - F. Pale brn. Some clay. Hard. W.B.	
				3.7 EoH.
F57	0.0	0.2	Soil	
	0.2	2.3	Clay -	Pale yellow brn. Sandy with carbonate patches. V silty past 1.8.
	2.3	2.6	Silt -	Off white to pale grey. Hard, indurated.
	2.6	12.0	Sand -	VF-F. Off white. Slightly clayey. Few hard bands to 7.0.
			-	F-M. Brn yellow. Clean. Tert.
				12.0 EoH.
F58	0.0	0.4	Soil	
	0.4	1.0	Calcrete	
	1.0	2.2	Silt -	Off white to pale brn. Minor clay.
	2.2	9.3	Sand -	VF-M. White to yellow brn. Clean to 5.5.
			-	F-C. Clean to 5.8.
			-	VF-M. White. Clean to 6.6.
			-	VF-M. Pale brn to brn yellow. Minor clay. Some F gravel zones. Few hard bands. Tert.
				9.3 EoH.
F59	0.0	0.2	Soil	
	0.2	1.0	Clay -	Brn red. V sandy.
	1.0	12.0	Sand -	F-M. Red. V clayey to 3.5
			-	M-F. Red. Clayey to V clayey to 11.4
			-	VF-M. Yellow brn. V clayey. Tert.
				12.0 EoH.
F60	0.0	0.7	Soil	
	0.7	1.0	Clay -	Dark brn. Sandy. Some carbonate.
	1.0	1.4	Calcrete	
	1.4	4.7	Sand -	VF-M. Yellow brn to brn. V clayey. Hard past 4.0. Indurated. Trace F gravel at base. Tert.
				4.7 EoH.
F61	0.0	1.3	Fill + sand	
	1.3	3.8	Clay - Red brn to red. Sandy.	
	3.8	11.4	Sand -	VF-F. Red to yellow brn. Clayey to V clayey to 7.3.
			-	VF-M. Off white to pale brn. Clayey. Some hard bands to 9.5.
			-	VF. Pale yellow. Minor clay.
	11.4	12.0	Silt -	Pale yellow brn. Minor clay. Grading to VF sand. Tert.
				12.0 EoH.

F62	0.0	0.4	Soil	
	0.4	1.5	Clay -	Brn. Sandy. Trace carbonate.
	1.5	8.5	Sand -	F-VF. Pale yellow brn. Clean. Some F gravel past 3.0 to 6.3.
			-	F-VC. Yellow brn. Abundant F gravel. Clayey to V clayey. Some hard bands. Tert.
	8.5	10.0	Clay -	Pale yellow brn. Silty. Chips past 9.5. W.S. 10.0 EoH.
F63	0.0	0.4	Soil	
	0.4	1.6	Clay -	Red brn to yellow brn. Sandy. Trace of carbonate.
	1.6	4.2	Sand -	VF-F. Orange. V clayey. Hard past 4.0. Tert. 4.2 EoH.
F64	0.0	0.4	Soil	
	0.4	1.1	Clay -	Yellow brn. V sandy.
	1.1	5.5	Sand -	VF-F. Orange. Clayey. Hard to 2.6.
			-	VF-M. Red brn - brn. Clayey to V clayey. Some hard bands.
	5.5	7.7	Clay -	Red brn. V sandy, silty.
	7.7	8.0	Sandstone -	F. White. Hard, indurated. Tert. 8.0 EoH.
F65	0.0	0.2	Soil	
	0.2	5.6	Sand -	F. Dark brn. V clayey to 1.4.
			-	VF-F. Brn yellow. Clayey to V clayey past 3.0.
	5.6	8.0	Clay -	Yellow brn. V sandy. Hard. Tert. 8.0 EoH..
F66	0.0	0.2	Soil	
	0.2	7.5	Clay -	Dark brn. Silty. Minor sand. White carbonate patches to 1.4.
			-	Yellow brn. Silty. Trace sand to 6.5. Tert.
			-	Reddish mottled. Hard past 7.0. W.S.? 7.5 EoH.
F67	0.0	0.2	Soil	
	0.2	0.9	Calcrete	
	0.9	4.7	Clay -	Yellow brn. Silty. Trace of carbonate to 1.4. Tert.
			-	Brn yellow. Trace sand. Minor silt W.S.?
	4.7 W.B.	5.0	Sandstone -	F-VF white. Hard. 5.0 EoH.

F68	0.0	0.3	Soil	
	0.3	4.5	Clay -	Dark grey brn. Silty. Minor sand to 1.7.
			-	Yellow brn. Traces sand and silt to 4.2. Tert.
			-	Mottled red and yellow brn. Silty, slightly sandy. Hard W.S.
				4.5 EoH.
F69	0.0	0.3	Soil	
	0.3	2.6	Clay -	Dark grey brn. Silty with carbonate to 1.2. Tert.
			-	Yellow brn to pale yellow brn mottled. Silty. W.S.?
	2.6	3.0	Sandstone - F. Off white.	
	Hard.			
				W.B.
				3.0 EoH.
F70	0.0	0.2	Soil	
	0.2	9.0	Clay -	Brn. Silty, sandy. Trace of carbonate to 1.4.
			-	Reddish brn to yellow brn. Silty. Minor sand. Plastic Quat.
			Note:	Hit water near 9.0. Possibly Tert. Sand.
				9.0 EoH.
F71	0.0	0.4	Soil	
	0.4	1.7	Clay -	Yellow brn. Sandy. Silty.
	1.7	5.5	Silt -	Off white to pale yellow brn. Clayey. Trace mica.
	5.5	8.5	Sand -	VF-F. Pale brn to orange. Silty, minor clay.
	8.5	10.5	Silt -	Pale brn to brn yellow. Clayey. Tert.
				10.5 EoH.
F72	0.0	0.2	Soil	
	0.2	1.2	Calcrete - Soft. Clayey.	
	1.2	7.0	Clay -	Brn. Sandy to 1.5
			-	Yellow brn. Sandy, silty.
	7.0	8.2	Silt -	Pale grey green. Clayey.
	8.2	9.0	Clay -	Yellow brn. V silty. Soft. Tert.
				9.0 EoH.
F73	0.0	0.5	Soil	
	0.5	5.0	Clay -	Brn to yellow brn. V sandy, clayey sand in part. Some VC quartz grains. Tert - Quat?? V hard at 5.0 - Basement. 5.0 EoH.
F74	0.0	0.4	Soil	
	0.4	1.1	Calcrete	
	1.1	1.5	Clay -	Buff. Sandy.
	1.5	3.5	Sand -	VF. Off white to pale yellow brn. Minor clay. Tert. Basement siltstone or shale at base. White, VF. Hard.
				3.5 EoH.

F75	0.0	0.8	Soil	
	0.8	5.5	Clay -	Yellow brn to brn. V sandy, silty. Few carbonate nodules to 3.5.
			-	Brn yellow. V sandy, silty. Wet at 5.0. Possibly clayey sand. Tert. 5.5 EoH.
F76	0.0	0.4	Soil	
	0.4	0.8	Calcrete	
	0.8	2.5	Clay -	Brn yellow. V sandy. Some carbonate nodules.
	2.5	4.5	Sand -	VF-F. Brn yellow. Clayey to 3.4.
			-	VF-F. Yellow. Clayey with rounded quartz gravel up to 2 cm. Tert.
	4.5	9.0	Clay -	Off white to buff. Some red brn Fe zones. Soft powdery. V silty. W.S. 9.0 EoH.
F77	0.0	0.3	Soil	
	0.3	1.2	Calcrete - Moderately hard.	
	1.2	4.6	Clay -	Yellow brn. Silty, sandy. Some carbonate patches to 2.4.
			-	Brn to red brn. V sandy.
	4.6	5.2	Sand -	VF-M. Brn yellow. Clayey. Some F gravel. Hard at 5.2. F sandstone Tert. or W.B.? 5.2 EoH.
F78	0.0	0.4	Soil	
	0.4	1.3	Calcrete	
	1.3	3.8	Silt -	White to pale brn. Minor clay.
	3.8	6.8	Sand -	VF-F. Orange. Minor clay to 4.3.
			-	VF. Pale brn to off white. Silty to 5.7.
			-	F-M. Brn yellow. Minor clay. Some C - VC grains. Tert.
	6.8	9.0	Clay -	Yellow. Silty to V silty. Powdery. Siltstone in part. W.S. 9.0 EoH.
F79	0.00	0.7	Soil	
	0.7	1.5	Calcrete	
	1.5	10.5	Sand -	F-M. Red. Moderately clayey to 2.6.
			-	VF-M. Orange to yellow bn. Clayey. Tert. 10.5 EoH.
F80	0.0	0.2	Soil	
	0.2	5.6	Clay -	Yellow brn to red brn. Sandy, silty.
	5.6	9.0	Sand -	F - C. Red. Occasional F gravel. V clayey to 6.
			-	F - M. Red. Some VC grains. Clayey. Tert 9.0 EoH.

APPENDIX B

LOGS OF WATER BORES

Obtained from SADME Bore General File on Sheet 6629

LOGS OF WATER BORES

Hole No.	Depth (m) From	To	Description	
216	0.0	0.3	Loam -	Brown.
	0.3	0.9	Clay -	Red brown.
	0.9	4.6	-	Brown and yellow brown.
	4.6	10.7	-	Sandy. Red-brown. More sandy near 10.7.
	10.7	25.9	Sand -	Silty. VF-F. Yellow.
	25.9	29.0	-	F-M. Red-brown.
	29.0	33.5	-	C with some grit. Yellow-brown.
	33.5	35.1	-	F-M. Red-brown.
	35.1	36.9	-	C. Yellow. Tert.
	36.9	38.1	Clay -	Buff. W.S.?
				38.1 EoH.
217	0.0	6.1	Clay -	Sandy. Red and brown.
	6.1	12.2	Sand -	F. Some hard bands.
	12.2	18.3	-	VF. Grey-yellow.
	18.3	24.4	-	F. Clayey. Yellow.
	24.4	27.4	Clay -	Sandy. Mottled grey, yellow and red.
	27.4	30.5	Sand -	Clayey. Mottled red and yellow.
	30.5	33.5	Grit -	Angular, some large rounded quartz pebbles
	33.5	35.7	-	With C quartz sand and rounded pebbles. Tert.
	35.7	36.0	Silt -	Clayey. Grey. W.B.?
				36.0 EoH.
220	0.0	1.5	Silt -	Clayey, sandy. Dark brown. Calcareous.
	1.5	4.6	Clay -	Very silty. Calcareous. Brown.
	4.6	21.3	Sand -	F. Silty. Yellow. Tert.
	21.3	76.2	Clay -	Silty. Powdery. Yellow and white. W.S.
				76.2 EoH.
223	0.0	1.8	Clay -	Red.
	1.8	4.6	-	Sandy. Red-brown.
	4.6	5.2	Limestone - Gravelly.	
	5.2	12.5	Clay -	Sandy. Red-brown. Tert.
	12.5	13.1	-	White. W.S.?
	13.1	31.1	-	Grey.
	31.1	34.2	Shale -	Dark grey.
	34.2	37.8	Slate -	Grey with quartz.
	37.8	39.7	Shale -	Grey.
				39.7 EoH.
224	0.0	0.9	Soil	
	0.9	3.4	Clay -	Cream.
	3.4	4.9	Limestone - Cream, soft.	
	4.9	6.7	Sand -	C. Yellow.
	6.7	11.6	Clay -	Light brown with gravel. Tert.
	11.6	13.7	-	Light grey with grit. W.S.?
	13.7	16.8	-	Grey with grit.

	16.8	23.2	-	Grey green with grit.
	23.2	42.3	-	Grey.
	42.3	46.1	Shale-	Grey.
	46.1	50.3	Slate-	Grey, soft.
	50.3	56.7	-	Grey with quartz.
				56.7 EoH.
244	0.0	0.9	Soil -	Sandy.
	0.9	5.5	Clay -	Red.
	5.5	7.9	-	Red with gravel. Tert.
	7.9	13.7	Slate-	Sandy. Soft. Grey-green W.S.
	13.7	21.0	-	Grey-green.
	21.0	62.0	-	Grey-green. Harder.
				62.0 EoH.
514	0.0	6.0	Clay -	Sandy. Mottled grey and brown. Quat.
	6.0	30.0	Sand -	VF. Clayey, silty. Tert.
	30.0	33.0	-	M-C. Pale yellow, clean. Angular to sub-rounded.
	33.0	34.5	-	M-C. Up to 10% clay.
	34.5	36.0	-	M-C. As above with some gravel. Yellow-grey. Angular to well rounded.
	36.0	36.5	Conglomerate -	Quartzite fragments with silt. Tert.
	36.5	42.0	Sand -	VF. Silty. Micaceous. Pale grey - yellow. W.B.
	42.0	45.0	-	Micaceous. Mottled pale grey-brown.
	45.0	46.5	-	M-C. White.
				46.5 EoH.
717	0.0	0.6	Soil	
	0.6	9.8	Clay -	Red and brown, mottled.
	9.8	12.8	Sand -	Clayey.
	12.8	18.0	-	With boulders. Quat.
	18.0	21.9	Clay -	Grey, sticky. W.S.?
	21.9	24.4	Sand -	Indurated, hard in part.
	24.4	31.1	-	With grey and yellow clay seams.
	31.1	32.0	-	Clean, F.
	32.0	35.7	-	Indurated.
	35.7	42.7	-	Grey, clayey.
	42.7	48.5	Clay -	Brown and grey.
	48.5	49.4	Sand -	F.
	49.4	53.0	Clay -	Brown.
	53.0	56.4	Sand -	F.
	56.4	60.7	Clay -	Grey and brown.
	60.7	61.6	Sand -	
	61.6	76.8	Clay -	White, micaceous.
	76.8	86.3	-	Grey-green. Soft.
				86.3 EoH.

1219	0.0	7.5	Clay -	Red.
	7.5	9.0	Sand -	Tert.
	9.0	51.0	Clay -	Grey, red and yellow. W.S.?
	51.0	54.0	Sand -	F. Clayey.
	54.0	63.0	-	F.
	63.0	64.0	Clay -	Yellow-grey.
	64.0	70.0	Sand	
				70.0 EoH.
1316	0.0	1.0	Clay -	Sandy. Pinkish brown.
	1.0	2.0	Silt -	Clayey. Pinkish brown.
	2.0	15.0	Clay -	Grey-yellow-brown with silty interbands. Tert.
				15.0 EoH.
1317	0.0	2.0	Sand -	Clayey. Pale brown.
	2.0	4.0	Clay -	Slightly silty, sandy.
	Red-brown.			
	4.0	10.0	Sand -	F-VF. Silty. Orange-brown, indurated in part.
	10.0	12.0	-	M-C. (0.2 - 0.5 mm)
	12.0	13.0		No sample
	13.0	14.0	Sand -	F - C. Clayey. Pale brown.
	14.0	15.0	Clay -	Sandy. Tert.
				15.0 EoH.
12384	0.0	3.0	Soil	
	3.0	9.0	Clay -	Brown, sandy.
	9.0	13.0	-	Brown and grey, sandy.
	13.0	13.5	Sand -	C with gravel.
	13.5	21.0	Gravel - F + C. Quat.	
	21.0	23.0	Clay -	Grey and brown, sandy. W.S.?
				23.0 EoH.

APPENDIX C

LOGS OF REVERSE CIRCULATION HOLES

Hole No.	Depth(m) From	To		Description
FR1	0.0	1.0	Soil -	Brn. Sandy clay. Traces of carbonate.
	1.0	1.5	Clay -	Yellow-brn. Silty. Minor F sand. Some off-white carbonate patches.
	1.5	3.7	-	Brn with some grey mottling. Sandy with traces of grit. Quat.
	3.7	4.8	Silt -	Red-brn. V clayey. Sl.sandy.
	4.8	6.0	Clay -	Red-brn. Silty. Moderately sandy. Trace of grit.
	6.0	7.8	-	Brn. As above.
	7.8	9.5	-	As above. V sandy.
	9.5	10.5	Sand -	-VF. Occasional VC. Yellow-brn. V clayey-sandy clay in part.
	10.5	17.0	Silt -	White to grey. V clayey.
	17.0	20.4	-	Yellow-brown. Clean.
	20.4	23.0	-	Pale grey to off-white. Occasional ferruginised lumps to 4mm. Tert. 23.0 EoH Rods stuck - hole abandoned.
FR2	0.0	0.8	Soil -	Brn. Sandy clay. Some F gravel.
	0.8	1.5	Sand -	F-VF. Light brn. V silty.
	1.5	5.6	Clay -	Brn with some grey zones. Some grit and gravel up to 3 cm. Few thin sand lenses. Quart.
	5.6	6.5	Sand -	VF-F. Reddish-brn.
	6.5	8.2	Silt -	Pale grey to white. Clayey. Some hard, indurated bands.
	8.2	14.5	-	Pale grey with pale yellow-brn bands. Hard, indurated past 12.5. V hard past 13.0. Tert. 14.5 EoH Very hard - hole abandoned.
FR3	0.0	0.7	Soil -	Grey-brn. Sandy clay. Some grit.
	0.7	1.3	Sand -	VF-M. Some VC. Reddish-brn. Some clay.
	1.3	2.0	Clay -	Brn with pale mottling - silty. Some carbonate.
	2.0	8.5	-	Brn with dark grey and grey-green banding. Silty with sandy bands. Occasional grit. Minor gravel, up to 1 cm, past 7.0. Quat.
	8.5	10.8	Silt -	Grey-green with some brn clay lenses. Iron staining. Abundant F sand.
	10.8	15.6	-	Grey to off-white. Abundant F sand.
	15.6	23.0	-	Grey with yellow-brn banding. Sandy. V clayey in part.
	23.0	26.7	-	Yellow-brn. V sandy.
	26.7	28.8	Sand -	F-M, some VC. Yellow-brn. Silty with few thin silt lenses. Some dark, F grains.
	28.8	33.2	Gravel-	Pale grey to 1 cm in M-Fsilty sand matrix. Quartz gravel angular to subangular. Tert.
	33.2	42.0	Silt -	Light grey to grey. V micaceous. Clayey. Occasional angular quartz grain. Dark grey past 39.0. Some angular, vein quartz chips 39.0-39.5 W.B.

				42.0 EoH.
FR4	0.0	0.8	Soil -	Brn sandy clay. Traces of carbonate.
	0.8	1.6	Clay -	Light brn, silty with abundant white carbonate zones.
	1.6	3.0	-	Brn with some black & grey mottling. Silty. Traces of carbonate & quartz grit.
	3.0	5.5	-	Brn with thin grey silty bands. Some F sand lenses.
	5.5	9.6	-	Grey silty bands more abundant, up to 2 cm thick. Sandy to V sandy, clayey sand in part. Some grit. Quat.
	9.6	12.5	Sandstone - VF-F. Mottled red &	off-white. Upper zone hard, indurated. Silty.
	12.5	14.0	Sand -	VF-F. Red-brn. V silty.
	14.0	17.2	Silt -	Yellow-brn. Abundant F sand. Clayey.
	17.2	20.2	-	Grey with some yellow-brn bands up to 20 cm. Clayey.
	20.2	34.0	-	Grey to off-white. Few indurated bands. Some F sand.
	34.0	42.6	-	Grey. Some sandy zones. Clayey in part.
	42.6	45.0	Sand -	VF-F. Grey to light grey. Silty, minor clay.
	45.0	48.5	-	As above. Yellow-brn. V silty.
	48.5	50.8	-	F-M some C. Yellow-brn, silty. Abundant dark grains.
	50.8	53.7	-	VC-M. Light grey. Silty matrix. Few narrow clay bands. Micaceous. Subangular-angular.
	53.7	55.4	-	VF-M Brn. to dark brn. Traces lignite, pyrite.
	55.4	57.5	-	F-C. As above. Occasional F gravel. Leaf impressions. Few thin indurated bands. Sub-angular to rounded.
	57.5	58.4	-	C-M. Dark grey. Sub-angular to rounded. Some F gravel.
	58.4	59.5	Gravel-	F. Pale grey to dark brn.Sub-angular to sub-rounded. C-M sandy, silty matrix, VC sand in part. Lignitic, few hard bands. Tert.
				59.5 EoH.
				Rods sticking.
FR5	0.0	0.8	Soil -	Dark brn. Sandy clay.
	0.8	3.0	Calcrete - Off-white. Mod. hard.	Clayey softer past 1.5.
	3.0	5.7	Clay -	Yellow-brn with thin dark grey banding, silty. Traces of carbonate to 3.5. Sandy. Thin gravel band at 5.7, angular quartz to 1.5 cm.
	5.7	11.5	-	Red-brn with grey silty bands up to 5 mm. Sandy.
	11.5	13.0	-	Grey. V silty, sandy.
	13.0	15.4	Gravel -	Up to 2.5 cm in grey-brnsandy silt matrix. Quat.
	15.4	17.5	Silt -	Yellow. Abundant F sand.

	17.5	19.0	Sand -	-F. Yellow-brn. Silty. Minor clay.
	19.0	21.6	-	VF-M. Yellow-brn. V clayey. Sandy clay in part.
	21.6	24.0	Clay -	Pale grey to yellow-brn. V silty, sandy.
	24.0	31.5	-	Dark grey to brn. Silty. Traces lignite, more abundant past 25.5. Traces pyrite near 29.0. Some C, angular gravel past 30.6. Tert.
	31.5	42.0	-	Pale grey to grey. V silty. Traces mica. Some white specks. Darker with depth, blue-grey. W.B. 42.0 EoH.
FR6	0.0	0.8	Soil -	Brn sandy clay.
	0.8	1.5	Clay -	Light brn with off-white carbonate.
	1.5	4.1	-	Yellow-brn. Sandy, silty. Few grey silt bands to 5 mm thick.
	4.1	6.3	Sand -	F-VF with few VC grains & cemented aggregates. Minor clay. Some F gravel 5.8-6.3. Yellow-brn. Quat.
	6.3	7.8	Sandstone - VF. Pale grey with yellow-brn bands. Mod. hard, indurated.	
	7.8	13.0	Clay -	Grey-brn & brn, mottled. Silty, sandy.
	13.0	21.5	-	Brn-yellow as above.
	21.5	24.0	-	Pale grey with some iron staining. Silty.
	24.0	32.8	-	Yellow-brn to red-brn. Silty. V sandy in part - clayey sand. Few pale grey bands.
	32.8	34.0	Sand -	M-C. Yellow-brn with some dark grains. Clayey.
	34.0	35.8	-	VC-F. Yellow-brn. Silty clay matrix up to 15%.
	35.8	37.0	Clay -	Pale grey. Silty, sandy. Some iron staining.
	37.0	39.2	-	Pale grey & grey-brn. V silty with few narrow F gravel bands. Sandy. Tert.
	39.2	48.0	-	Pale grey. Silty to V silty. White specks. Darker with depth. Clayey silt in part. W.S. 48.0 EoH.
FR7	0.0	0.5	Soil -	Dark brn. Sandy clay.
	0.5	1.8	Clay -	Brn. Sandy. Silty.
	1.8	7.0	-	Pale yellow-brn with grey-brn banding. Quat?
	7.0	9.4	Sand -	F-VF. Mottled red & off-white. Indurated, mod. hard to 8.5.
	9.4	12.0	-	VF-M. Red-brn. Silty. Occasional indurated lumps.
	12.0	14.4	-	VF-F. Red-brn. V silty, clayey.
	14.4	16.5	Clay -	Grey. V silty with F sand.
	16.5	23.8	Silt -	Grey to pale grey. Occasional VC grain. Few silty clay bands to 20 cm.
	23.8	24.5	-	Dark grey brn. Lignitic??
	24.5	30.0	-	Yellow-brn with pale grey interbands. Clayey zones. Tert. 30.0 EoH. Rods stuck - hole abandoned.

FR8	0.0	0.4	Soil -	Brn. Clayey F sand.
	0.4	1.0	Clay -	Pale brn. Silty with white carbonate inclusions. Trace of grit.
	1.0	1.9	Calcrete -	Off-white to pale brn.Hard.
	1.9	3.3	Clay -	Pale yellow-brn with some carbonate zones to 20 cm.
	3.3	6.0	-	Red-brn. Sandy, silty. Some thin grey silt banding.
	6.0	7.9	Sand -	F-VF. Pale yellow-brn. Silty. Few narrow M gravel bands to 5 cm thick. Quat.
	7.9	14.0	Silt -	Pale grey. Hard to 10.0. Some F sand bands.
	14.0	37.0	-	Yellow-brn with few grey bands. Few indurated chips. Some clayey zones past 18.5. Harder past 29.0.
	37.0	40.4	Sand -	VF-F. Yellow-brn and grey. V silty.
	40.4	40.8	Gravel-	F. Brn-yellow to brn. Angular to sub-rounded quartz. Sandy silt matrix.
	40.8	45.5	Sand -	VC-M. Brn-yellow to yellow-brn. Silty. Yellow grains with some dark grains. Angular to sub-rounded. Few thin gravel bands. Occasional clay band to 5 cm.
	45.5	53.0	Gravel-	Up to 1.5 cm diameter. Angular to sub-rounded quartzite & white quartz in pale grey to grey-brn silty C sand matrix. Some C-VC sand bands to 25 cm thick. Abundant iron staining past 48.5.
	53.0	55.6	Clay -	Dark brn. Lignitic. Silty, sandy with few F gravel bands. Some pale grey bands. Tert.
	55.6	56.0	-	Pale grey. Silty. Micaceous. W.S.?? 56.0 EoH. Circulation lost - 0.4 m of bottom clay in tube.
FR9	0.0	0.5	Soil -	Red-brn. Sandy clay.
	0.5	1.3	Calcrete -	Off-white with some pale brn clay zones.
	1.3	3.5	Clay -	Brn. Silty, sandy. Traces carbonate. Occasional grit.
	3.5	14.8	-	Brn with green-grey banding to 3 mm. Few thin F sandy bands. Occasional quartz & quartzite gravel near base.
	14.8	15.5	Sand -	F-M. Red-brn. V clayey with some gravel. Quat.
	15.5	34.0	Silt -	Grey with brn-yellow bands to 25 cm. Hard, indurated to 19.0 m. Some VF-M sandy zones - common past 30.0.
	34.0	34.7	Sand -	M-VC. Brn-yellow with silty clay. Some F gravel.
	34.7	36.5	Clay -	Grey. Sandy, V silty.
	36.5	37.0	Sand -	F-VC. Dark grey. V clayey.
	37.0	38.0	Clay -	Dark brn-grey. Lignitic. V sandy in part. Tert. 38.0 EoH.

				Circulation lost - hole collapsed.	
FR10	0.0	0.7	Soil -	Brn sandy loam - clayey	near 0.7.
	0.7	1.5	Calcrete - Pale yellow-brn with clay. Some nodules. Mod. hard.		
	1.5	2.8	Clay -	Brn. Few off-white carbonate inclusions & thin sandy lenses.	
	2.8	3.5	-	Brn. Silty. Minor sand.	Occasional grit.
	3.5	11.2	-	Ditto with green-grey silty bands to 5 mm thick, up to 5 cm past 8.0.	
	11.2	14.6	-	Grey with some yellow-brn mottling. V sandy, silty. Some C gravel at base. Quat.	
	14.6	18.5	Silt -	Grey with yellow-brn bands.	Hard at top. Abundant F-M sand.
	18.5	20.8	Sand -	M-VC some F gravel.	Brn-yellow. Clayey bands. Angular to sub-rounded quartz sand. Cleaner past 20.0 - abundant F gravel.
	20.8	24.0	Clay -	Grey. V sandy, silty. Few	narrow F gravel bands.
	24.0	25.7	Sand -	F-C, some VC. Grey silty.	Some C gravel at base.
	25.7	26.5	Clay -	White & yellow-brn. V	sandy.
	26.5	27.0	Sand -	M-F. Grey. Clayey.	
	27.0	28.5	Clay -	Grey to dark grey. Silty.	Gravel to 1.5 cm. Tert.
	28.5	30.6	-	Grey to brn-grey. Silty.	'Sticky'. W.S.
	30.6	35.0	-	Green-grey, darker with 35.0 EoH.	depth. Silty.
FR11	0.0	0.3	Soil -	Brn. Sandy clay.	
	0.3	2.5	Clay -	Brn. Sandy. Trace carbonate. Some F gravel.	
	2.5	4.3	-	Brn to red-brn. Green-grey past 3.5. Sandy.	silty bands to 5 mm
	4.3	5.9	-	Red-brn. Silty. Some thin F Occasional grit.	sand bands to 5 cm.
	5.9	10.0	Sand -	VF-F. Occasional VC. silty. Clay bands past 8.4.	Yellow-brn. Clayey,
	10.0	12.4	Clay -	Yellow-brn. Sandy, silt.	
	12.4	17.1	Gravel-	Rounded to 2 cm diameter with angular to sub-angular quartzite & quartz in dark brn sandy clay matrix. Some hard bands. Abundant clay past 14.8 with F gravel. Quat.	
	17.1	29.9	Silt -	Pale grey with yellow-brn bands past 25.0. Some F gravel past 28.5.	bands to 25 cm. Abundant F sand in parts. Few narrow clayey
	29.9	38.0	-	Grey to dark grey. Clayey. interbands.	Some green-grey
	38.0	42.5	-	Pale grey to grey with brn-yellow zones. F sandy bands common.	
	42.5	44.5	Sand	F-C few VC grains. Brn-yellow with grey zones. V silty. Sandy silt in part. Clayey bands to 10 cm. Dark F sand grains common. Tert.	

				44.5 EoH. Hole collapsed - rods sticking.
FR12	0.0	0.6	Soil -	Brn sandy clay.
	0.6	1.4	Calcrete -	Off-white to pale brn. Clayey. Quat.
	1.4	2.1	Clay -	Yellow-brn. Sandy. Carbonate inclusions.
	2.1	2.8	-	Pale yellow-brn. V sandy.
	2.8	4.5	Sand -	VF-F. Yellow-brn. Clayey, silty.
	4.5	8.7	-	VF-M. Brn-yellow. Silty. Some indurated bands. Clayey past 6.0.
	8.7	14.6	-	VF-M. Occasional VC. Yellow-brn with few grey-brn zones. Clayey to V clayey.
	14.6	18.0	Clay -	Pale grey. V silty. Trace F sand. Few indurated lumps.
	18.0	32.6	Silt -	Grey to pale grey. Clayey. Some F sand. Hard 20.0-23.0, with some yellow-brn zones. V clayey past 23.0. Some sandy bands. V sandy past 31.5 with occasional VC.
	32.6	33.5	Gravel-	Mainly F, some up to 2 cm. C-F sandy clay matrix. Brn-yellow. Angular to sub-rounded.
	33.5	41.0	Clay -	Grey. Silty. Brn-yellow with some red mottling to 36.0. Traces sand & grit.
	41.0	42.8	-	Grey-brn as above.
	42.8	43.5	Gravel -	Up to 3 cm. Rounded to sub-angular quartz in yellow-brn clayey matrix. Some VC-M sand. Tert.
	43.5	44.1	Silt -	Greenish-brn. Clayey. Micaceous. W.B.
	44.1	46.0	Phyllite -	Greenish-brn. Weathered. Fresher near 46.0. 'Cores' with 75^{o}-80^{o} dip. 46.0 EoH.
FR13	0.0	0.8	Soil -	Brn. Sandy clay. Quat.
	0.8	2.2	Clay -	Yellow-brn. Sandy. Some white carbonate zones to 1.4.
	2.2	13.0	Sand -	VF-M. Minor clay. Pale yellow-brn. Few hard, indurated bands past 5.5 with few VC grains.
	13.0	23.6	Silt -	Pale grey. Clayey. Minor F sand. Occasional grit. Some yellow-brn bands to 25 cm. V clayey in part. Dark brn lignitic clay band 22.5-23.0. Hard, indurated 23.0-23.6.
	23.6	38.9	-	Grey-brn to brn-yellow & brn banded. Some grey clayey zones & sandy bands. Hard band at 35.5. Sand more abundant past 37.0. Silty sand in part.
	38.9	39.8	Gravel-	F. Angular quartz & quartzite. Yellow-brn silty matrix. Tert.
	39.8	41.5	Clay -	Dark grey to grey. Silty. Occasional ferruginised grains. W.S.
	41.5	48.0	-	Grey with yellow-brn & red-brn mottling.

				Silty with traces of ferruginous grit. Occasional sand. Dark grey past 43.0. 48.0 EoH.
FR14	0.0	0.5	Soil -	Brn sandy clay.
	0.5	2.0	Clay -	Yellow-brn. Sandy. Some thin sand bands to 5 cm.
	2.0	2.8	Sand -	VF-F. Yellow-brn. Silty. Minor clay. Some VC grains near 2.8.
	2.8	8.2	Silt -	Pale grey. Clayey. Mod. hard, indurated to 6.0. Few F sandy zones. Trace mica. Some yellow-brn zones past 6.0. Sand more abundant.
	8.2	8.7	Sand -	VF-M. Red-brn. Clayey. Few VC grains.
	8.7	12.3	Silt -	Grey with yellow-brn & brn zones. Some F sand. Clayey in part.
	12.3	16.0	Clay -	Grey. Silty. Minor F sand. Occasional grit.
	16.0	27.6	Silt -	As at 8.7. V clayey in part.
	27.6	29.0	Sand -	F-C. Yellow-brn. V silty.
	29.0	31.4	-	VC-M. Yellow-brn. Silty some gravel. Sub-angular to rounded.
	31.4	34.2	-	VC-F. Grey. Clayey. Abundant F gravel.
	34.2	34.9	Gravel-	F in C-F sandy matrix.Clayey. Grey. Sub-rounded.
	34.9	42.5	Clay -	Pale grey with red & yellow-brn mottling. Sl. silty. Trace of sand. Plastic. Some yellow-brn bands past 39.5. Silty past 42.0.
	42.5	43.8	Silt -	Yellow-brn. Sandy.
	43.8	46.0	Sand -	VC-F. Yellow-brn. Silty with some gravel. Angular to sub-rounded. Abundant gravel past 45.0, quartz with some iron staining. Tert. 46.0 EoH. Rods stuck in gravel.
FR15	0.0	0.4	Soil -	Dark brn sandy clay.
	0.4	9.8	Clay -	Brn. Sandy, silty with white carbonate inclusions to 1.5. Occasional grit. Red-brn. with thin grey banding past 2.8. V sandy past 4.6 with some F gravel.
	9.8	11.0	Gravel-	C. Iron stained quartz & quartzite in brn sandy clay matrix.
	11.0	12.7	Clay -	Grey-green & brn mottled/banded. V silty, sandy. Some VC gravel bands up to 10 cm thick. Quat.
	12.7	21.5	Silt -	Pale grey. Clayey. Minor sand. Occasional ferruginous grit. Brn-yellow & yellow-brn zones past 15.0. Sandy to V sandy past 18.0.
	21.5	22.0	Sand -	F-VC. Yellow-brn. V silty. Angular to sub-rounded quartz. Some F gravel.
	22.0	22.8	Clay -	Pale grey. V silty, sandy.
	22.8	25.0	-	Pale grey. Sl.sandy, silty with some yellow-brn ferruginous mottling. Plastic.
	25.0	28.7	-	As above. V sandy, silty. Some F gravel. Few VC-F sand bands up to 10 cm. Tert.

28.7	32.0	-	Grey to dark grey. Silty.	W.S.
32.0	40.7	-	Greenish-grey to grey. Silty. Occasional pyrite fragment.	
40.7	45.0	Sand -	M-C. Brn-yellow. V clayey. Silty. Rounded grains. Sandy clay in part.	
45.0	47.0	Clay -	Dark grey & greenish-brn.	Silty. V sandy.
47.0	53.5	Sand -	F-M. Brn-grey. V clayey, silty. Some aggregates.	
			53.5EoH.	

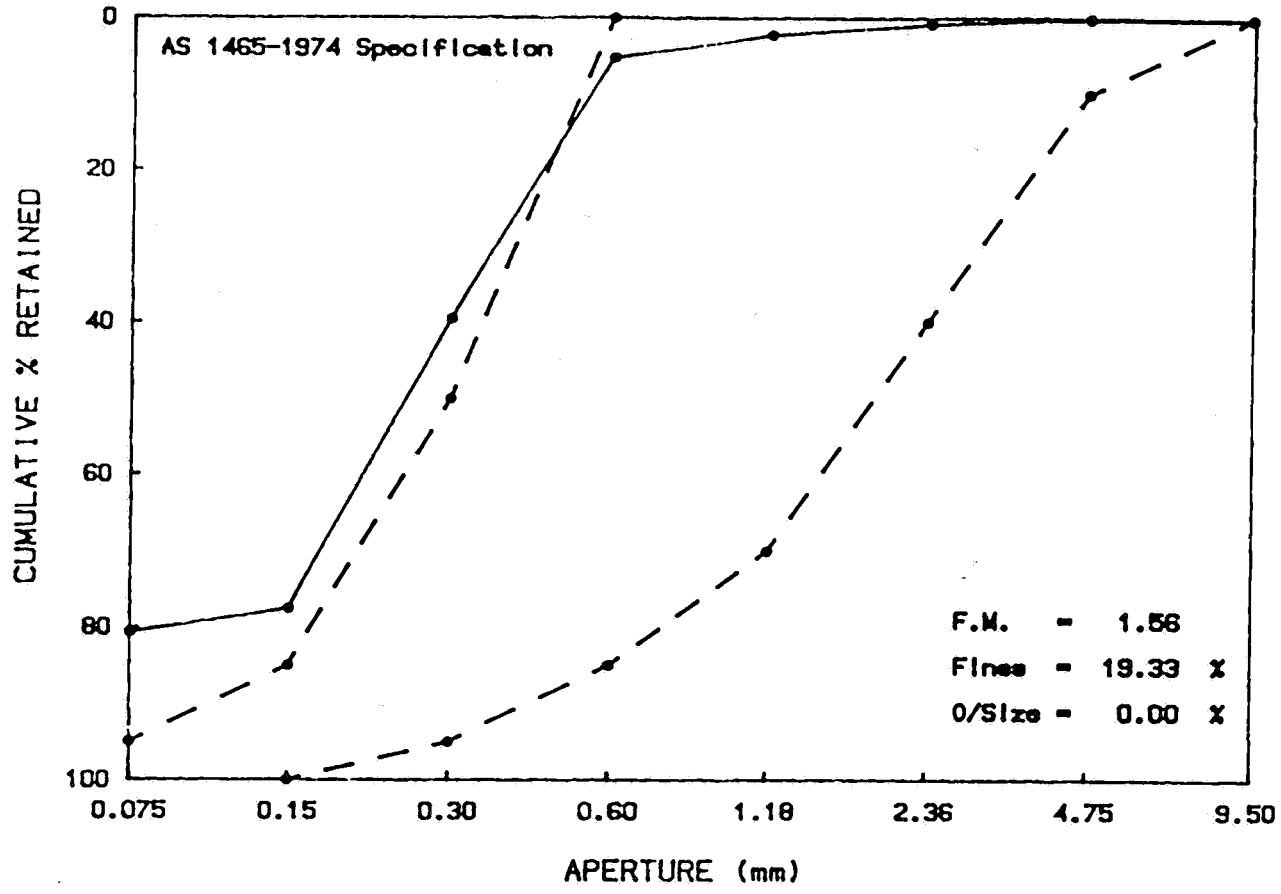
APPENDIX D
SIEVE SIZING ANALYSES

by

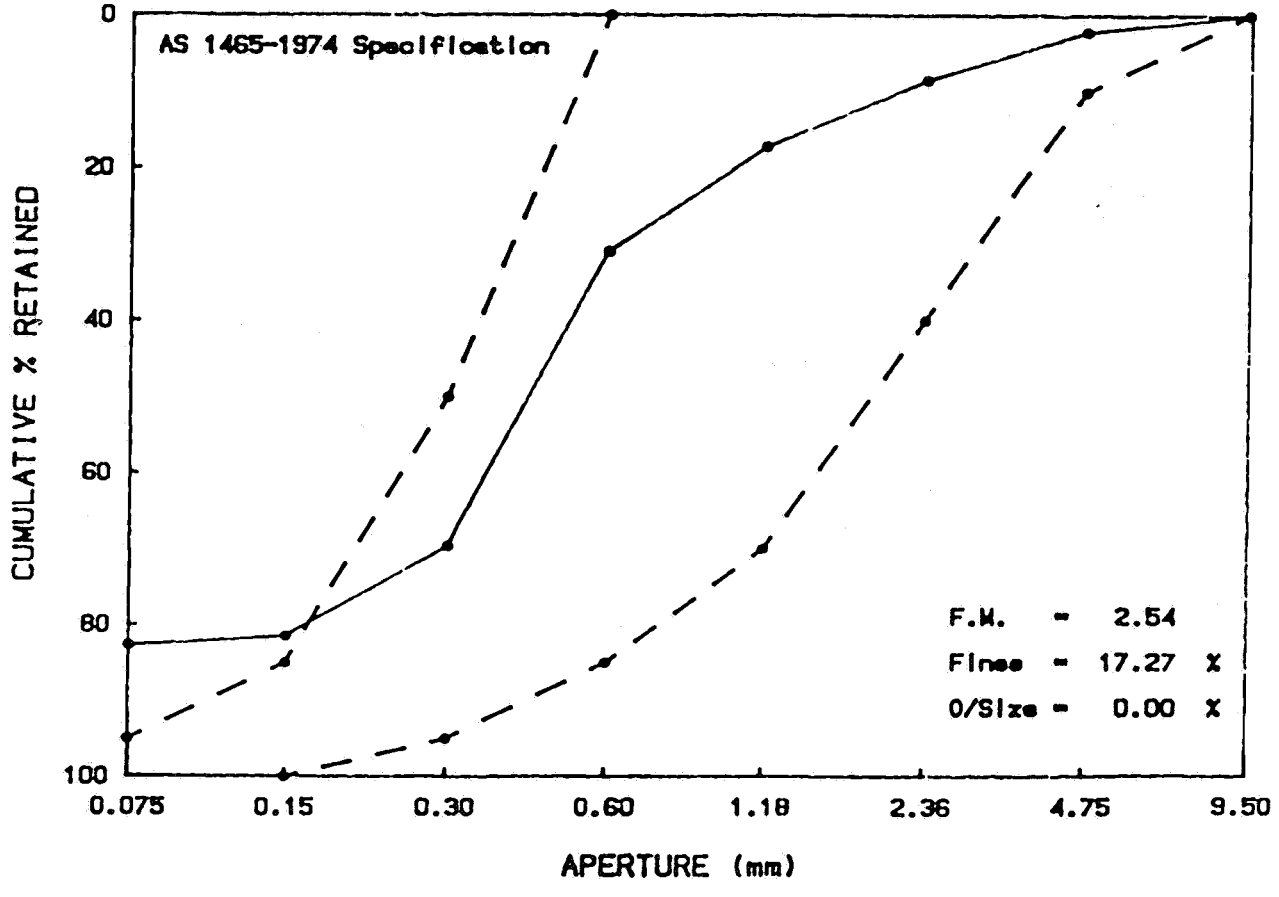
S.J. EWEN

D1-3 Auger holes
D4-8 Reverse circulation holes
D9 Determination of Fineness Modules

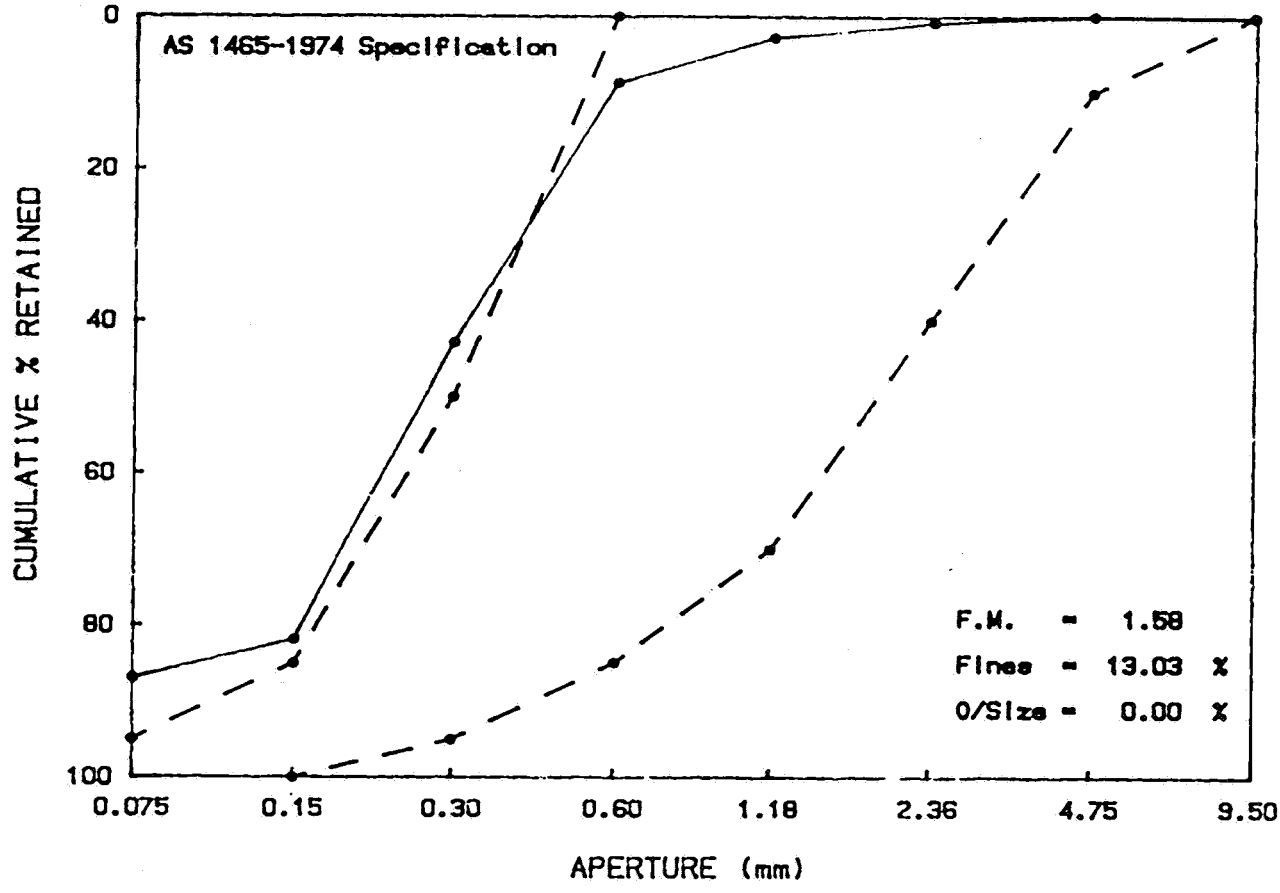
F10,4-5.3M



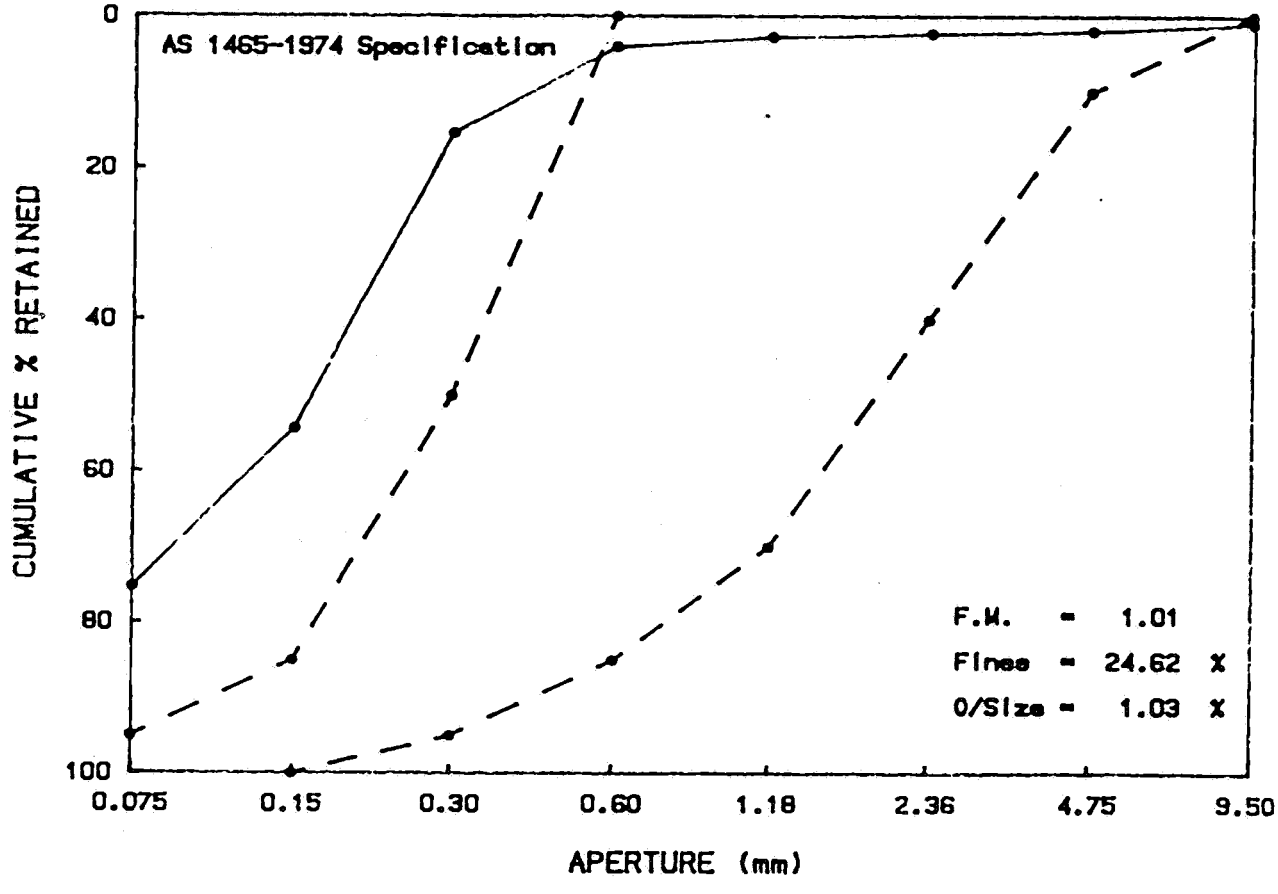
F15,2-3M



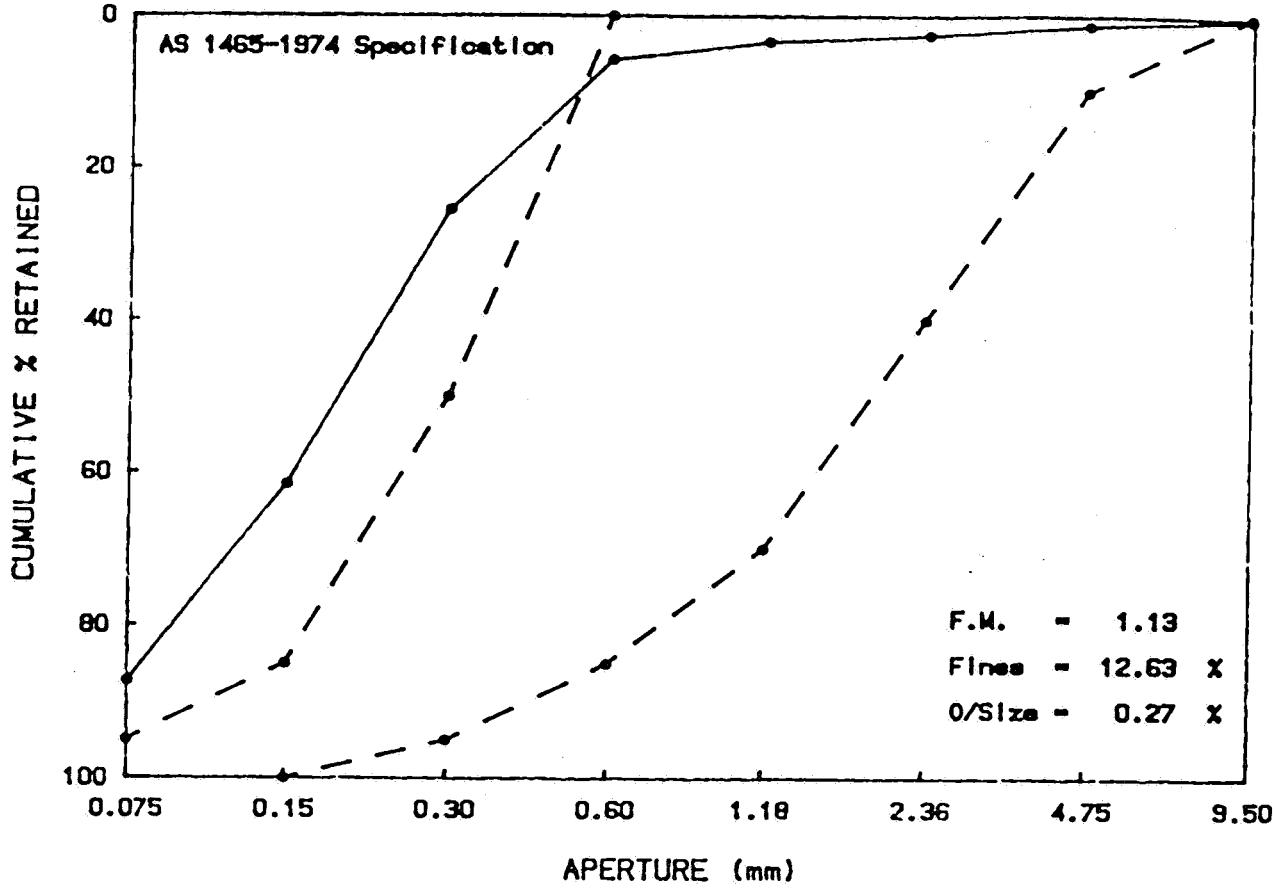
F27,2-7.5M



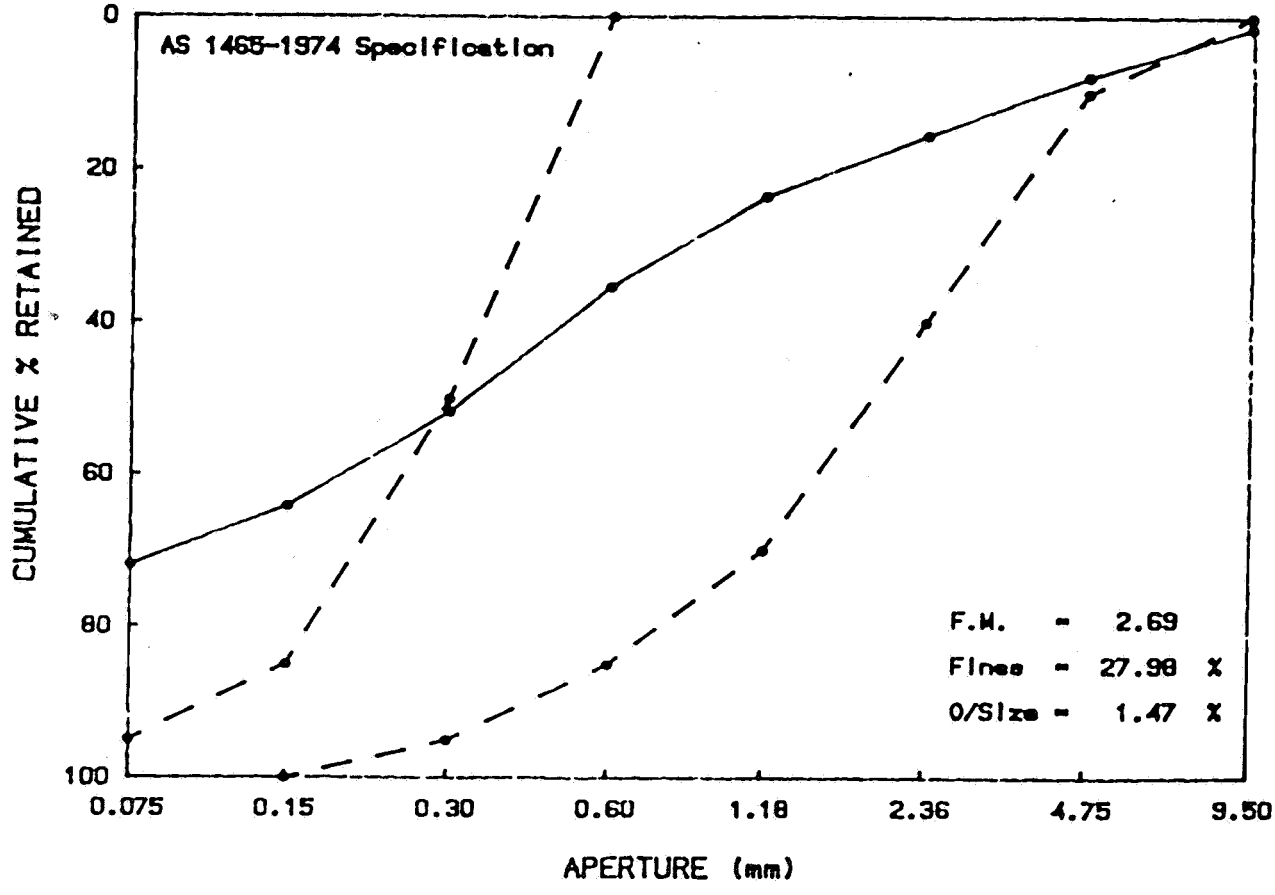
F32,2-12M



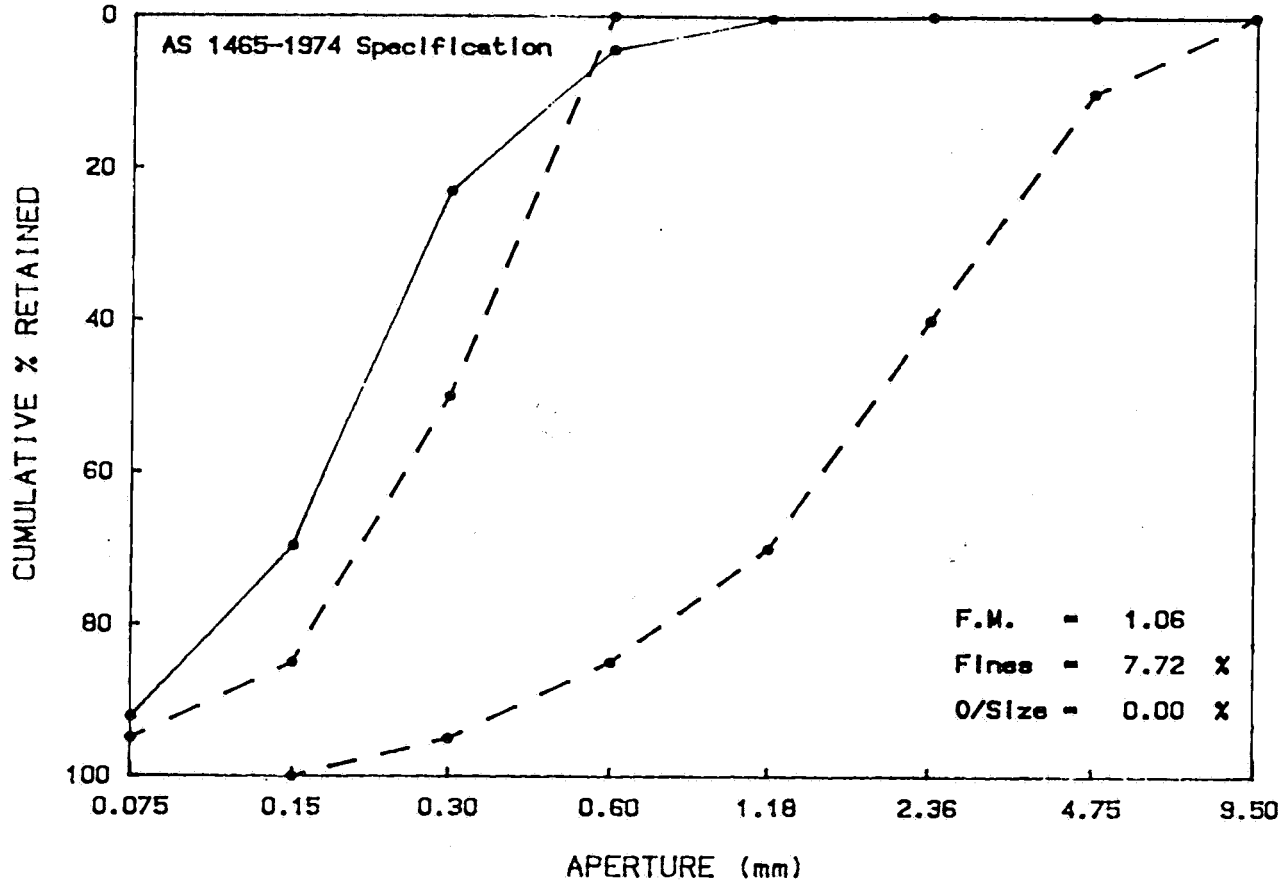
F42,4-8M



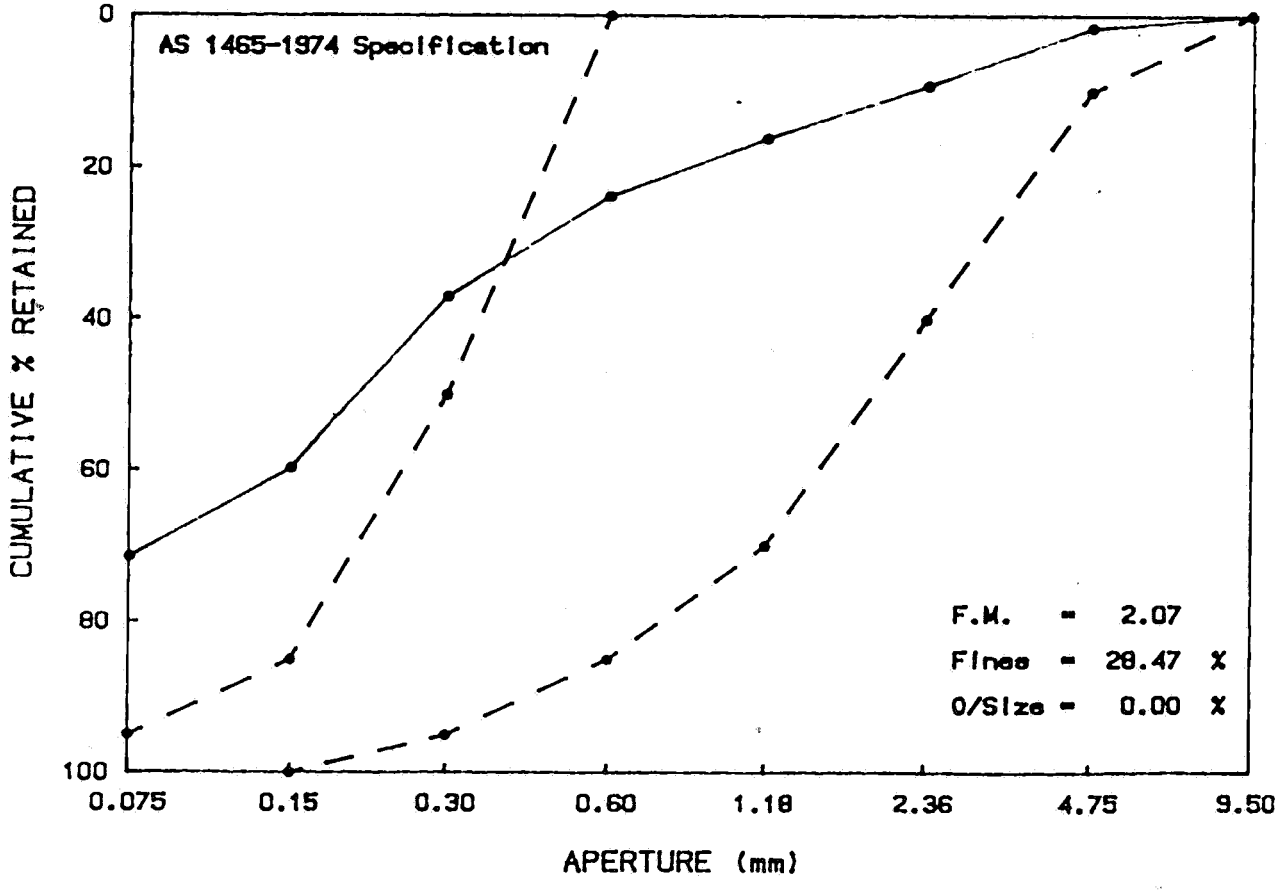
F62,6-8.5M



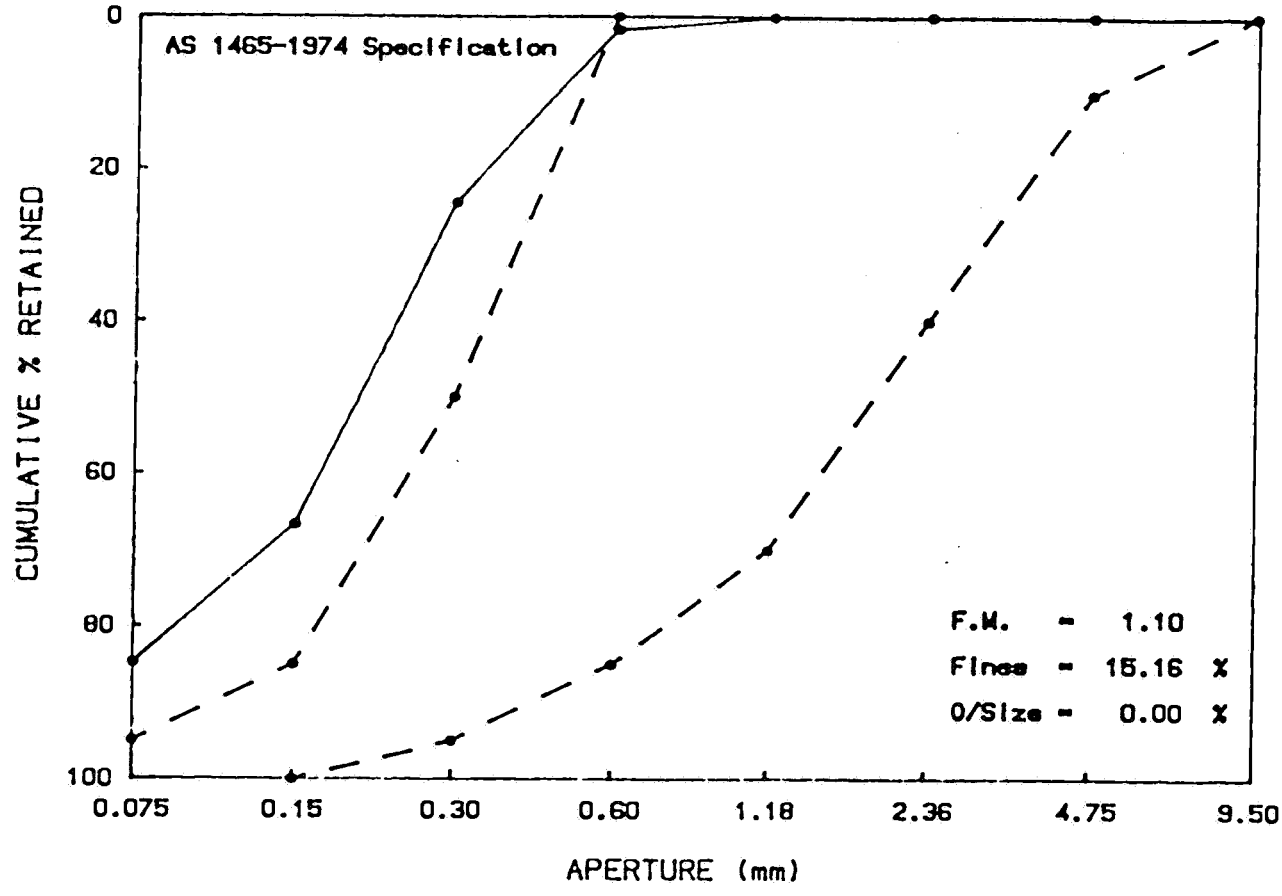
FR3, 26-28M



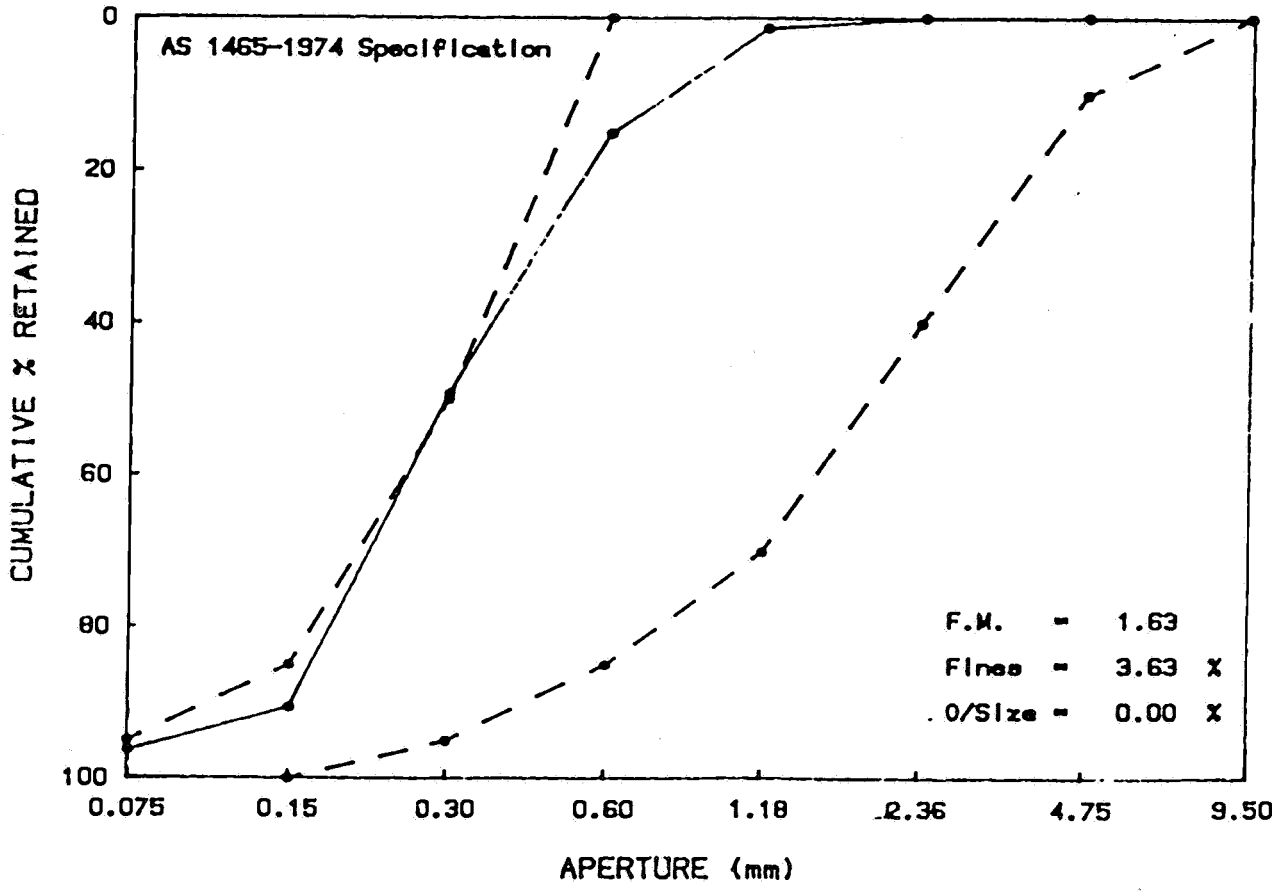
FR3, 28-34M



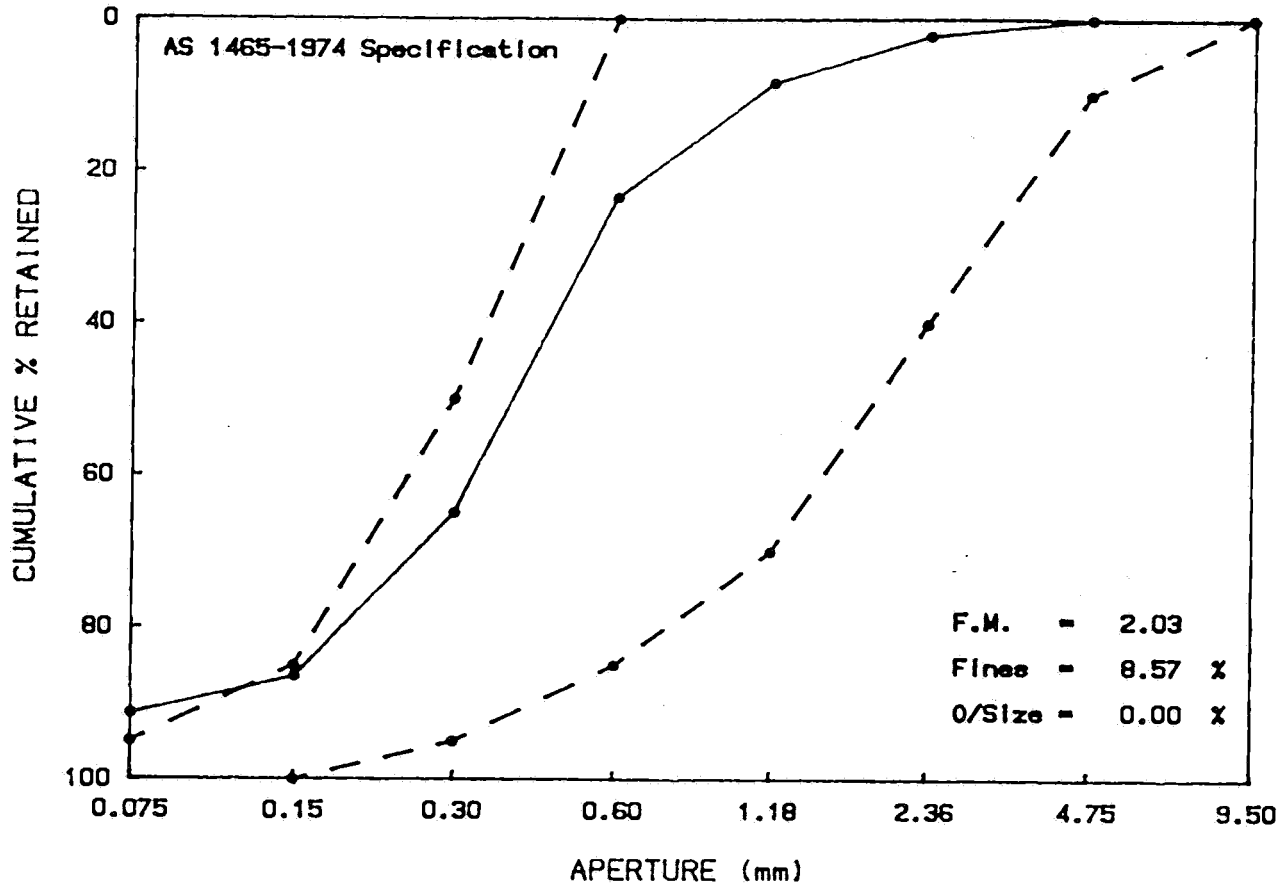
FR4,48-50M



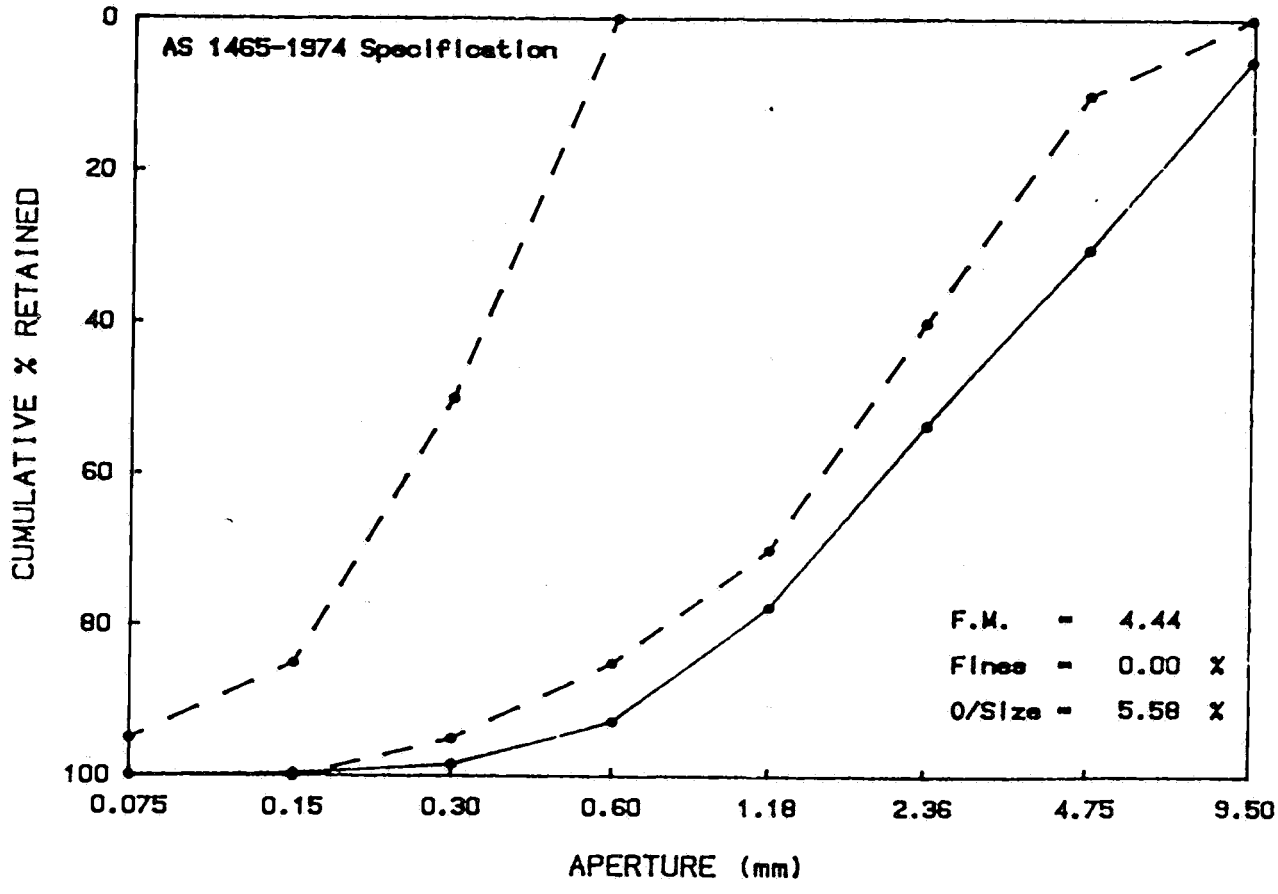
FR4,50-54M



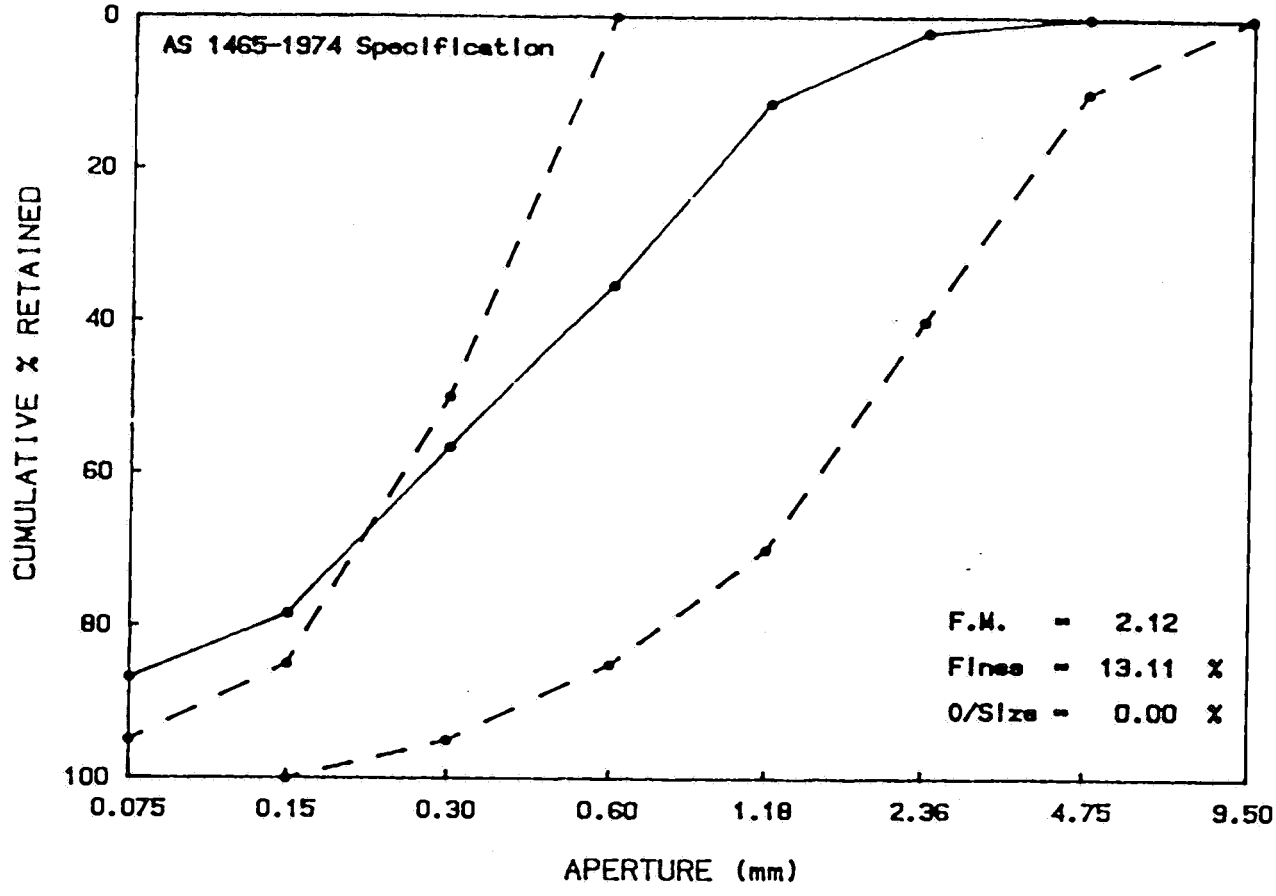
FR4,54-58M



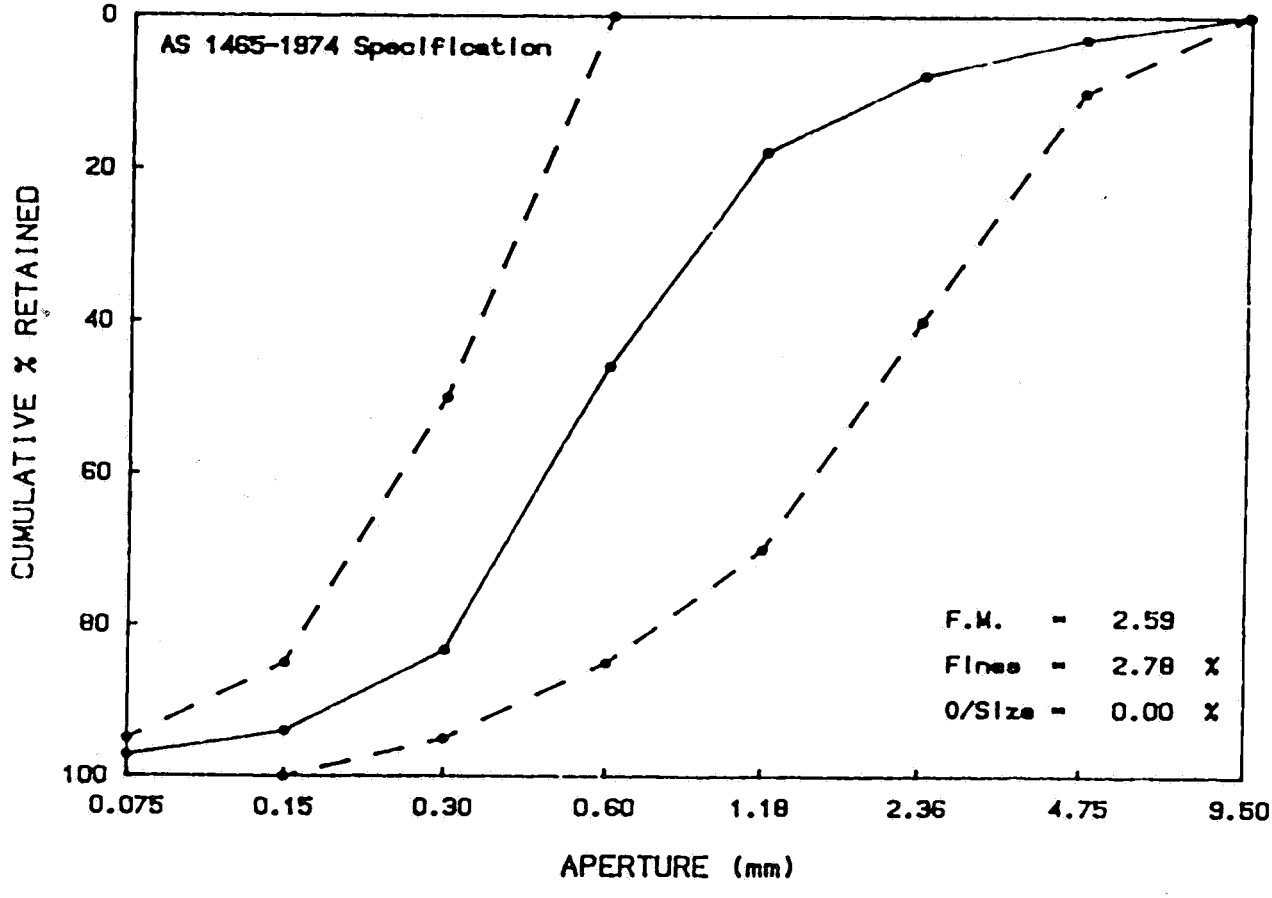
FR4,58-59.5M



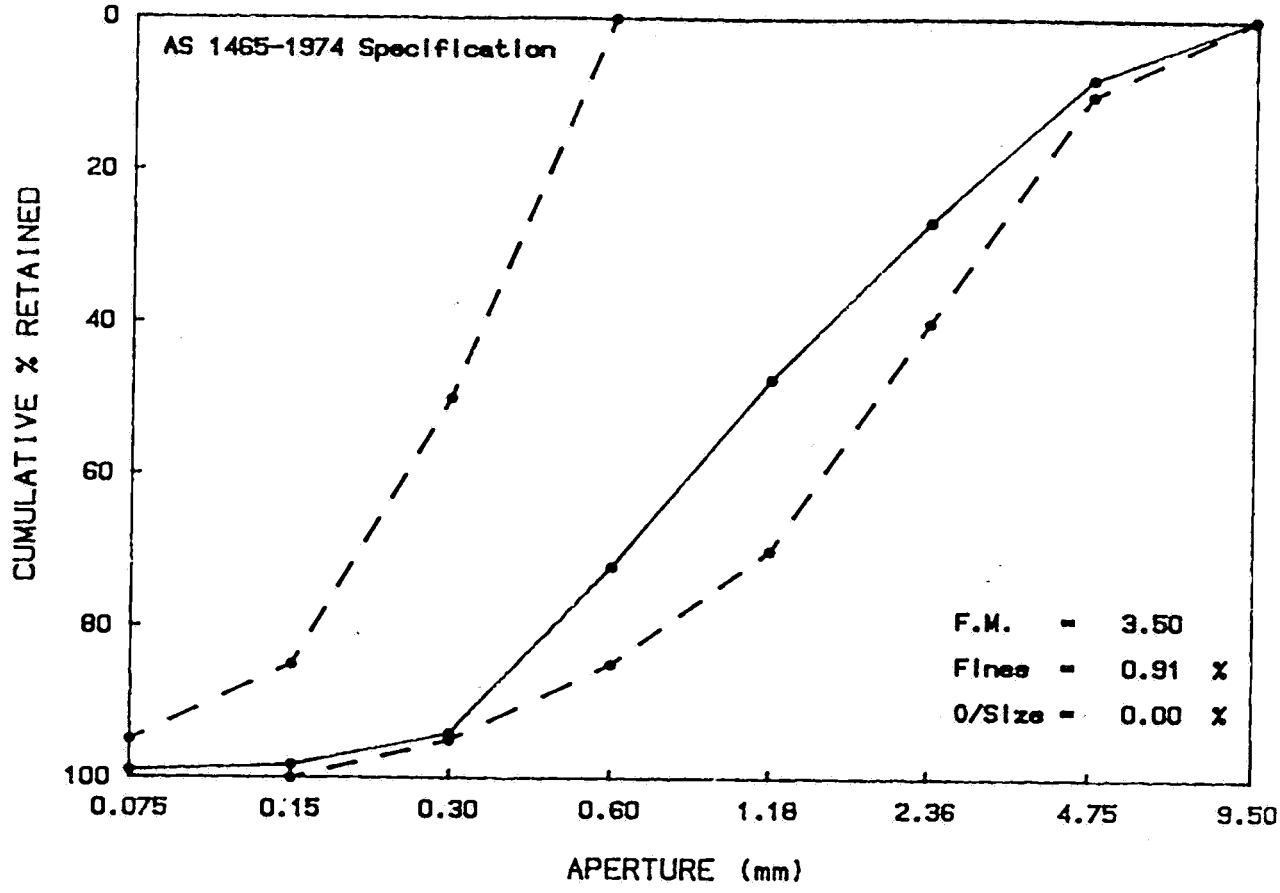
FR6, 32-36M



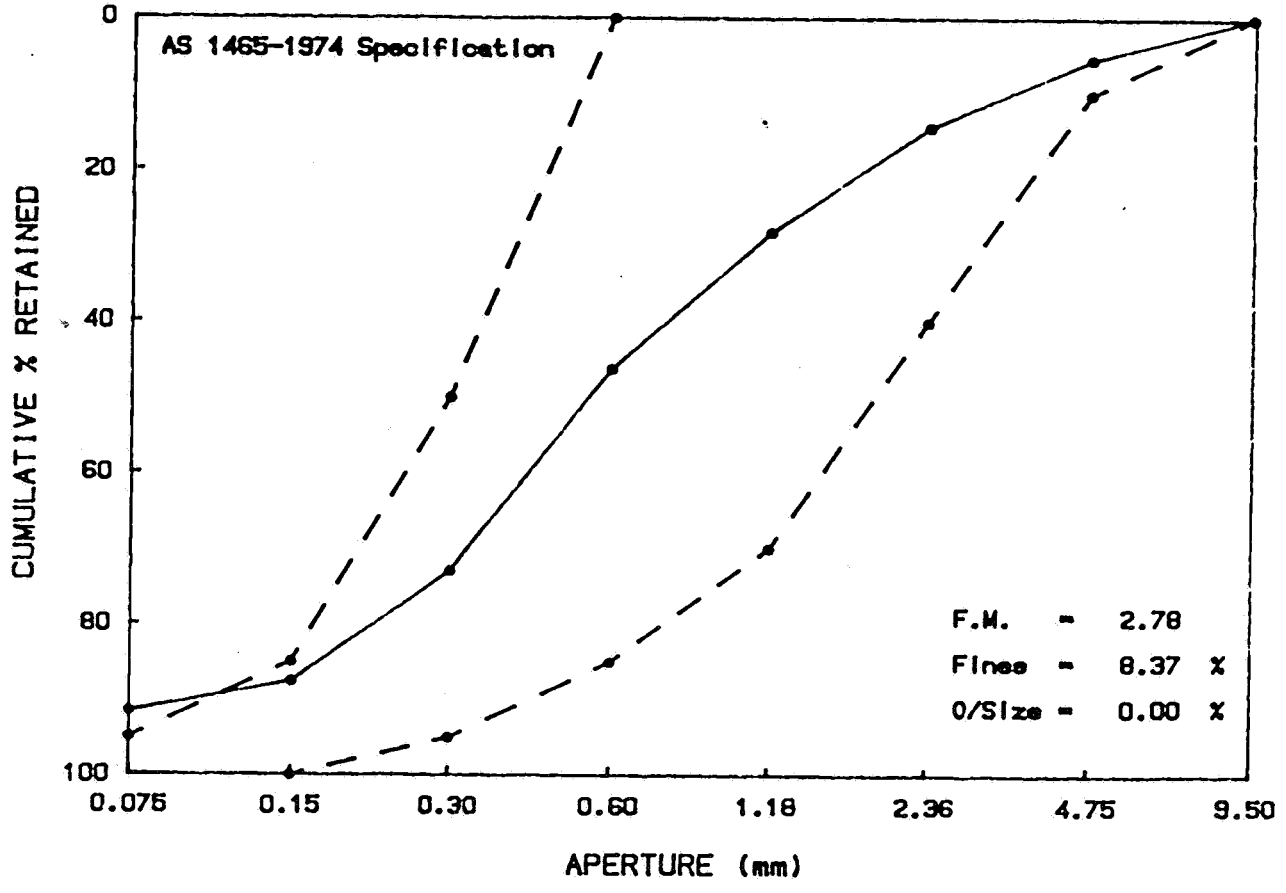
FR8, 40-46M



FR8,46-52M



FR14,28-34M



DETERMINATION OF 'FINES FREE' FINENESS MODULUS

1. Particle size distribution is determined according to the procedure described in A.S.1141-1974, sections 11 and 12. Sieves are chosen such that each has nominal aperture double that of the preceding one:-

Aperture (mm)	0.075	0.15	0.30	0.60	1.18	2.36	4.75	9.5	19.0
B.S.S. Mesh	200	100	52	25	14	7	3½	3/8"	3/4"

2. The proportion of material finer than 0.075 (200 mesh BSS) is designated as 'fines'.

3. The cumulative amount of sand retained on each of the nominated sieves is recalculated as a percentage of the material coarser than 0.075 mm (200 mesh).

4. Cumulative percentages calculated in 3 (above) retained on 100 mesh BSS and coarser sieves are summed and divided by 100 to give Fineness Modulus.

Example

BSS Mesh	Nominal Aperture (mm)	Cum.Wt. Retained (gm)	Cum.% Retained	Cum.% of +200 mesh fraction retained	
3/8"	9.50	0.00	0.00	0.00)	
3½	4.75	0.56	0.28	0.29)	
7	2.36	4.36	2.19	2.26)	
14	1.18	13.34	6.70	6.91)	Sum=166.5
25	0.60	35.71	17.93	18.50)	
52	0.30	85.67	43.03	44.39)	
100	0.15	181.65	91.23	94.12)	
200	0.075	192.99	96.93	100.00	

Fines = 100.00-96.93 = 3.07%

$$FM = \frac{166.5}{100} = 1.67$$

APPENDIX E

MINERALOGY OF TWO SAND SAMPLES

by

Michael Farrand

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

PET RPT. 15/88
1:100 000 SHEET 6629

RPT BK NO. 88/59
DME NO. 454/82
DISK NO. 3

MINERALOGY OF SAND FROM TWO DRILL HOLES, FR4 AND FR8, NEAR FREELING, SOUTH AUSTRALIA

ABSTRACT

Sands from drillholes FR4 and FR8 are essentially similar in major constituents but differ in rare trace constituents, in grain size and in state of oxidation. The two sands are probably different parts of the same unit.

INTRODUCTION

Two samples of unconsolidated sand from reverse-cycle drill holes, FR4 and FR8, near Freeling, north of Gawler were received for examination from D.C. Scott of the Mineral Resources Branch. Brief, general descriptions were requested. The samples were examined with a binocular microscope and a petrological microscope using refractive index liquids. The heavy mineral fractions were concentrated by panning before examination.

For the identification of opaque grains it is necessary to prepare a polished mount of the sample and to examine it in incident light.

MINERALOGY

Drill hole FR4, 52 m - 54 m

The sample is a fine sand of a pale grey colour containing 1%-2% dark minerals. Grain size varies between about 0.1 mm and 5 mm but the majority of grains are in the range 0.2 mm to 0.5 mm.

The majority of grains consists of quartz with little or no surface coating. Grain shape varies from angular to well-rounded but even the subspherical grains are pitted by solution at pressure points and have been derived from an earlier sandstone rather than direct from a dune or beach.

Among the heavy minerals the most abundant are opaque. The grains are nonmagnetic to a hand magnet and are probably ilmenite. A few grains may be haematite since a translucent red colour is occasionally seen on thin edges.

A strongly pleochroic, pink to brown tourmaline is also common. Rutile is moderately abundant, zircon less frequent.

The less common grains include biotite, staurolite, kyanite, andalusite and sphene.

Drill hole FR8, 46 m-52 m.

The sand is of coarser grain size than that of FR4 and is a pale rusty brown colour with frequent orange brown grains. Dark minerals are less abundant than in FR4. Grain size varies from about 0.1 mm to over 10 mm with a major proportion between 0.5 mm and 1.5 mm. Many grains are stained by limonitic iron oxide, suggesting that the sand has been exposed to oxidising conditions, possibly intermittently. A few grains are rose coloured. Quartz is the main constituent. Some grains are frosted and well rounded. Others show the dimpled pressure points seen in the sand from FR4.

The heavy mineral fraction is dominated by opaque, nonmagnetic grains, probably ilmenite. The same pink and brown tourmaline seen in FR4 is also abundant but less so in the sample from FR8. Zircon, rutile and sphene are rarer and the aluminosilicates are absent.

Comment

The two sands are essentially similar. Differences are in grain size, oxidation state and the presence of a few sparse heavy minerals.

APPENDIX F

GOLD ANALYSES

Extracted from Amdel report AC 0228/89

Sample No	Hole No (FR)	Depth (m)	Gold (ppm)
1000	3	28-34	<0.02
1001		34-42	<0.02
1002	4	54-59.5	<0.02
1003	5	28-32	<0.02
1004		32-42	<0.02
1005	6	38-40	<0.02
1006		40-48	0.02
1007	8	46-52	<0.02
1008		52-56	<0.02
1009	9	36-38	<0.02
1010	10	28-35	<0.02
1011	11	42-44.5	<0.02
1012	12	42-44	<0.02
1013		44-46	<0.02
1014	13	38-40	<0.02
1015		40-46	<0.02
1016	14	44-46	<0.02
1017	15	24-26	<0.02
1018		28-32	<0.02
1019		32-42	<0.02

Note: Full sample number 6629 A1000/88

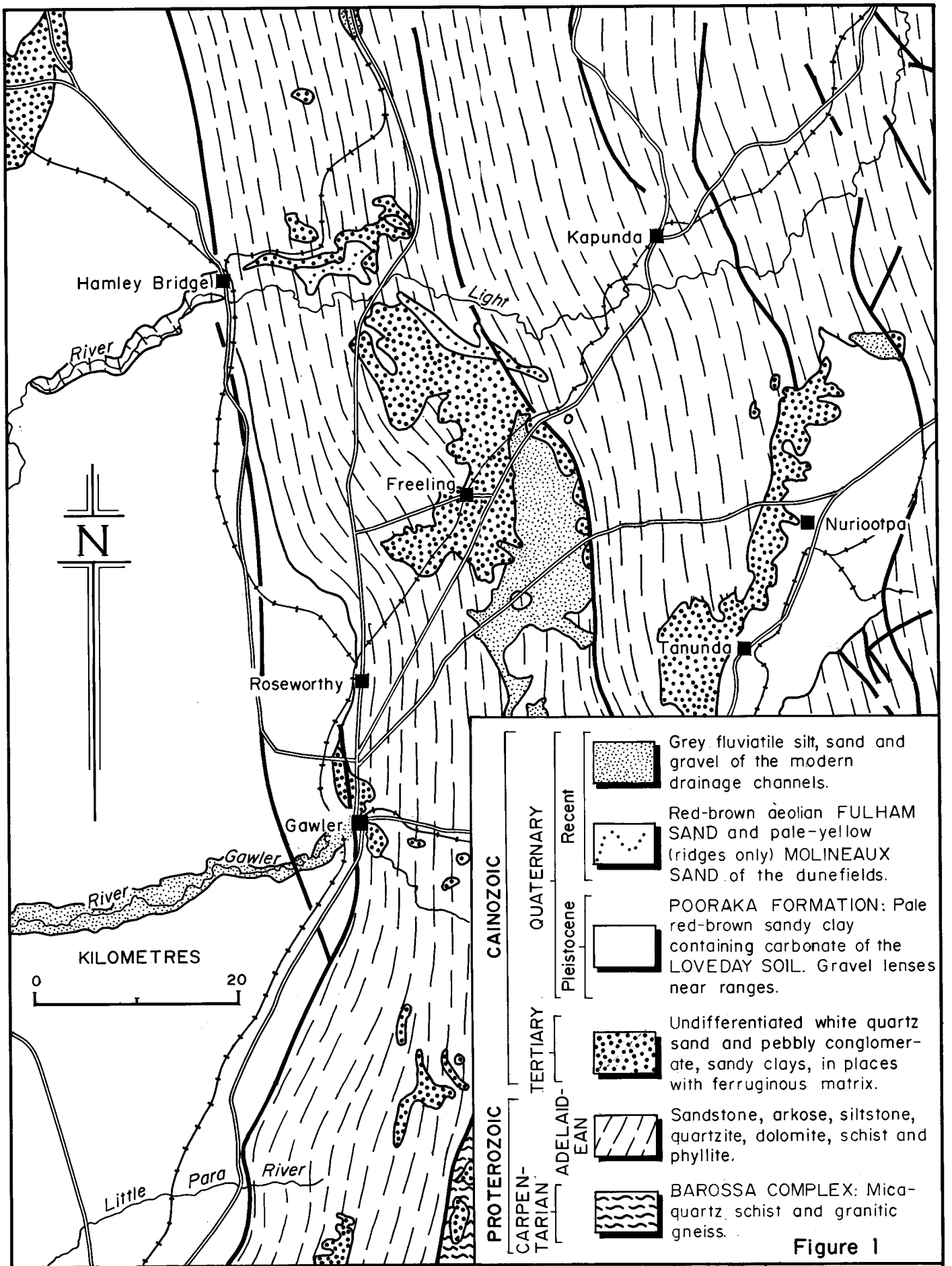


Figure 1

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

COMPILED D. C. Scott	CDO 25.5.89 DATE
DRAWN L. A. W.	SCALE 1:250 000
DATE Jan. 1989	PLAN NUMBER S20634
CHECKED	

TERTIARY SAND DEPOSITS NEAR FREELING

LOCALITY PLAN

4737

N

Stockport

Hamley Bridge

Gilbert River

River

Light

KITCHENER FAULT

Freeling

LEGEND

QUATERNARY
Mainly mottled sandy clay_ some gravel zones at base.

TERTIARY
Fine sand and silt, clayey in part_ coarse sand and gravel at or near base. Some Quaternary sand to north.

ADELAIDEAN
Undifferentiated quartzite, siltstone, phyllite, schist and minor dolomite.

Geological boundaries
Observed
Approximate, inferred

Topographic contour (interval, 50m) A.H.D.

Drillhole location and number:
Auger
Bore General File
Reverse circulation

Section location

Roads

0 1 2 3 4 5
KILOMETRES

SCALE: $\frac{V}{H} = 20$

Figure 2

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

TERTIARY SAND DEPOSITS
NEAR FREELING

GEOLOGICAL PLAN
AND SECTIONS

D.C.Scott
L. A. W.
Jan. 1989
25·5·89
1:50 000
89-18

4737