

**NATIONAL
MINERAL SANDS PTY. LTD.**

MINES

File Ref. **EL 28/85**
22 DEC 1989

Doc. Ref.

Action Officer Initials

LETTER

19. 12. '89

REFERS

Resubmit to Date

EL 28/85 - NARACOOPA, KING ISLAND

ANNUAL REPORT

1.0. During the 12 months ending 31/12/89, field investigation concentrated on 3 main areas:

- a) a hand and RC rig drilling programme for a total of 60 drillholes. This programme was supplementary to that carried out in the previous year.
- b) two separate metallurgical testwork programmes were carried out. The first on composite drillhole samples from the previous year's drilling programme and the second on a bulk drillhole sample taken from Lanherne beach - 1400 N 240 W to 280 W.
- c) hydrogeological study of the Naracoopa sands.

2.0 APPENDIX 1

"Addendum to Report No. 20/88 Further Investigation to the Mineral Sand Resources at Naracoopa, King Island EL 28/85" P.H. STITT & ASSOC. REPORT No. 7/89.

APPENDIX 11

"Metallurgical Testing of a Heavy Mineral Concentrate prepared from Lanherne Raw Sand Drill Samples for National Mineral Sands Pty Ltd" AMMTEC, APRIL 1989

APPENDIX 111

"Metallurgical Testwork Conducted upon a three Tonne Bulk Sample from the Lanherne Deposit for National Mineral Sands Pty. Ltd" AMMTEC, JULY 1989

APPENDIX 1V

"Hydrogeological Study for Proposed Heavy Mineral Sand Mines Naracoopa Project, King Island" COFFEY & PARTNERS PTY LTD., APRIL 1989

D. GILLETT
PROJECT MANAGER
DECEMBER 1989.

MICROFILMED

PETER H. STITT & ASSOCIATES PTY. LTD.
MINING AND GEOLOGICAL CONSULTANTS

89-3068 A

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OPEN FILE

REPORT NO 7/89

MICROFILMED

Addendum to Report No. 20/88

Further Investigation to the Mineral Sand Resources
at
Naracoopa, King Island. E.L. 28/85

Report Prepared for National Mineral Sands Pty. Ltd.

G. Lee
A. Dove
May, 1989

89-3068A
APPX 1/4
VOL 2/5

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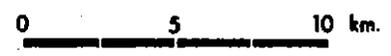
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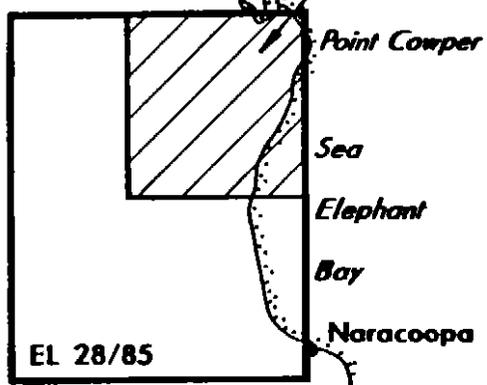


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KING ISLAND

AREA EXCLUDED DUE TO
KINGS PARADISE PROPOSAL

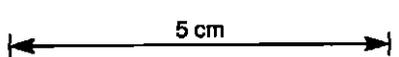


Currie
230670E,
5574090N.

248080E
5561040N
Grassy

ISG REFER REPORT 70-0676

NATIONAL MINERAL SANDS		
EL 28/85		
LOCATION MAP		
Author: A.DOVE	Date: JULY 1988	Fig.No.: 1



SYNOPSIS

1. AIM

To up-date the overall reserves of economic mineral sands at Naracoopa, following work undertaken during November, 1988 and January-February, 1989.

2. REASON

National Mineral Sands Pty. Ltd., as operators of a joint venture with Peko Wallsend Ltd. and Sanidine N.L. are evaluating the feasibility of recovering known heavy mineral sand resources at Naracoopa on King Island. The principal economic minerals comprising these sands are rutile and zircon which are currently undergoing buoyant market conditions.

3. SUMMARY & CONCLUSIONS

- 3.1 Drilling on the north end of the Lanherne Beach deposit has more closely defined the extent and grade of mineralisation.
- 3.2 Drill holes on the line called "Tip Road" were infilled to 20m. spacings.
- 3.3 Two additional lines were completed on 1600N and 1800N at 20m. spacings.
- 3.4 The Tip Road line average grade increases from 2.3% to 3.4% heavy mineral.
- 3.5 Overall raw sand tonnage on Tip Road line drops from 460,800 t to 240,800t.
- 3.6 On Sea Beach and Milford Beach drilling was undertaken on lines 1600N, 1800N and 2000N.
- 3.7 Mineralisation above 1.5% cut-off was intersected on each line.

- 3.8 A total increase of 8,000 t of heavy mineral occurs in the combined area of Milford and Sea Beaches, as shown in Tables 3 and 4.
- 3.9 Results previously not available from drill holes 60E, 80E and 100E from the 600N line within the Lanherne Beach sand tailings are shown in Figure 7.
- 3.10 Recalculation of the resource estimates for sand tailings (Table 5) on the 600N line show a resultant nett down-grading of the resource.
- 3.11 Hand drilling on line 700N was carried out to extend the line to the bank of the Frazer River.
- 3.12 The resource estimates for Lanherne Beach sand tailings (Table 5) have been modified to include these holes. An up-grading of the resource has resulted.
- 3.13 Overall, the resource estimates (Table 8) have not altered from those recorded in Report No. 20/88, however there is better definition of the boundaries and the grades.
- 3.14 Initial investigations were carried out by Readings Metallurgical Services to determine the response of ilmenite to magnetic beneficiation, and are recorded in Section 8.

4. RECOMMENDATIONS

That further geological investigations be deferred until a favourable feasibility study is available.

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5. INTRODUCTION

During March and April, 1988, an investigation was carried out to determine the heavy mineral sand resources contained in the deposits at Naracoopa on King Island. Results of this investigation were recorded in a report titled "Evaluation of Mineral Sand Resources at Naracoopa, King Island"; Peter H. Stitt & Associates Report No. 20/88, August, 1988.

Upon obtaining and reviewing the results of the 1988 programme it was apparent that some additional investigations should be undertaken, at an appropriate time, in an attempt to more fully define the limits of the resource as well as the contained mineral quantity and grade. The programme was principally directed towards the northern extensions of Lanherne Beach, Milford Beach and Sea Beach. As well a few holes were drilled along the western side of Lanherne Beach.

The work was undertaken during November, 1988 and January-February, 1989, in conjunction with drilling investigations at Cowper Point.

This report is written to supplement Report No. 20/88. Investigations were undertaken in the same manner as described in the above report. Results are recorded along with up-dated resource estimates derived from these additional results, and comments are made insofar as the understanding of the Naracoopa deposit has changed. Modified and updated plans and sections are included where appropriate. The modified Figure Nos and Table Nos used in this report are the same as used in Report No. 20/88 prior to the recent updating.

6. REVISED RESOURCE ESTIMATES

Revised resource estimates are set out in Tables 2, 3, 4, 5 and 8 as follows:

Lanherne Beach Raw Sand	Table 2
Milford Beach Raw Sand	Table 3
Sea beach Raw Sand	Table 4
Lanherne Beach Sand Tailings	Table 5
Naracoopa Resource Summary	Table 8

Drillhole descriptive logs are attached as Appendix 1. Laboratory result certificates are included as Appendix 2.

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7. COMMENTS7.1 Lanherne Beach Raw Sand

Drilling on the north end of the Lanherne Beach deposit has more closely defined the extent and grade of mineralisation. On the line called "Tip Road" and previously drilled at 40m. hole spacing, additional holes were drilled over the mineralised section to give 20m. spacings. Results are plotted on cross section Figure 12.

Two additional lines of drillholes were completed on 1600N and 1800N at 20m. spacings. Results are plotted on cross section Figures 19 and 20.

Results obtained have given better definition of the mineralisation. On "Tip Road" the mineralisation splits into two separate bodies which extend north to 1600N but on 1800N are below cut-off grade.

Figure 3 shows drillhole locations and grades at 1.5% cut-off.

Analysis of results and revised resource estimates as set out in Table 2 has shown:

- . The Tip Road line average grade has increased from 2.3% to 3.4% heavy mineral.
- . The northern extension for resource calculation has been reduced to 50m.
- . Mineralisation on the 1600N line has not been included since grades are only marginally above 1.5% and intersections narrow.
- . Overall raw sand tonnage on Tip Road drops from 460,800t previously to 240,800t now.
- . However because of increased heavy mineral grade contained rutile 630t previously, drops to 498t now, zircon 630t previously, drops to 498t now, within the Tip Road block.

TABLE 2

Revised May, 1989

RAW SAND - LANHERNE BEACH INDICATED RESOURCES AT 1.5% CUT-OFF

LINE	EXTENSION			t/m EXTENSION		% H.M.	MINERALOGY %			TONNES				
	North (m)	South (m)	Total (m)	Raw Sand	H.M.		Rutile	Zircon	Leucoxene	Sand	H.M.	Rutile	Zircon	Leucoxene
100N (180E-20E)	100	100	200	1,948	119	6.1	8	10	4	389,600	23,800	1,900	2,380	950
300N (140E-60W)	100	100	200	1,723	62	3.6	9	12	4	344,600	12,400	1,120	1,490	500
500N (120E-120W)	50	100	150	2,752	162	5.9	5.7	9.7	4	412,800	24,300	1,390	2,360	970
600N	-	-	-											
700N (120E-60E)	150	50	200	784	125	16.0	6	6	2	156,800	25,000	1,500	1,500	500
1000N (160W-540W) (60E-120W)	100	150	250	2,363 832	109 22	4.6 2.6	7 10	7 15	6 8	590,750 208,000	27,250 5,500	1,910 550	1,910 830	1,640 440
1200N (180W-340W)	100	100	200	1,392	61	4.4	8	9	5	287,400	12,200	980	1,100	610
1400N (240W-360W)	50	100	200	1,744	73	4.2	9	12	7	348,800	14,600	1,310	1,750	1,020
TIP ROAD (TR28-TR 50)	50	50	100	2,408	83	3.4	6	6	6	240,800	8,300	498	498	498
						5.1%	TOTAL TONNES			2,979,550	153,350	11,158	13,818	7,128
							TOTAL ROUNDED TONNES			2,980,000	153,000	11,200	13,800	7,100

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7.2 Milford and Sea Beaches

On Milford Beach and Sea Beach drilling was undertaken on lines 1600N, 1800N and 2000N, i.e. extending 600m. north of the area previously defined. Mineralisation above 1.5% cut-off was intersected on each line. Figure 3 shows the mineralised holes with depths and grades. Tables 3 and 4 have been updated to include the additional resources.

A total increase of 8,000t of heavy mineral results, comprises 2,000 t on Sea Beach and 6000 t on Milford Beach. Assuming the rutile and zircon contents determined previously for 0 - 1400N lines persist into this area, then additional

rutile = 740t

zircon = 740t

on the combined area of Sea and Milford Beaches.

7.3 Lanherne Beach Sand Tailings

Drill holes 60E, 80E and 100E on line 600N previously had incomplete results. Full results are now available and have been included. The cross-section, Figure 7, has been updated to include these results and drillhole logs in Appendix 1 include the full test results.

Recalculation of resource estimates has been completed as shown in Table 5. A nett down grading of the resource has resulted. The depths and grades for 40E, 600N and 120E, 600N previously projected to cover the area of influence of hole 60E, 80E and 100E were higher than the results subsequently obtained.

Drillholes 340W and 360W on line 700N were hand drilled in order to extend this line to the bank of the Fraser river. The cross section, Figure 8, has been updated to include these drillholes and

TABLE 3

MILFORD BEACH INDICATED RESOURCES AT 1.5% CUT-OFF

REVISED MAY 1989

LINE	EXTENSION			t/m EXTENSION		% H.M.	MINERALOGY %				TONNES					
	North (m)	South (m)	Total (m)	Raw Sand	H.M.		Rutile	Zircon	Leucoxene	Ilmenite	Sand	H.M.	Rutile	Zircon	Leucoxene	Ilmenite
100N	100	100	200	76.8	29.8	38.8	9	11	2	37	15,360	5,690	536	626	114	2,105
300N	100	100	200	73.6	23.6	32.1	9	11	2	37	14,720	4,720	425	519	94	1,746
500N	50	100	150	89.6	24.7	27.5	9	11	2	37	13,440	3,705	333	408	74	1,371
600N	-	-	-													
700N	-	-	-													
1000N	100	150	250	250	44.2	17.8	11	9	2	38	62,500	11,050	1,215	995	221	4,774
1200N	100	100	200	278	22.2	8.0	11	9	2	38	55,600	4,440	488	400	89	1,687
1400N	100	100	200	171	7.8	4.5	11	9	2	38	34,200	1,560	172	140	31	593
1600N	100	100	200	253	14.2	5.6	-	-	-	-	50,600	2,840	-	-	-	-
1800N	100	100	200	180	5.5	3.1	-	-	-	-	36,000	1,100	-	-	-	-
2000N	100	100	200	210	8.4	4.0	-	-	-	-	42,000	1,680	-	-	-	-
						11.3	TOTAL TONNES				324,420	36,785				
							TOTAL ROUNDED TONNES				320,000	37,000				

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TABLE 4

SEA BEACH INDICATED RESOURCES AT 1.5% CUT-OFF

REVISED MAY 1989

LINE	EXTENSION			t/m EXTENSION		% H.M.	MINERALOGY %				TONNES					
	North (m)	South (m)	Total (m)	Raw Sand	H.M.		Rutile	Zircon	Leucoxene	Ilmenite	Sand	H.M.	Rutile	Zircon	Leucoxene	Ilmenite
100N	100	100	200	93.6	46.7	49.9	8	8	1	33	18,700	9,340	747	747	93	3,080
300N	100	100	200	176.0	33.6	19.1	8	8	1	33	35,200	6,720	538	538	67	2,220
500N	50	100	150	92.8	22.2	23.9	7	6	2	32	13,900	3,330	233	200	66	1,070
600N	50	50	100	48.0	7.8	16.3	7	6	2	32	4,800	780	55	47	16	250
700N	150	50	200	94.4	20.7	21.9	7	6	2	32	18,900	4,140	290	248	82	1,320
1000N	100	150	250	70.4	13.6	19.4	7	9	2	29	17,600	3,400	238	306	68	990
1200N	100	100	200	70.4	10.8	15.3	7	9	2	29	14,100	1,980	139	178	40	570
1400N	100	100	200	112.0	12.2	10.9	7	9	2	29	22,400	2,440	171	220	49	710
1600N	100	100	200	122.0	5.6	4.6	-	-	-	-	24,400	1,120	-	-	-	-
1800N	100	100	200	64.0	2.3	3.5	-	-	-	-	12,800	460	-	-	-	-
2000N	100	100	200	64.0	2.4	3.7	-	-	-	-	12,800	480	-	-	-	-
						17.5	TOTAL TONNES				195,600	34,190				
							TOTAL ROUNDED TONNES				195,000	34,000				

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TABLE 5

SAND TAILINGS LANHERNE BEACH INDICATES RESOURCES AT 1.5% CUT-OFF

REVISED MAY 1989

LINE	EXTENSION			t/m EXTENSION		% H.M.	MINERALOGY %			TONNES				
	North (m)	South (m)	Total (m)	Raw Sand	H.M.		Rutile	Zircon	Leucoxene	Sand	H.M.	Rutile	Zircon	Leucoxene
100N (000-140W)	100	100	200	1,630	106	6.5	6	6	3	326,000	21,200	1,270	1,270	640
300N (80W-240W)	100	100	200	2,824	277	9.8	5	6	3	564,800	55,400	2,770	3,320	1,660
500N (220W-380W)	50	100	150	2,544	221	8.7	4.5	5	5	381,600	33,150	1,490	1,660	1,660
600N (140E-380W)	50	50	100	7,678	618	8.1	5.2	6	3.5	767,800	61,800	3,210	3,710	2,160
700N (80W-360W)	150	50	200	3,362	208	6.2	6	6	5	672,400	41,600	2,500	2,500	2,080
1000N														
1200N														
1400N														
TIP ROAD														
7.9 TOTAL TONNES										2,712,600	213,150	11,240	12,460	8,200
TOTAL ROUNDED TONNES										2,710,000	213,000	11,200	12,500	8,200

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test results. Drillhole logs are included in Appendix 1.

Resource estimates have been modified to include these additional resources as shown in Table 5. An upgrading of the resource has resulted.

Overall resource estimates in Table 5 show only minor and insignificant variation from those previously published in Report No. 20/88. The down grading on 600N line is largely compensated by an upgrading on 700N line.

7.4 Resource Estimate Revision

Table 8 has been revised to reflect the current situation. Estimates for rutile, zircon and leucoxene in Table 8 are based on the assumption that the ratio of rutile, zircon and leucoxene in the total heavy mineral suite remains the same as previously determined and recorded in Report No. 20/88. No mineralogical studies have been carried out on any recent drill samples.

Figure 14 has been revised to reflect the revised resource estimates.

Overall the resource estimate quantities for the Naracoopa deposit have not altered. However there is better definition of the boundaries and grades.

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TABLE 8

RESOURCE SUMMARY

REVISED MAY 1989

RESOURCES STATED AS INDICATED EXCEPT FOR *BURIED HEAVY TAILINGS
AT 1.5% HEAVY MINERAL CUT-OFF

CATEGORY	IN-SITU CONTENT			TONNES				
	% H.M.	% R	% Z	SAND	H.M.	R	Z	Leu
<u>RAW SAND</u>								
LANHERNE BEACH	5.1	0.38	0.46	2,980,000	153,000	11,200	13,800	7,100
MILFORD BEACH	11.3	1.17	1.14	320,000	37,000	3,740	3,640	740
SEA BEACH	17.5	1.32	1.35	195,000	34,000	2,570	2,640	510
<u>SAND TAILINGS</u>	7.9	0.41	0.46	2,710,000	213,000	11,200	12,500	8,200
<u>HEAVY TAILINGS</u>								
ABOVE SURFACE	82.90	3.31	4.13	139,000	115,000	4,600	5,800	1,200
BURIED*	47.30	1.90	1.90	245,000*	116,000*	4,600*	4,600*	2,300*
TOTAL				6,589,000	668,000	37,910	42,980	20,050
ROUNDED TONNES				6,600,000	670,000	38,000	43,000	20,000

* . Less certain that quantities stated are reliable since lateral extent is not known. Further drilling would be required to quantify this resource. This resource is stated as INFERRED.

. It is possible that part of this resource is replaced by an equivalent quantity of sand tailings of an untested heavy mineral grade.

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8. ILMENITE BENEFICIATION

A preliminary investigation was undertaken during December, 1988 to determine if a significant reduction in Cr_2O_3 content of ilmenite could be achieved by magnetic separation. Test work was carried out by Readings Metallurgical Services Pty. Ltd.

Feed utilised by Readings comprised magnetic material from the mineralogical samples set out below; with weight of magnetics and percentage of composite also shown.

Sample 2	Sea Beach	180E and 160E, 500N)	
		160E , 600N)	160.6g = 22.1%
		160E , 700N)	
Sample 5	Milford Beach	80E and 100E, 1000N)	
		60E, 80E and 100E, 1200N)	88.6g = 12.2%
		60E and 80E, 1400N)	
Sample 17	Magnetic Tailings	140W, 160W, 180W and 200W, 500N)	477.8g =
) 65.7%

The above figures show that the composite sample was heavily biased towards Magnetic Tailings (sample 17).

Overall the results obtained from this sample are not encouraging. Yields of ilmenite product are low and Cr_2O_3 levels in the products are all greater than 1%.

Appendix 3 is a copy of the Readings report detailing the testwork carried out. It also details results of the mineralogical examination carried out on the non-magnetic fraction of the samples comprising the ilmenite beneficiation sample. Of particular note is the percentage magnetics contained in the mineralogical samples.

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APPENDIX 1

Drill hole Descriptive Logs

Lines:

600N	100E to 60E
700N	340W and 360W
1200N	380W
1400N	380W and 400W
Tip Road	50 to 26
1600N	80E to 520W
1780N	300W and 320W
1800N	80E to 520W
2000N	80E to 20E
S.I.	

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CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85'

AREA: NARACOOPA

HOLE NO: 100E 600N

LOGGED BY: ANDREW DOVE

R.C. RIG DRILLED

DATE DRILLED: 17.4.88

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 μ m	% H.M.
0 - 1.5	1.53	SAND, med. grained, grey brown, H.M. rich.	0.91	0.25	13.86
1.5 - 3.5	1.18	SAND, med. grained, light grey. H.M. rich.	0.69	0.01	8.81
3.5 - 5.5	1.99	AS ABOVE, grades into grey-brown.	1.96	0.03	2.39
		WATER TABLE			
5.5 - 7.5	2.68	SAND, med. to coarse grained, red-brown to dark brown	3.75	0.80	1.39
7.5 - 8.5	0.70	AS ABOVE. Hit gravel then grey green micaceous clay.	5.14	0.36	8.43
		END OF HOLE 8.5m.			
		Down hole average			<u>6.4</u>
0 - 8.5		Depth and grade at 1.5% cut-off			<u>6.4</u>

542020 15

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

020 AREA: NARACOOPA

HOLE NO: 80E 600N

LOGGED BY: ANDREW DOVE

R.C. RIG DRILLED

DATE DRILLED: 17.4.88

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	5.82	SAND, medium grained, light grey, H.M. rich.	0.67	0.03	10.63
1.5 - 3.5	5.92	AS ABOVE, grades into light med-brown at 3.0m.	1.65	0.00	2.02
3.5 - 5.5	8.23	SAND, medium grained, pale brown, grading into amber.	1.18	0.05	1.18
5.5 - 7.5	8.56	SAND, medium grained, dark brown.	2.93	0.19	1.03
7.5 - 9.5	5.93	AS ABOVE, hit gravel then micaceous clay.	6.52	4.11	1.26
9.5 - 11.5 (No sample)		CLAY			
		END OF HOLE 11.5m.			
		Down hole average			<u>2.83</u>
0 - 3.5		Depth and grade at 1.5% cut-off			<u>5.71</u>
		Test results received 15/2/88			

542021

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

AREA: NARACOOPA

HOLE NO: 60E 600N

LOGGED BY: ANDREW DOVE

R.C. RIG DRILLED

DATE DRILLED: 17.4.88

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	5.68	SAND, medium grained, brown grey grading to amber. H.M. rich.	2.09	0.31	26.33
1.5 - 3.5	6.61	SAND, medium gained, brown grey. WATER TABLE.	1.31	0.07	8.06
3.5 - 5.5	9.04	AS ABOVE, slightly lighter at base.	1.48	0.02	1.81
5.5 - 7.5	9.50	AS ABOVE, grades into red-brown sand.	2.28	0.04	1.71
7.5 - 9.5	6.03	AS ABOVE, contains gravel. Hit grey micaceous clay. END OF HOLE 9.5m.	7.21	4.28	1.40
		Down hole average			<u>6.89</u>
0 - 7.5		Depth and grade at 1.5% cut-off			<u>8.35</u>
		Test results received 15/12/88			

542022 17

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

AREA: NARACOOPA

HOLE NO: 340W 700N
On top of bank near dam

LOGGED BY: ANDREW DOVE

DATE DRILLED: 6.11.88

022

542023

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.0	3.06	SAND fine to medium grained, dark brown, contains rock and pebbles	9.00	0.62	12.26
1.0 - 2.0	1.94	SAND fine to medium grained, grey contains organic and pebbles	9.21	0.70	10.28
2.0 - 3.0	1.75	AS ABOVE contains H.M. Started sludging	16.00	0.71	12.52
3.0 - 4.0	4.31	AS ABOVE H.M. present. Hit clay and sand. EOH 4.0m. clay	1.16	0.13	9.14
		Down hole average			<u>11.05</u>
0 - 4.0		Depth and grade at 1.5% cut-off			<u>11.05</u>

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

AREA: NARACOOPA

HOLE NO: 360W 700N

023 LOGGED BY: ANDREW DOVE

DATE DRILLED: 6.11.88

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.0	2.31	SAND fine to medium grained, dark grey organic, H.M. present.	8.87	0.49	12.67
1.0 - 2.0	2.21	SAND fine to medium grained, light brown, clay rich, H.M. present. Hit water 1.5m. Started sludging	7.43	1.61	5.97
2.0 - 2.3	0.94	AS ABOVE EOH 2.3m. clay.	10.40	0.63	10.33
		Down hole average			<u>9.45</u>
0 - 2.3		Depth and grade at 1.5% cut-off			<u>9.45</u>

542024 19

CLIENT: NATIONAL MINERAL SANDS

TITLE NO:

E.L. 28/85

AREA: NARACOOPA

HOLE NO: 380W 1200N

LOGGED BY: GRAHAM LEE

DATE DRILLED:

29.1.89

METHOD:

Hand

024

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	3.15	SAND, medium grained, well sorted, pale grey.	7.99	2.17	0.73
1.5 - 3.5	8.45	SAND, as above at top. Indurated, hard. 3.2 - 3.5m. Coarse sand and gravel with rich H.M.	1.79	2.44	1.93
3.5 - 5.0	8.55	SAND , mostly medium - fine. Mica rich, pale brown. Hand drilling 5.0m. Stopped hole E.O.H. 5.0m.	3.12	4.56	2.19
		Down hole average			<u>1.64</u>
0 - 5.0		Depth and grade at 1.5% cut-ff			<u>1.64</u>

542025

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 380W 14 00N

025 LOGGED BY: GRAHAM LEE

DATE DRILLED: 30.1.89 METHOD: Hand

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		PEAT, very wet. Minor sand at 1.3 - 1.5m.			
1.5 - 3.5	3.70	SAND, medium grained, well sorted, grey. Indurated layers.	2.68	0.54	1.73
3.5 - 5.5	5.00	AS ABOVE, with some coarse grains at bottom. Indurated.	4.60	0.23	1.42
5.5 - 5.7	0.65	Pyrite layer.	2.87	2.55	5.72
		E.O.H. 5.7m.			
		PIEZOMETER			
		Down hole average			<u>1.15</u>

542026
21

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 400W 1400N

026

LOGGED BY: GRAHAM LEE

DATE DRILLED: 29.1.89

METHOD: Hand

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% F.M.
0 - 1.5		PEAT, swamp, wet. Pushed casing down easily, no sludging.			
1.5 - 3.5		PEAT, only minor sand.			
3.5 - 5.0	2.45	SAND, coarse moderately sorted. Some very coarse sand. Indurated hard layers. Stopped 5.0m. Hard Indurated. E.O.H. 5.0m.	5.31	1.57	1.13
		Down hole average			<u>0.21</u>

542027

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

02 AREA: NARACOOPA - TIP ROAD

HOLE NO: TR. 50

LOGGED BY: GRAHAM LEE

DATE DRILLED: 29.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% +1000 um	% H.M.
0 - 1.5	5.15	SAND, medium to coarse, well sorted, grey.	2.78	0.09	0.67
1.5 - 3.5	6.30	AS ABOVE. H.M. Tr.	4.23	0.05	3.38
3.5 - 5.5	9.80	AS ABOVE. H.M. 1%.	2.43	0.13	4.84
5.5 - 7.5	9.35	SAND, coarse, moderate sorting. H.M. 2%.	1.96	0.58	3.28
7.5 - 9.5	4.60	SAND, as above, becomes pyritic then at 9.0m. fine micaceous sand with clay at 9.5m. E.O.H. 9.5m.	9.80	8.10	2.13
		Down hole average			<u>2.98</u>
0 - 9.5		Depth and grade at 1.5% cut-off			<u>2.98</u>

542028

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA - TIP ROAD

HOLE NO: TR 48

LOGGED BY: GRAHAM LEE

DATE DRILLED: 29.1.89

METHOD: Rig

028

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	3.30	SAND, medium - coarse, well sorted, pale grey.	1.24	0.06	0.55
1.5 - 3.5	5.85	AS ABOVE, grey.	4.52	0.11	2.99
3.5 - 5.5	10.85	AS ABOVE, grey with coarse heavies H.M. 2-5%.	2.65	0.14	6.43
5.5 - 7.5	7.70	SAND, as above with gravel at 6.5 - 7.0m. Rich H.M. +5%.	2.67	2.84	11.95
7.5 - 9.5	6.00	SAND, coarse grained, some very coarse. Poorly sorted. Pyritic. Clayey sand near bottom.	5.11	3.01	5.57
9.5 - 11.5	5.20	SAND, fine to very fine, clayey and mica rich with clay bands, grey. E.O.H. 11.5m.	28.67	7.37	1.63
		Down hole average			<u>5.04</u>
0 - 9.5		Depth and grade at 1.5% cut-off			<u>5.76</u>

542029

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

029 AREA: NARACOOPA - TIP ROAD

HOLE NO: TR 42

LOGGED BY: GRAHAM LEE

DATE DRILLED: 29.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.45	sand, medium - coarse, well sorted. White.	0.78	0.04	0.55
1.5 - 3.5	9.10	AS ABOVE	1.85	0.00	1.77
3.5 - 5.5	7.80	AS ABOVE, brownish grey	2.70	0.02	0.60
5.5 - 7.5	5.80	AS ABOVE, with indurated. Dark brown.	9.56	1.45	0.78
7.5 - 9.5	5.10	AS ABOVE	4.04	0.14	0.11
9.5 - 11.5	8.25	AS ABOVE, heavily pyritic. Brown clay at 11.4m. E.O.H. 11.5m.	4.44	5.23	2.46
		Down hole average			<u>1.07</u>

542030
25

030

CLIENT: NATIONAL MINERAL SANDS

TITLE NO:

E.L.28/85

AREA: NARACOOPA

HOLE NO: TR 38

LOGGED BY: GRAHAM LEE

DATE DRILLED: 29.1.89

METHOD: RIG

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.25	SAND, medium grained, well sorted, white.	1.36	0.06	0.73
1.5 - 3.5	7.35	AS ABOVE, H.M. 1 - 2%	2.06	0.01	1.26
3.5 - 5.5	10.30	AS ABOVE, dark brown. H.M. 1 - 2%	5.09	0.06	1.60
5.5 - 7.5	6.90	SAND, medium to fine grained, well sorted. Indurated hard bands, H.M. 1%.	5.42	0.39	1.54
7.5 - 9.5	4.65	AS ABOVE	9.69	0.49	0.33
9.5 - 11.5	7.05	SAND, medium to coarse grained, moderate sorting. Pyritic clay at 11.5m. EOH 11.5m.	4.35	2.70	2.56
		Down hole average			<u>1.36</u>

542031 26

CLIENT: NATIONAL MINERAL SANDS

TITLE NO:

E.L. 28/85

AREA: NARACOOPA - TIP ROAD - 2m. N. of peg

HOLE NO: TR 34

LOGGED BY: GRAHAM LEE

DATE DRILLED:

METHOD: Rig

031

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.80	SAND, medium - coarse grained, well sorted. Pale grey.	1.37	0.01	0.65
1.5 - 3.5	8.15	AS ABOVE	0.88	0.02	0.54
3.5 - 5.5	8.50	AS ABOVE, brownish grey with H.M. 1-2%.	2.36	0.03	0.99
5.5 - 7.5	8.80	AS ABOVE, H.M. 2-5%.	2.86	0.02	4.25
7.5 - 9.5	6.25	AS ABOVE, with some peat. H.M. 1-2%.	7.60	1.44	3.56
9.5 - 11.5	3.90	SAND, medium grained, well sorted. Peaty. H.M. Tr.	9.48	0.74	0.49
11.5 - 13.5	7.15	SAND, coarse and very coarse, poor sorting, Pyritic. Mica rich sand at 13.0m. E.O.H. 13.5m. Just into clay	6.07	5.59	3.53
		Down hole average			<u>2.05</u>
0 - 9.5		Depth and grade at 1.5% cut-off			<u>2.17</u>

542032

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

032 AREA: NARACOOPA - TIP ROAD

HOLE NO: TR 30

LOGGED BY: GRAHAM LEE

DATE DRILLED: 29.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	3.60	SAND, medium to coarse, well sorted, grey.	3.91	0.53	0.78
1.5 - 3.5	7.20	AS ABOVE, darker grey.	5.28	0.19	1.12
3.5 - 5.5	6.00	sand, as above. Peaty. H.M. Tr.	8.54	1.01	7.04
5.5 - 8.5	7.30	SAND, medium - coarse grained. Well sorted. brown. H.M. 2-5%.	2.06	0.13	6.83
7.5 - 9.5	4.55	SAND, as above, peaty. H.M. Tr.	14.83	3.39	1.31
9.5 - 11.5	8.90	SAND, as above. Pyritic. Clay, grey, mica rich 11.5m. E.O.H. 11.5m.	4.77	3.69	1.96
		Down hole average			<u>3.28</u>
0 - 7.5		Depth and grade at 1.5% cut-off			<u>4.15</u>

542033

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA - TIP ROAD - 2m. N. of peg

HOLE NO: TR 26

LOGGED BY: GRAHAM LEE

DATE DRILLED: 29.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% +1000 um	% H.M.
0 - 1.5	3.35	SAND, medium grained, well sorted, grey.	1.72	0.13	0.82
1.5 - 3.5	7.20	AS ABOVE	1.42	0.04	0.69
3.5 - 5.5	6.15	AS ABOVE, grey brown	5.43	0.02	0.85
5.5 - 7.5 (Do not test)		PEAT			
7.5 - 9.5	4.95	PEAT, to 8.7m. then sand, medium grained, well sorted.	13.35	6.53	4.08
9.5 - 11.5	3.75	SAND, as above with some peat.	11.76	2.81	1.98
11.5 - 13.25	6.65	SAND, medium to coarse, Poorly sorted. Pyritic. Clay, brown, mica rich 13.25m. E.O.H. 13.25m.	4.47	5.37	1.24
		Down hole average			<u>1.40</u>

542034

033

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

AREA: NARACCOOPA

HOLE NO: 80E 1600N

LOGGED BY: ANDREW DOVE

DATE DRILLED: 6.11.88

HWM

03

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.0	1.68	SAND fine to medium grained, light grey to white. H.M. present.	0.12	0.07	7.59
1.0 - 2.0	2.23	AS ABOVE grades to orange brown becomes coarser with depth. H.M. present. Hit water, started sludging.	0.34	0.09	4.46
2.0 - 3.0	3.18	SAND fine to medium grained, grey to brown slightly indurated.	2.00	0.99	2.49
3.0 - 3.8	2.45	SAND fine to medium grained grey, fine shell, hit gravel then rock. EOH 3.8m. rock.	1.06	1.59	3.62
		<u>Down hole average</u>			<u>4.59</u>
0 - 3.8		Depth and grade at 1.5% cut-off			<u>4.59</u>

542035

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

AREA: NARACOOPA

HOLE NO: 60E 1600N

035

LOGGED BY: ANDREW DOVE

DATE DRILLED: 6.11.88

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.0	1.96	SAND fine to medium grained, grey organic grades to light brown	1.86	0.13	2.67
1.0 - 2.0	2.56	SAND, medium to coarse grained, orange brown. H.M. present	0.26	0.07	2.20
2.0 - 3.0	2.11	SAND medium to coarse grained, brown grades to light grey becoming coarser with depth. Hit water. Started sludging.	0.24	0.52	0.72
3.0 - 4.0	3.82	SAND medium grained, grey slightly indurated	1.11	0.76	2.01
4.0 - 4.2	1.36	AS ABOVE EOH Hit rock. 4.2m.	1.32	1.37	4.24
		Down hole average			<u>2.01</u>
0 - 4.2		Depth and grade at 1.5% cut-off			<u>2.01</u>

542036

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

035 AREA: NARACOOPA

HOLE NO: 40E 1600N

LOGGED BY: ANDREW DOVE

DATE DRILLED: 6.11.88

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.0	1.95	SAND fine to medium grained, grey organic grading to light brown. H.M. present	2.05	0.16	3.79
1.0 - 2.0	2.24	SAND medium grained orange brown. H.M. present	0.85	0.03	3.54
2.0 - 3.0	2.23	AS ABOVE grades to light grey. Hit water 2.4m. started sludging. H.M. present, indurated.	0.91	0.16	10.05
3.0 - 3.7	2.66	SAND medium grained light grey to grey slightly indurated. H.M. present. Hit clay. EOH 3.7m. clay.	1.37	0.33	26.66
		Down hole average			<u>9.74</u>
0 - 3.7		Depth and grade at 1.5% cut-off			<u>9.74</u>

542037

037

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

AREA: NARACOOPA

HOLE NO: 20E 1600N
2.5m. south of peg

LOGGED BY: ANDREW DOVE

DATE DRILLED: 6.11.88

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.0	1.46	SAND fine to medium grained, grey organic grades to light grey	3.43	0.21	0.66
1.0 - 2.0	1.74	SAND medium grained, light grey. H.M. traces.	0.27	0.03	0.75
2.0 - 3.0	2.97	SAND medium grained, dark grey. Hit water 2.2m. started sludging, indurated.	2.83	0.14	0.42
3.0 - 4.2	4.52	SAND medium grained, dark brown, indurated, hit gravel then rock. EOH 4.2m. rock.	2.51	1.62	0.22
		Down hole average			<u>0.50</u>

542038

33

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 6W 1600N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 2.2.89

METHOD: Rig

038

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5	4.25	SAND, medium grained, well sorted, grey.	1.68	0.13	0.29
1.5 - 3.5	7.65	AS ABOVE, medium to coarse grained.	1.44	0.03	0.21
3.5 - 5.5	7.60	AS ABOVE, dark grey at 5.5m.	2.22	0.04	0.45
5.5 - 7.5	8.05	SAND, medium to coarse grained, well sorted. Dark brown, indurated.	2.02	0.31	0.77
7.5 - 9.5	5.85	SAND, coarse, grading down to very coarse. Moderate well sorted. Indurated, dark brown.	2.64	22.97	0.27
9.5 - 11.5	8.80	AS ABOVE to 10.2m. then sand, fine to medium, moderate sorted, mica rich, with some clay layers; with this coarser granule layers.	6.16	1.30	0.67
11.5 - 12.4	0.90	AS ABOVE	9.15	1.73	0.68
		12.4m. CLAY			
		E.O.H. 13.4m.			
		PIEZOMETER HOLE			
		Down hole average			<u>0.47</u>

542039

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 26W 1600N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 2.2.89

METHOD: Rig

039

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5	5.00	SAND, medium grained, well sorted, pale grey.	1.68	0.04	0.48
1.5 - 3.5	8.05	AS ABOVE. Slightly coarser (medium-coarse)	1.26	0.03	0.98
3.5 - 5.5	8.15	AS ABOVE, dark brown, light, indurated.	2.02	0.02	1.32
5.5 - 7.5	11.05	SAND. very coarse grained fining up sequence. Clean rounded quartz granules. Little matrix. Moderately sorted (Beach sequence).	2.19	17.55	0.68
7.5 - 9.5	8.95	AS ABOVE, indurated, dark brown.	2.36	15.83	0.19
9.5 - 11.5	5.90	AS ABOVE to 9.8m. then sand, fine to medium grained, moderate sorted. Mica rich, grey.	10.48	3.26	0.84
11.5 - 12.6	2.75	SAND, as above	10.38	0.36	0.85
		12.6m. E.O.H. BROWN CLAY			
		PIEZOMETER HOLE			
		Down hole average			0.77

542040 35

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 46W 1600N

040

LOGGED BY: GRAHAM LEE

DATE DRILLED: 2.2.89 METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5	5.00	SAND, medium grained, well sorted, pale grey.	1.46	0.16	0.43
1.5 - 3.5	8.40	AS ABOVE, medium - coarse grained.	0.83	0.09	0.67
3.5 - 5.5	8.75	SAND, coarse grained, moderately sorted. Mid grey.	1.83	2.55	0.34
5.5 - 7.5	10.60	SAND, very coarse grained with some gravel. Poorly sorted. Brown, lightly indurated. (Base of old beach sequence)	1.86	10.60	0.30
7.5 - 9.5	7.10	SAND, medium to coarse grained, well sorted. Dark brown.	2.32	21.32	0.37
9.5 - 11.5	5.90	SAND, medium grained, well sorted. Some mica, pale grey.	8.08	1.00	0.61
11.5 - 13.5	4.95	AS ABOVE. Brown clay at 13.5m. E.O.H. 13.5m. PIEZOMETER HOLE	9.55	1.62	0.81
		Down hole average			<u>0.51</u>

542041

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 200W 1600N

041 LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89 METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5	5.90	SAND, medium - coarse grained. Well sorted, pale grey. H.M. tr.	1.60	0.06	1.68
1.5 - 3.5	8.35	AS ABOVE	0.74	0.00	0.85
3.5 - 5.5	7.40	AS ABOVE. Dark brown, lightly indurated.	4.14	0.02	0.66
5.5 - 7.5	7.25	AS ABOVE	2.55	0.01	0.85
7.5 - 9.0	6.30	AS ABOVE, peaty, dark brown mica clay at 9.0 m.	4.37	4.10	0.62
9.0 - 11.5		CLAY			
No sample		E.OH. 11.5m.			
		PIEZOMETER			
		Down hole average			<u>0.91</u>

542042

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

042

AREA: NARACOOPA - Drilled 3m. south of peg

HOLE NO: 220W 1600N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.00	SAND, medium - coarse, well sorted. Pale amber. H.M. Tr.	3.05	1.79	0.90
1.5 - 3.5	7.80	AS ABOVE, grey 3.0 - 3.5m.	2.68	0.05	0.86
3.5 - 5.5	9.25	AS ABOVE, brownish grey.	3.12	0.04	1.26
5.5 - 7.5	9.35	AS ABOVE, Tr of H.M.	1.32	1.20	0.90
7.5 - 8.5	4.40	AS ABOVE, coarser grained than above. Clay, dark brown at 8.4m. E.O.H. 8.5m.	3.93	12.70	0.67
		Down hole average			<u>0.95</u>

542043

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85.

AREA: NARACOOPA

HOLE NO: 240W 1600N

043

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.75	SAND, medium - coarse grained, well sorted. H.M. Tr.	1.02	0.06	0.42
1.5 - 3.5	6.75	AS ABOVE, dark brown, indurated, wet and peaty.	9.29	1.90	1.20
3.5 - 5.5	9.40	SAND, medium - coarse. Well sorted, brown.	1.23	0.03	2.67
5.5 - 7.5	9.25	AS ABOVE. H.M. 1%.	1.85	0.13	2.41
7.5 - 9.0	6.10	AS ABOVE, clay at 9.0m. Dark grey, plastic. Mica rich. E.O.H. 9.0m.	4.31	4.34	1.46
		Down hole average			<u>1.71</u>
0 - 7.5		Depth and grade at 1.5% cut-off			<u>1.76</u>

542044

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85 .

AREA: NARACOOPA

HOLE NO: 260W 1600N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

044

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.90	SAND, medium - coarse grained , well sorted, white. H.M. Tr	1.05	0.09	0.54
1.5 - 3.5	6.15	AS ABOVE, indurated black at 3.3m.	2.14	0.39	0.59
3.5 - 5.5	7.50	SAND, as above. Peat rich, dark brown.	9.99	2.25	2.74
5.5 - 7.5	9.25	SAND, COARSE GRAINED, WELL SORTED, BROWN. H.M. 1-2%.	0.89	0.75	4.11
7.5 - 9.5	9.35	AS ABOVE, indurated 9.0m. H.M. 2-5%.	1.63	0.95	3.47
9.5 - 10.5	3.85	AS ABOVE, coarser at bottom. H.M. 2-5%. Clay at 10.5m. Possible water bore E.O.H. 10.5m.	2.83	16.39	6.36
		Down hole average			<u>2.76</u>
0 - 10.5		Depth and grade at 1.5% cut-off			<u>2.76</u>

542045 40

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

045 AREA: NARACOOPA

HOLE NO: 280W 1600N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	5.50	SAND, medium grained, well sorted, white. H.M. Tr.	1.13	0.04	0.53
1.5 - 3.5	3.80	AS ABOVE, indurated, peaty, dark brown.	6.08	0.29	0.76
3.5 - 5.5	8.10	SAND, medium to coarse, dark grey. H.M. 2%+	3.84	0.35	3.14
5.5 - 7.5	8.00	sand, as above. H.M. 2-5%.	1.89	0.06	4.47
7.5 - 9.5	7.10	AS ABOVE, coarser grained, pyritic at 9.0 - 9.5m.	6.93	3.00	2.46
9.5 - 9.75	1.20	AS ABOVE, dark grey, micaceous clay at 9.7m. E.O.H. 9.75m.	11.87	8.40	2.05
		Down hole average			<u>2.36</u>
0 - 9.75		Depth and grade at 1.5% cut-off			<u>2.36</u>

542046

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 300W 1600N

046

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	2.75	SAND, medium to coarse grained, well sorted. Pale brownish grey	2.30	1.09	0.32
1.5 - 3.5	8.75	AS ABOVE	2.50	0.00	0.50
3.5 - 5.5	9.05	AS ABOVE	1.22	0.02	0.50
5.5 - 7.5	8.05	AS ABOVE, slightly darker colour	3.62	0.11	0.68
7.5 - 9.5	4.85	AS ABOVE, dark brown, indurated and peaty. Pyritic at 9.0m. to 9.5m.	8.58	0.94	0.45
9.5 - 10.5	4.55	SAND, medium to very coarse grained, some gravel at bottom. Dark brown. Clay at 10.4m. E.O.H. 10.5m.	4.42	9.68	3.55
		Down hole average			<u>0.79</u>

542047
42

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 320W 1600N

047

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	5.50	SAND, medium to coarse grained, well sorted, pale grey.	1.93	0.08	0.53
1.5 - 3.5	9.05	AS ABOVE, but coarser	1.17	0.01	0.58
3.5 - 5.5	7.90	AS ABOVE, darker and indurated.	3.26	0.02	0.54
5.5 - 7.5	9.50	AS ABOVE, hard, indurated.	2.83	0.09	1.05
7.5 - 9.5	5.90	AS ABOVE, hard, indurated.	5.02	2.86	1.01
9.5 - 11.5	9.65	SAND, medium to very coarse grained. Poorly sorted. Pyritic sand with coarse lumps.	4.67	3.33	1.85
11.5 - 11.75	1.90	AS ABOVE, 11.75 - 17.0. Clay, dark grey, micaceous, plastic.	5.44	7.37	1.69
No Sample 11.75 - 17.5m.					
17.0 - 17.5		SAND, fine grained, well sorted, some mica but little clay. Pale grey. Tr. H.M.			
17.5 - 19.5		SAND, as above, coarser and clayey.			
19.5 - 21.5		AS ABOVE, clay, dark brown at 21.3m. E.O.H. 21.5m.			
		Down hole average			0.96

542048

43

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 340W 1600N

040 LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.40	SAND, medium to coarse grained, well sorted, pale grey. H.M. Tr.	3.32	0.31	0.44
1.5 - 3.5	7.90	AS ABOVE.	1.68	0.00	0.40
3.5 - 5.5	10.45	AS ABOVE. Dark brown, hard, indurated. H.M. Tr.	4.27	0.11	0.80
5.5 - 7.5	6.15	SAND, as above, peaty and indurated.	8.59	1.06	0.90
7.5 - 9.5	4.90	AS ABOVE	9.08	0.55	0.44
9.5 - 11.5	5.75	SAND, medium grained, well sorted. Clay at end of sample. Dark grey, micaceous. E.O.H. 11.5m.	6.66	5.67	1.22
		Down hole average			<u>0.71</u>

542049

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 360W 1600N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.85	SAND, medium to coarse grained. well sorted. Grey. H.M. 1-2%.	0.65	0.13	0.28
1.5 - 3.5	7.80	AS ABOVE	0.77	0.02	0.55
3.5 - 5.5	6.90	AS ABOVE, brown, indurated.	4.01	0.02	2.12
5.5 - 7.5	6.10	SAND, as above. Peat at 7.4m.	6.03	1.72	0.99
7.5 - 9.5	7.15	SAND, as above with peat layers and indurated. Dark brown.	7.23	0.21	0.56
9.5 - 11.5	10.15	SAND, medium grained with some coarse grains. Pyrite rich with large nodules. Some coarse H.M. Clay, grey, mica rich at 11.4m. E.O.H. 11.5m.	4.48	4.21	1.71
Down hole average					<u>1.07</u>

542050

45

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

050 AREA: NARACOOPA

HOLE NO: 380W 1600N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.70	SAND, medium to coarse grained, white, well sorted. Some H.M.	1.99	0.11	0.70
1.5 - 3.5	6.65	AS ABOVE, H.M. 1-2%.	0.96	0.01	0.64
3.5 - 5.5	7.90	AS ABOVE to 4.75m. then dark brown, lightly indurated. H.M. 1-2%.	3.34	0.01	0.79
5.5 - 7.5	8.00	SAND, coarse grained, well sorted, dark brown. H.M. Tr.	4.45	0.02	1.22
7.5 - 9.5	8.25	AS ABOVE, with some peat. H.M. 2-5%. So coarse pyritic nodules.	6.33	1.11	1.97
9.5 - 11.5	5.85	SAND, medium to coarse grained, well sorted. Peaty in places. H.M. Tr.	9.03	1.97	0.82
11.5 - 13.5	7.75	SAND, medium grained, well sorted, rich pyrite. Some peat. H.M. ≈1%.	7.61	3.41	1.44
13.5 - 14.5	2.65	SAND, mediu to fine grained, clayey and silty, mich rich. Grey, H.M. 1-2%.	8.84	10.27	1.78
		E.O.H. 14.5m. in grey clay			
		Down hole average			<u>1.14</u>

542051 46

051 CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 400W 1600N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 27.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.65	SAND, medium grained, well sorted, white. H.M. 1-2%.	1.74	0.10	0.62
1.5 - 3.5	8.80	AS ABOVE, H.M. 1-2% with richer bands.	0.87	0.03	0.59
3.5 - 5.5	5.35	SAND, medium grained, dark greyish brown, lightly indurated. H.M. 1-2%.	3.48	0.04	0.97
5.5 - 7.5	7.90	AS ABOVE	3.61	0.08	1.19
7.5 - 9.5	7.95	AS ABOVE	5.45	1.38	1.29
9.5 - 11.5	6.55	SAND & PEAT to 10.0m. then sand as above. Indurated with H.M. 2-5%.	13.77	2.56	0.61
11.5 - 13.5	8.40	SAND, coarse to very coarse. Some pebbles. Dark brown. Clayey at bottom with clay lumps and pebbles. E.O.H. 13.5m.	4.72	5.84	1.83
Down hole average					<u>1.03</u>

542052 47

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 420W 1600N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 27.1.89

METHOD: Rip

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	5.15	SAND, medium grained, well sorted, white. H.M. 1-2%.	1.72	0.06	0.67
1.5 - 3.5	7.80	AS ABOVE, brown at 3.4m.	2.20	0.04	0.53
3.5 - 5.5	7.15	SAND, medium grained, well sorted. Brown, lightly indurated.	6.70	0.35	1.12
5.5 - 7.5	8.20	AS ABOVE.	2.36	0.01	1.06
7.5 - 9.5	7.60	AS ABOVE. Peaty clay at 9.4m.	4.47	1.70	1.36
9.5 - 11.5	7.90	SAND, as above with peat and H.M.	9.43	1.18	0.86
11.5 - 13.5	4.75	SAND, medium grained, well sorted, pale grey. Pyritic v.v. fine pyrite matrix with some coarser aggregates. Water has pyrite colour, greenish grey. H.M. 1-2%.	4.75	5.24	2.11
13.5 - 15.5	8.15	AS ABOVE, becomes more clayey and mica rich with depth. Wood fragments 14.5-15.0m. Brown micaceous clay 14.8 - 15.0m. E.O.H. 15.5m.	11.00	1.97	2.08
		Down hole average			<u>1.24</u>

542053

CLIENT: NATIONAL MINERAL SANDS

TITLE NO:

E.L. 28/85

055

AREA: NARACOOPA

HOLE NO: 440W 1600N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 27.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.55	SAND, medium grained, white. H.M. Tr.	1.25	0.11	0.63
1.5 - 3.5	6.65	AS ABOVE, becomes brown and lightly indurated at 3.0m.	4.19	0.15	0.72
3.5 - 5.5	3.40	SAND, medium grained, brown, indurated to 4.5m. then peat with fine sand and mud.	40.82	5.19	0.46
5.5 - 7.5	9.10	SAND, medium grained, well sorted, grey. Minor peat at top. H.M. 2-5%. Some richer layers.	2.82	0.28	1.77
7.5 - 9.5	9.25	AS ABOVE, peat at 9.3m. to 9.5m.	3.81	0.39	2.20
9.5 - 11.5	7.10	PEATY CLAY 9.5 - 10.5 then sand, coarse grained, poorly sorted. H.M. Tr.	8.99	1.26	0.69
11.5 - 13.5	9.10	SAND, coarse grained, poorly sorted. Grey pyritic matrix. Some H.M. Clay at 13.5m. E.O.H. 13.5m.	3.65	3.81	2.22
		Down hole average			<u>1.26</u>

542054 49

CLIENT: NATIONAL MINERAL SANDS

TITLE NO:

E.L. 28/85

AREA: NARACOOPA

HOLE NO: 460W 1600N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 27.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	5.00	SAND, medium grained, white. H.M. Tr.	1.08	0.10	0.79
1.5 - 3.5	5.95	AS ABOVE to 2.5m. then dark brown, indurated.	2.91	0.04	0.64
3.5 - 5.5	4.10	AS ABOVE, indurated.	9.23	1.60	0.56
5.5 - 7.5	6.15	CLAY, brown, peaty, Indurated sand at 7.4m.	26.98	5.79	1.42
7.5 - 9.5	10.90	SAND, medium grained, indurated, brown to 8.5m. then clean coarse sand. Pyrite nodules, H.M. 1-2%.	1.06	0.11	1.91
9.5 - 11.5	7.40	SAND, medium to coarse grained, brown earth. H.M. 1 - 2%.	7.84	1.08	0.46
11.5 - 13.5	9.35	SAND, coarse grained, poorly sorted with H.M. visible. V. fine pyritic matrix and some fragments clay at 13.5m. E.O.H. 13.5m.	2.85	6.95	1.57
Down hole average					<u>1.06</u>

542055

50

CLIENT: NATIONAL MINERAL SANDS

TITLE NO:

E.L. 28/85

AREA: NARACOOPA

HOLE NO: 480W 1600N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 27.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	5.00	SAND, medium grained, well sorted, white. H.M. 1%.	1.39	0.09	0.57
1.5 - 3.5	7.70	SAND, as above, pale grey to brownish grey.	7.58	0.14	0.91
3.5 - 5.5	7.95	AS ABOVE, brown, lightly indurated.	3.63	0.02	0.87
5.5 - 7.5	1.95	SAND, peaty and clayey.	53.49	23.62	0.60
7.5 - 9.5	8.05	AS ABOVE to 8.0m. then sand, coarse grained.	3.62	1.38	4.46
9.5 - 11.5	6.65	SAND, coarse grained, dark brown. H.M. Tr.	4.94	0.60	2.17
11.5 - 13.5	5.50	SAND, coarser with depth, some gravel, pyritic.	3.41	3.72	1.21
13.5 - 13.9		CLAY, dark grey, micaceous E.O.H. 13.9m.			
		Down hole average			<u>1.58</u>
0 - 13.5		Depth and grade at 1.5% cut-off			<u>1.58</u>

542056

51

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 500W 1600N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

050

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.45	SAND, medium grained, well sorted, grey.	1.38	0.11	0.61
1.5 - 3.5	6.60	SAND, medium to coarse grained, dark grey, highly indurated.	6.38	0.20	0.40
3.5 - 5.5	6.95	AS ABOVE, brown.	4.36	0.02	0.58
5.5 - 7.5	2.65	AS ABOVE, to 6.2m. then peat/clay, dark brown.	19.29	8.21	0.36
7.5 - 9.5	3.80	AS ABOVE to 8.8m. then sand, medium grained, black, heavily indurated with H.M.	11.33	3.73	5.98
9.5 - 11.5	9.00	SAND, medium to fine grained, well sorted, pale brown. No visible H.M.	3.77	0.39	1.54
11.5 - 13.5	5.50	SAND, coarse to very coarse grained, Poorly sorted. Some fine pyrite.	6.40	3.99	0.73
13.5 - 14.0	3.70	SAND, as above, pyritic and micaceous. 14.0m. Clay, dark grey, mica rich.	9.76	5.65	2.02
		E.O.H. 14.0m.			
		Down hole average			<u>1.51</u>
0 - 11.5		Depth and grade at 1.5% cut-off			<u>1.62</u>

542057 52

CLIENT: NATIONAL MINERAL SANDS

TITLE NO:

E.L. 28/85

057 AREA: NARACOOKA

HOLE NO: 520W 1600N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.95	SAND, medium to coarse grained, well sorted, white.	1.48	0.07	0.46
1.5 - 3.5	6.50	SAND, as above, grey.	5.62	0.23	0.55
3.5 - 5.5	9.25	SAND, medium grained, dark grey and brown. Lightly indurated.	6.09	0.01	0.87
5.5 - 7.5	3.05	AS ABOVE to 7.0m. then peat to 7.5m.	16.92	7.45	0.52
7.5 - 9.5 DO NOT TEST	5.40	PEAT.	23.19	7.22	1.04
9.5 - 11.5	5.80	SAND, medium grained, well sorted, H.M. Tr.	4.94	0.06	0.41
11.5 - 13.5	6.90	SAND, as above. Pyritic matrix and pyrite nodules. E.O.H. 13.5m.	5.21	3.52	0.74
		Down hole average			0.66

542058

058

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 300W 1780N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89 METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5	5.20	SAND, medium - coarse. Well sorted. White.	1.10	0.15	0.51
1.5 - 3.5	8.30	AS ABOVE	1.34	0.01	0.49
3.5 - 5.5	7.77	AS ABOVE	0.64	0.00	0.32
5.5 - 7.5	8.20	AS ABOVE. Brownish grey.	2.13	0.05	0.30
7.5 - 9.5	9.85	AS ABOVE. Some hard induration. H.M. Tr.	2.10	0.13	0.18
9.5 - 11.5	6.65	AS ABOVE, becomes pyritic. Pale clay. 11.5m. E.O.H. 11.5m. PIEZOMETER	5.94	3.79	1.23
		Down hole average			<u>0.50</u>

542059

54

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

059 AREA: NARACOOPA - Holes moved south 20m. to avoid swamp

HOLE NO: 320W 1780N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.95	SAND, medium grained, well sorted. Pale grey.	2.21	0.11	0.56
1.5 - 3.5	8.30	AS ABOVE	1.81	0.02	0.60
3.5 - 5.5	7.95	AS ABOVE, brownish grey.	2.02	0.03	0.48
5.5 - 7.5	8.60	SAND, medium to coarse, moderately sorted, brown.	3.08	0.05	0.53
7.5 - 9.5	8.80	AS ABOVE. Tr H.M.	4.01	0.54	0.30
9.5 - 11.5	6.15	SAND, fine with coarser grains. Poor sorting. Heavy pyrite, pale coloured clay 11.5m. E.O.H. 11.5m.	6.05	5.99	1.39
Down hole average					<u>0.65</u>

542060

060

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

AREA: NARACCOOPA

HOLE NO: 80E 1800N
(Middle of Beach)

LOGGED BY: ANDREW DOVE

DATE DRILLED: 6.11.88

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.0	2.90	SAND, fine to medium grained, light grey to white. H.M. present. Hit water becoming orange brown. Started sludging.	0.49	0.35	5.94
1.0 - 2.0	2.12	SAND fine to medium grained, light grey. Hit wood. H.M. present	1.80	0.97	2.29
2.0 - 2.8	3.69	AS ABOVE becomes coarser with depth. Hit gravel. EOH 2.8m. gravel.	1.14	4.54	0.47
		Down hole average			<u>3.07</u>
0 - 2.0		Depth and grade at 1.5% cut-off			<u>4.12</u>

542061

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061

CLIENT: NATIONAL MINERAL SANDS
 AREA: NARACOOPA
 LOGGED BY: ANDREW DOVE

TITLE NO: EL 28/85
 HOLE NO: 60E 1800 N
 DATE DRILLED: 6.11.88

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.0	2.07	SAND fine to medium grained, grey organic grades to orange brown	1.20	0.14	4.18
1.0 - 2.0	2.36	SAND fine to medium grained, light grey, H.M. present	0.25	0.02	3.45
2.0 - 3.0	2.47	AS ABOVE becomes coarser with depth, grades to light brown, indurated. H.M.present.	0.31	0.01	2.81
3.0 - 4.0	1.59	SAND medium to coarse grained, light grey, hit water. Started sludging	0.38	0.26	3.36
4.0 - 5.0	3.48	SAND coarse grained, light grey, some gravel	1.02	0.87	0.66
5.0 - 5.6	2.75	AS ABOVE hit rock. EOH 5.6m. rock.	1.39	1.72	1.37
		<u>Down hole average</u>			<u>2.73</u>
0 - 4.0		Depth and grade at 1.5% cut-off			<u>3.45</u>

542062
57

062

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

AREA: NARACOOPA

HOLE NO: 40E 1800N

LOGGED BY: ANDREW DOVE

DATE DRILLED: 6.11.88

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.0	1.62	SAND fine to medium grained, grey organic grading to light grey, becoming coarser with depth. Hit water, started sludging	1.79	0.19	2.23
1.0 - 2.0	2.33	SAND medium to coarse grained, light grey, some gravel	0.79	0.59	0.63
2.0 - 2.9	2.98	SAND medium grained, hit gravel, then clay, then rock	1.15	0.48	1.24
		EOH 2.9m. clay.			
		Down hole average			<u>1.37</u>
0 - 1.0		Depth and grade at 1.5% cut-off			<u>2.23</u>

512063

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

385 AREA: NARACOOPA

HOLE NO: 20E 1800N

LOGGED BY: ANDREW DOVE

DATE DRILLED: 6.11.88

Interval (m)	Wet Wt. (kg)	Description	% Slime	% +600 um	% H.M.
0 - 1.0	0.94	SAND, fine - medium grained, grey. Organic then light grey, clay rich.	18.26	0.64	2.09
		Started sludging			
1.0 - 1.25	0.31	AS ABOVE, hit clay.	1.86	0.17	8.03
		E.O.H. 1.25m.			
		Down hole average			<u>3.30</u>
0 - 1.25		Depth and grade at 1.5% cut-off			<u>3.30</u>

542064

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

064 AREA: NARACOOPA

HOLE NO: 340W 1800N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	0.90	SAND, medium - coarse. Well sorted, amber (small sample).	2.79	1.73	0.30
1.5 - 3.5	8.40	AS ABOVE, grey.	2.57	0.07	0.45
3.5 - 5.5	9.60	AS ABOVE, dark brown, lightly indurated	5.19	0.04	0.46
5.5 - 7.5	9.10	AS ABOVE, heavy induration in part. H.M. visible. Coarse 1%.	2.60	0.04	2.75
7.5 - 9.5	6.85	AS ABOVE. H.M. 1%.	6.95	0.21	0.34
9.5 - 11.5	6.65	SAND, medium with some very coarse grains. Pyritic, some mica. 11.5m. brown micaceous clay. E.O.H. 11.5m.	7.43	6.30	2.18
		Down hole average			<u>1.11</u>

542065

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

000 AREA: NARACOOPA

HOLE NO: 360W 1800N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	3.20	SAND, medium grained, well sorted. White.	1.99	0.08	0.58
1.5 - 3.5	7.55	AS ABOVE, grey.	3.10	0.01	0.60
3.5 - 5.5	7.65	AS ABOVE, grey.	7.18	0.41	0.95
5.5 - 7.5	7.60	AS ABOVE, brownish grey.	5.80	0.16	1.14
7.5 - 9.5	7.05	AS ABOVE, with minor clay layers.	5.94	0.56	0.73
9.5 - 11.5	7.75	SAND, medium to very coarse grained, poorly sorted, pyritic, 11.0 - 11.5m fine sand with mica and clay layers. E.O.H. 11.5m.	4.66	2.94	1.44
		Down hole average			0.92

542066

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 380W 1800N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

068

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.90	SAND, medium - coarse grained. Well sorted, pale grey.	1.32	0.12	0.56
1.5 - 3.5	8.05	AS ABOVE	3.42	0.03	0.47
3.5 - 5.5	6.95	AS ABOVE, dark brown, hard indurated layers.	6.49	0.04	1.06
5.5 - 7.5	5.90	SAND, medium grained, well sorted. Indurated with some hard layers.	7.46	1.02	1.26
7.5 - 9.5	6.55	AS ABOVE.	4.00	0.40	0.23
9.5 - 11.5	5.05	SAND, grades down to very coarse. Some fine gravel. Pyritic.	5.14	3.19	0.49
11.5 - 12.5	2.15	AS ABOVE, heavily pyritic. Clay, dark grey, mica rich. E.O.H. 12.5m.	6.31	8.74	3.45
Down hole average					<u>0.90</u>

542067

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

007 AREA: NARACOOPA

HOLE NO: 400W 1800N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.95	SAND, medium - coarse, well sorted, white. H.M. Tr.	1.80	0.14	0.55
1.5 - 3.5	7.20	AS ABOVE, but brown.	3.63	0.02	0.64
3.5 - 5.5	9.00	AS ABOVE, dark brown.	5.79	0.02	1.56
5.5 - 7.5	8.45	SAND, medium grained, well sorted, peaty and indurated in layers. brown.	4.74	0.36	1.04
7.5 - 9.5	7.30	AS ABOVE	4.53	0.26	0.53
9.5 - 11.5	7.20	SAND, medium to very coarse grained. some granules moderate sorting coarser with depth. Pyrite 11.0 - 11.5m.	4.12	2.03	0.46
11.5 - 12.0	1.80	AS ABOVE 12.0 Clay, brown, micaceous E.O.H. 12.0m.	2.95	7.84	3.80
Down hole average					<u>0.93</u>

542068

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 420W 1800N

068

LOGGED BY: GRAHAM LEE

DATE DRILLED: 29.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	5.60	SAND, medium grained, well sorted, pale grey.	2.28	0.13	0.71
1.5 - 3.5	8.75	SAND, as above, heavily indurated with peat on top.	7.80	0.22	0.33
3.5 - 5.5	8.85	SAND, medium - coarse grained, well sorted, brownish grey.	4.34	0.22	0.40
5.5 - 7.5	9.70	SAND, as above.	8.11	0.68	0.72
7.5 - 9.5	8.35	SAND, as above. H.M. Tr.	6.22	0.11	
9.5 - 11.5	4.25	PEAT then sand, as above	5.90	0.15	0.27
11.5 - 13.0	5.25	SAND, coarse to very coarse grained, poorly sorted. Heavily pyritic 13.0m. clay, brown plastic, mica rich. No sample 13.0 - 13.5.	5.41	13.48	2.51
		E.O.H. 13.5m.			
		Down hole average			0.70

542069

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 440W 1800N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 29.1.89

METHOD: R12

083

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	5.55	SAND, medium - coarse grained, well sorted, pale grey.	1.52	0.10	0.39
1.5 - 3.5	7.30	AS ABOVE, pale brown.	7.35	0.03	0.54
3.5 - 5.5	3.85	PEAT with some sand as above.	11.34	0.73	0.80
5.5 - 7.5	4.45	SAND, medium - coarse grained, well sorted, brown.	5.99	1.78	0.38
7.5 - 9.5	8.10	AS ABOVE	6.91	0.04	0.30
9.5 - 11.5	7.60	AS ABOVE with some indurated and clay bands. Dark brown.	6.17	0.27	0.46
11.5 - 13.5	6.45	SAND, coarse grained, poorly sorted. Pyritic. Clay, sandy micaceous, grey at 13.4m. E.O.H. 13.5m.	6.85	10.62	1.44
		Down hole average			<u>0.62</u>

542070

070

CLIENT: NATIONAL MINERAL SANDS

TITLE NO:

E.L. 28/85

AREA: NARACOOPA

HOLE NO: 460W 1800N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 29.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	5.15	SAND, medium to coarse grained, well sorted, grey.	1.92	0.11	0.60
1.5 - 3.5	7.90	AS ABOVE, darker grey from 3.3m.	3.34	0.08	0.53
3.5 - 5.5	6.25	AS ABOVE, dark brownish grey.	8.50	0.06	0.52
5.5 - 7.5 (Do not test)		PEAT and clay, very little sand, dark brown.			
7.5 - 9.5	5.15	AS ABOVE with fine sand from 9.0 - 9.5m.	9.45	3.59	0.81
9.5 - 11.5	7.85	SAND, medium grained, well sorted, indurated, dark brown.	3.18	0.07	0.17
11.5 - 13.5	3.80	AS ABOVE, with pyrite near end of sample.	4.92	0.24	0.26
13.5 - 14.5	2.70	SAND, coarse to very coarse, moderate to poor sorting. Pyritic. Clay at 14.5m. E.O.H. 14.5m.	6.68	16.30	0.95
		Down hole average			<u>0.44</u>

542071

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

071 AREA: NARACOOKA

HOLE NO: 480W 1800N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 29.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	5.10	SAND, medium to coarse grained, well sorted. Pale grey.	5.30	0.24	0.79
1.5 - 3.5	7.85	AS ABOVE, darker brownish grey 3.2m.	5.18	0.19	0.43
3.5 - 5.5	7.15	AS ABOVE, some light induration. Dark brown.	7.28	0.04	0.55
5.5 - 7.5	5.80	SAND, as above with peaty clay layers. Dark brown.	9.14	0.96	0.70
7.5 - 9.5 (Do not test)		PEAT			
9.5 - 11.5	5.20	Peat thensand, medium grained, well sorted, indurated.	4.75	0.24	0.63
11.5 - 13.5	3.25	SAND, coarse grained, moderately sorted. Dark brown. Small sample peat, blockage of bit.	4.84	0.11	0.30
13.5 - 15.5	5.30	SAND, as above, pyritic. Increased clay with depth. Clay with pyrite nodules 15.3m. E.O.H. 15.5m.	7.90	8.60	0.69
Down hole average					<u>0.50</u>

542072

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

072 AREA: NARACOOPA

HOLE NO: 500W 1800N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 29.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	3.80	SAND, medium - coarse grained, well sorted, grey.	2.91	0.21	0.43
1.5 - 3.5	9.40	AS ABOVE	6.93	0.35	0.52
3.5 - 5.5	6.70	AS ABOVE, brown, lightly indurated.	7.08	0.08	0.41
5.5 - 7.5	5.35	SAND, medium grained, well sorted, peaty and indurated. Dark brown.	12.51	1.84	0.69
7.5 - 9.5 (Do not test)		PEAT and clay with minor sand			
9.5 - 11.5	7.15	SAND, medium grained, well sorted. Peaty at top then some indurated.	4.32	0.12	0.54
11.5 - 13.5	3.65	SAND, grading coarser with depth. Some induration. Clayey matrix.	4.30	0.20	0.38
13.5 - 14.75	5.30	SAND, as above, pyritic. Clay, dark brown, mica rich 14.75m. E.O.H. 14.75m.	11.35	8.72	0.79
		Down hole average			0.46

542073

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

HOLE NO: 520W 1800N

LOGGED BY: GRAHAM LEE

DATE DRILLED: 29.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	4.20	SAND, medium - coarse grained, well sorted, grey.	4.03	0.33	0.71
1.5 - 3.5	8.80	AS ABOVE, brown.	7.55	0.14	0.75
3.5 - 5.5	6.55	AS ABOVE, brown.	5.78	0.02	0.66
5.5 - 7.5 (Do not test)		PEAT. Some sand as above at top of interval.			
9.5 - 11.5	7.75	SAND, medium to fine grained, well sorted, brown.	7.51	0.04	0.24
11.5 - 13.5	4.15	AS ABOVE, peaty and indurated in part.	8.04	0.94	0.47
13.5 - 14.5	4.25	SAND, medium grained, poorly sorted, pyritic. Clay at 14.2m. E.O.H. 14.5m.	15.30	8.94	0.65
		Down hole average			<u>0.41</u>

542074

073

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

074

AREA: NARACOOPA

HOLE NO: 80E 2000N

LOGGED BY: ANDREW DOVE

DATE DRILLED: 6.11.88

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.0	2.30	SAND fine to medium grained, white to light grey graded to orange, indurated at base, started sludging	0.76	0.19	5.70
1.0 - 2.0	2.61	SAND fine to medium grained, dark brown, indurated, hit rock.	2.01	1.37	1.74
2.0 - 3.0	3.31	SAND fine to medium grained, grey to brown becomes coarser with depth, hit gravel at base.	0.73	7.05	0.59
3.0 - 3.4	1.18	AS ABOVE hit rock. EOH 3.4m. rock.	0.72	2.67	0.82
		Down hole average			<u>2.46</u>
0 - 2.0		Depth and grade at 1.5% cut-off			<u>3.72</u>

542075
70

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

AREA: NARACOOPA

HOLE NO: 60E 2000N

075

LOGGED BY: ANDREW DOVE

DATE DRILLED: 6.11.88

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.0	2.08	SAND fine to medium grained, grey organic grades to orange then brown	1.97	0.38	3.16
1.0 - 2.0	2.36	SAND medium grained, amber	0.20	0.04	1.66
2.0 - 3.0	2.42	AS ABOVE grades to orange brown. Hit water, started sludging	0.25	0.07	1.60
3.0 - 4.0	2.51	SAND medium to coarse grained, light grey, some gravel.	0.74	0.46	1.72
4.0 - 5.0	4.04	AS ABOVE indurated.	1.47	1.79	1.04
5.0 - 5.6	1.69	SAND medium to coarse grained, dark brown, indurated. Hit rock.	2.17	3.36	1.01
		EOH 5.6m. rock.			
		Down hole average			<u>1.75</u>
0 - 4.0		Depth and grade at 1.5% cut-off			<u>2.04</u>

543076 71

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

AREA: NARACOOPA

HOLE NO: 40E 2000N

LOGGED BY: ANDREW DOVE

DATE DRILLED: 6.11.88

078

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.0	1.82	SAND fine to medium grained, grey organic grades into orange brown. H.M. present. Becomes coarser with depth.	0.74	0.07	1.54
1.0 - 2.0	2.05	SAND medium to coarse grained, orange brown grades to brown, indurated.	0.86	0.27	1.03
2.0 - 3.0	1.98	SAND medium to coarse grained, brown grading to light grey. Hit water 2.5m. becomes coarser with depth. Started sludging.	0.42	0.26	0.58
3.0 - 4.0	3.66	SAND medium to coarse grained, light grey, slightly indurated. Some gravel and clay.	1.30	0.90	0.90
4.0 - 4.4	2:31	AS ABOVE hit clay. EOH 4.4m. clay	1.50	0.85	2.38
		Down hole average			<u>1.14</u>
0 - 1.0		Depth and grade at 1.5% cut-off			<u>1.54</u>

542077 72

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

07: AREA: NARACOOPA

HOLE NO: 20E 2000N

LOGGED BY: ANDREW DOVE

DATE DRILLED: 6.11.88

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.0	0.13	PEAT. Started sludging	59.41	0.24	1.15
1.0 - 2.0	1.69	SAND fine grained, grey very peaty.	1.69	0.10	7.44
2.0 - 3.0	2.92	AS ABOVE. H.M. present	1.18	0.19	22.05
3.0 - 3.1	1.63	AS ABOVE. Hit clay.	2.05	0.27	28.59
		EOH 3.1m. clay.			
		Down hole average			<u>10.81</u>
0 - 3.1		Depth and grade at 1.5% cut-off			<u>10.81</u>

542078 73

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: EL 28/85

078 AREA: NARACOOPA West of Sea Elephant Road near tip

HOLE NO: SI

LOGGED BY: GRAHAM LEE

DATE DRILLED: 2.2.89

Interval (m)	Dry Wt. (kg)	Description	% Slime	% + 1000 um	% H.M.
0 - 1.5	5.50	SAND, medium, well sorted, grey at top then brown. Water Table 1.0m. Hard indurated layer at 1.3m.	3.63	0.11	1.20
1.5 - 3.5	7.65	AS ABOVE, brown with some hard indurated layers	4.19	0.13	0.56
3.5 - 5.5	9.00	AS ABOVE to 4.5m. then hard indurated layers.	5.40	0.09	0.40
5.5 - 7.5	8.60	SAND, medium, well sorted, pale brown.	5.28	0.05	0.67
7.5 - 9.5	8.10	AS ABOVE	2.81	0.12	0.44
9.5 - 11.0	1.85	SAND, medium, grading down to coarse with fine gravel at bottom. Clay, brown, stiff at 11.0m. E.O.H. 11.5m.	13.67	14.69	1.12
		Down hole average			<u>0.75</u>

542079 74

073

APPENDIX 2

R.H.F. Laboratory Results Certificates



OSU
RHF

Laboratory Services

542081

76

33 Nelson St,
P.O. Box 5,
Smithton 7330
Ph. 52 1982

A Division of Circular Head Dolomite & Trading Co. Pty. Ltd.
(Incorporated in Tasmania)

15th December, 1988

Peter Stitt & Associates Pty. Ltd.,
5th Floor King York House,
32 York Street,
SYDNEY. N.S.W. 2000

ATTENTION: MR. G. LEE

Dear Sir,

Please find enclosed raw data documentation for the completion of the reconnaissance work on King Island.

Yours faithfully,

For RHF LABORATORY

G.P. Dowson,
MANAGER.

081

	Depth	Total wt. (Kg)	% Slime	%+1000u	%-1000u	% H.M.	
1600N							
20E	0-1.0	1.46	3.43	0.21	99.79	0.66	
	1.0-2.0	1.74	0.27	0.03	99.97	0.75	
	2.0-3.0	2.97	2.83	0.14	99.86	0.42	
	3.0-4.2	4.52	2.51	1.62	98.38	0.22	
40E	0-1.0	1.95	2.05	0.16	99.84	3.79	
	1.0-2.0	2.24	0.85	0.03	99.97	3.54	
	2.0-3.0	2.23	0.91	0.16	99.84	10.05	
	3.0-3.7	2.66	1.37	0.33	99.67	26.66	
60E	0-1.0	1.96	1.86	0.13	99.87	2.67	
	1.0-2.0	2.56	0.26	0.07	99.93	2.20	
	2.0-3.0	2.11	0.24	0.52	99.48	0.72	
	3.0-4.0	3.82	1.11	0.76	99.24	2.01	
4.0-4.2	4.0-4.2	1.36	1.32	1.37	98.63	4.24	
	80E	0-1.0	1.68	0.12	0.07	99.93	7.59
		1.0-2.0	2.23	0.34	0.09	99.91	4.46
		2.0-3.0	3.18	2.00	0.99	99.01	2.49
3.0-3.8		2.45	1.06	1.59	98.41	3.62	
2000N							
20E	0-1.0	0.13	59.41	0.24	99.76	1.15	
	1.0-2.0	1.69	1.69	0.10	99.90	7.44	
	2.0-3.0	2.92	1.18	0.19	99.81	22.05	
	3.0-3.1	1.63	2.05	0.27	99.73	28.59	
1800N							
40E	0-1.0	1.62	1.79	0.19	99.81	2.23	
	1.0-2.0	2.33	0.79	0.59	99.41	0.63	
	2.0-2.9	2.98	1.15	0.48	99.52	1.24	
60E	0-1.0	2.07	1.20	0.14	99.86	4.18	
	1.0-2.0	2.36	0.25	0.02	99.98	3.45	
	2.0-3.0	2.47	0.31	0.01	99.99	2.81	
	3.0-4.0	1.59	0.38	0.26	99.74	3.36	
	4.0-5.0	3.48	1.02	0.87	99.13	0.66	
	5.0-5.6	2.75	1.39	1.72	98.28	1.37	
80E	0-1.0	2.90	0.49	0.35	99.65	5.94	
	1.0-2.0	2.12	1.80	0.97	99.03	2.29	
	2.0-2.8	3.69	1.14	4.54	95.46	0.47	
20E	0-1.0	0.94	18.26	0.64	99.36	2.09	
	1.0-1.25	0.31	1.86	0.17	99.83	8.03	
2000N							
40E	0-1.0	1.82	0.74	0.07	99.93	1.54	
	1.0-2.0	2.05	0.86	0.27	99.73	1.03	
	2.0-3.0	1.98	0.42	0.26	99.74	0.58	
	3.0-4.0	3.66	1.30	0.90	99.10	0.90	
	4.0-4.4	2.31	1.50	0.85	99.15	2.38	
60E	0-1.0	2.08	1.97	0.38	99.62	3.16	
	1.0-2.0	2.36	0.20	0.04	99.96	1.66	
	2.0-3.0	2.42	0.25	0.07	99.93	1.60	
	3.0-4.0	2.51	0.74	0.46	99.54	1.72	
	4.0-5.0	4.04	1.47	1.79	98.21	1.04	
	5.0-5.6	1.69	2.17	3.36	96.64	1.01	

542082

084

2000N

542083

	Depth	Total wt. (Kg)	% Slime	%+1000u	%-1000u	% H.M.
80E	0-1.0	2.30	0.76	0.19	99.81	5.70
	1.0-2.0	2.61	2.01	1.37	98.63	1.74
	2.0-3.0	3.31	0.73	7.05	92.95	0.59
	3.0-3.4	1.18	0.72	2.67	97.33	0.82
700N						
340W	0-1.0	3.06	9.00	0.62	99.38	12.26
	1-2.0	1.94	9.21	0.70	99.30	10.28
	2.0-3.0	1.75	16.00	0.71	99.29	12.52
	3.0-4.0	4.31	1.16	0.13	99.87	9.14
360W	0-1.0	2.31	8.87	0.49	99.51	12.67
	1.0-2.0	2.21	7.43	1.61	98.39	5.97
	2.0-2.3	0.94	10.40	0.63	99.37	10.33
600N						
60E	0-1.5	5.68	2.09	0.31	99.69	26.33
	1.5-3.5	6.61	1.31	0.07	99.93	8.06
	3.5-5.5	9.04	1.48	0.02	99.98	1.81
80E	0-1.5	5.82	0.67	0.03	99.97	10.63
	1.5-3.5	5.92	1.65	0.00	100.00	2.02
	3.5-5.5	8.23	1.18	0.05	99.95	1.18
	5.5-7.5	8.56	2.93	0.19	99.81	1.03
	7.5-9.5	5.93	6.52	4.11	95.89	1.26
100E	0-1.5	1.53	0.91	0.25	99.75	13.86
	1.5-3.5	1.18	0.69	0.01	99.99	8.81
	3.5-5.5	1.99	1.96	0.03	99.97	2.39
	5.5-7.5	2.68	3.75	0.80	99.20	1.39
	7.5-8.5	0.70	5.14	0.36	99.64	8.43

**RHF****Laboratory Services**

33 Nelson St,
P.O. Box 5,
Smithton 7330
Ph. 52 1982

A Division of Circular Head Dolomite & Trading Co. Pty. Ltd.
(Incorporated in Tasmania)

12th May, 1989

Peter Stitt & Associates Pty. Ltd.,
5th Floor King York House,
32 York Street,
SYDNEY. N.S.W. 2000

ATTENTION Mr. G. Lee

Dear Sir,

Please find enclosed complete raw data documentation for the Cowper Point and Naracoopa Surveys.

Yours faithfully,
For RHF LABORATORY SERVICES

Per 

G.P. Dowson,
Manager.

GPD;CJH
Encl.

R.H.F. LABORATORY HEAVY MINERAL SEPARATION

HOLE NUMBER	DEPTH	TOTAL WEIGHT	% + 2mm	% +1000u	% -1000u	% SLIME	% HEAVY MINERAL
Na 200W 1600N	0-1.5	5.90	0.0402	0.02	99.98	1.60	1.68
Na 200W 1600N	1.5-3.5	8.35	0.0000	0.00	100.00	0.74	0.85
Na 200W 1600N	3.5-5.5	7.40	0.0036	0.02	99.98	4.14	0.66
Na 200W 1600N	5.5-7.5	7.25	0.0000	0.01	99.99	2.55	0.85
Na 200W 1600N	7.5-9.0	6.30	1.9437	2.16	97.84	4.37	0.62
Na 220W 1600N	0-1.5	4.00	1.3875	0.41	99.59	3.05	0.90
Na 220W 1600N	1.5-3.5	7.80	0.0059	0.04	99.96	2.68	0.86
Na 220W 1600N	3.5-5.5	9.25	0.0044	0.04	99.96	3.12	1.26
Na 220W 1600N	5.5-7.5	9.35	0.5044	0.70	99.30	1.32	0.90
Na 220W 1600N	7.5-8.5	4.40	7.9695	4.73	95.27	3.93	0.67
Na 240W 1600N	0-1.5	4.75	0.0324	0.03	99.97	1.02	0.42
Na 240W 1600N	1.5-3.5	6.75	0.1767	1.72	98.28	9.29	1.20
Na 240W 1600N	3.5-5.5	9.40	0.0151	0.01	99.99	1.23	2.67
Na 240W 1600N	5.5-7.5	9.25	0.0558	0.08	99.92	1.85	2.41
Na 240W 1600N	7.5-9.0	6.10	2.6016	1.74	98.26	4.31	1.46
Na 260W 1600N	0-1.5	4.90	0.0645	0.03	99.97	1.05	0.54
Na 260W 1600N	1.5-3.5	6.15	0.0000	0.39	99.61	2.14	0.59
Na 260W 1600N	3.5-5.5	7.50	0.0000	2.25	97.75	9.99	2.74
Na 260W 1600N	5.5-7.5	9.25	0.1437	0.61	99.39	0.89	4.11
Na 260W 1600N	7.5-9.5	9.35	0.4172	0.54	99.46	1.63	3.47
Na 260W 1600N	9.5-10.5	3.85	13.9468	2.44	97.56	2.83	6.36
Na 280W 1600N	0-1.5	5.50	0.0204	0.02	99.98	1.13	0.53
Na 280W 1600N	1.5-3.5	3.80	0.0105	0.28	99.72	6.08	0.76
Na 280W 1600N	3.5-5.5	8.10	0.2414	0.11	99.89	3.84	3.14
Na 280W 1600N	5.5-7.5	8.00	0.0081	0.05	99.95	1.89	4.47
Na 280W 1600N	7.5-9.5	7.10	1.8720	1.13	98.87	6.93	2.46
Na 280W 1600N	9.5-9.75	1.20	3.6675	4.73	95.27	11.87	2.05
Na 300W 1600N	0-1.5	2.75	0.9865	0.10	99.90	2.30	0.32
Na 300W 1600N	1.5-3.5	8.75	0.0029	0.00	100.00	2.50	0.50
Na 300W 1600N	3.5-5.5	9.05	0.0000	0.02	99.98	1.22	0.50
Na 300W 1600N	5.5-7.5	8.05	0.0083	0.10	99.90	3.62	0.68
Na 300W 1600N	7.5-9.5	4.85	0.2130	0.73	99.27	8.58	0.45
Na 300W 1600N	9.5-10.5	4.55	5.9459	3.73	96.27	4.42	3.55
Na 320W 1600N	0-1.5	5.50	0.0129	0.07	99.93	1.93	0.53
Na 320W 1600N	1.5-3.5	9.05	0.0000	0.01	99.99	1.17	0.58
Na 320W 1600N	3.5-5.5	7.90	0.0000	0.02	99.98	3.26	0.54
Na 320W 1600N	5.5-7.5	9.50	0.0000	0.09	99.91	2.83	1.05
Na 320W 1600N	7.5-9.5	5.90	2.4924	0.37	99.63	5.02	1.01
Na 320W 1600N	9.5-11.5	9.65	1.9327	1.40	98.60	4.67	1.85
Na 320W 1600N	11.5-11.75	1.90	5.9184	1.45	98.55	5.44	1.69

085

R.H.F. LABORATORY HEAVY MINERAL SEPARATION

HOLE NUMBER	DEPTH	TOTAL WEIGHT KG	% + 2mm	% +1000u	% -1000u	% SLIME	% HEAVY MINERAL
Na 340W 1600N	0-1.5	4.40	0.1866	0.12	99.88	3.32	0.44
Na 340W 1600N	1.5-3.5	7.90	0.0000	0.00	100.00	1.68	0.40
Na 340W 1600N	3.5-5.5	10.45	0.0061	0.10	99.90	4.27	0.80
Na 340W 1600N	5.5-7.5	6.15	0.4351	0.62	99.38	8.59	0.90
Na 340W 1600N	7.5-9.5	4.90	0.0055	0.54	99.46	9.08	0.44
Na 340W 1600N	9.5-11.5	5.75	3.5899	2.08	97.92	6.66	1.22
Na 360W 1600N	0-1.5	4.85	0.0674	0.06	99.94	0.65	0.28
Na 360W 1600N	1.5-3.5	7.80	0.0000	0.02	99.98	0.77	0.55
Na 360W 1600N	3.5-5.5	6.90	0.0000	0.02	99.98	4.01	2.12
Na 360W 1600N	5.5-7.5	6.10	0.1749	1.55	98.45	6.03	0.99
Na 360W 1600N	7.5-9.5	7.15	0.0688	0.14	99.86	7.23	0.56
Na 360W 1600N	9.5-11.5	10.15	2.6626	1.55	98.45	4.48	1.71
Na 380W 1600N	0-1.5	4.70	0.0379	0.07	99.93	1.99	0.70
Na 380W 1600N	1.5-3.5	6.65	0.0000	0.01	99.99	0.96	0.64
Na 380W 1600N	3.5-5.5	7.90	0.0000	0.01	99.99	3.34	0.79
Na 380W 1600N	5.5-7.5	8.00	0.0000	0.02	99.98	4.45	1.22
Na 380W 1600N	7.5-9.5	8.25	0.1621	0.95	99.05	6.33	1.97
Na 380W 1600N	9.5-11.5	5.85	0.8756	1.09	98.91	9.03	0.82
Na 380W 1600N	11.5-13.5	7.75	2.1330	1.28	98.72	7.61	1.44
Na 380W 1600N	13.5-14.5	2.65	5.6117	4.66	95.34	8.84	1.78
Na 400W 1600N	0-1.5	4.65	0.0342	0.07	99.93	1.74	0.62
Na 400W 1600N	1.5-3.5	8.80	0.0000	0.03	99.97	0.87	0.59
Na 400W 1600N	3.5-5.5	5.35	0.0000	0.04	99.96	3.48	0.97
Na 400W 1600N	5.5-7.5	7.90	0.0725	0.01	99.99	3.61	1.19
Na 400W 1600N	7.5-9.5	7.95	0.3610	1.02	98.98	5.45	1.29
Na 400W 1600N	9.5-11.5	6.55	0.1844	2.38	97.62	13.77	0.61
Na 400W 1600N	11.5-13.5	8.40	4.1937	1.65	98.35	4.72	1.83
Na 420W 1600N	0-1.5	5.15	0.0425	0.02	99.98	1.72	0.67
Na 420W 1600N	1.5-3.5	7.80	0.0000	0.04	99.96	2.20	0.53
Na 420W 1600N	3.5-5.5	7.05	0.0000	0.35	99.65	6.70	1.12
Na 420W 1600N	5.5-7.5	8.20	0.0000	0.01	99.99	2.36	1.06
Na 420W 1600N	7.5-9.5	7.60	0.6229	1.08	98.92	4.47	1.36
Na 420W 1600N	9.5-11.5	7.90	0.2223	0.96	99.04	9.43	0.86
Na 420W 1600N	11.5-13.5	4.75	3.5945	1.65	98.35	4.75	2.11
Na 420W 1600N	13.5-15.5	8.15	0.5836	1.39	98.61	11.00	2.08
Na 440W 1600N	0-1.5	4.55	0.0536	0.06	99.94	1.25	0.63
Na 440W 1600N	1.5-3.5	6.65	0.0062	0.14	99.86	4.19	0.72
Na 440W 1600N	3.5-5.5	3.40	0.0176	5.17	94.83	40.82	0.46
Na 440W 1600N	5.5-7.5	9.10	0.0467	0.23	99.77	2.82	1.77
Na 440W 1600N	7.5-9.5	9.25	0.2511	0.14	99.86	3.81	2.20
Na 440W 1600N	9.5-11.5	7.10	0.0334	1.23	98.77	8.99	0.69
Na 440W 1600N	11.5-13.5	9.10	2.5238	1.29	98.71	3.65	2.22

086

R.H.F. LABORATORY HEAVY MINERAL SEPARATION

HOLE NUMBER	DEPTH	TOTAL WEIGHT KG	% + 2mm	% +1000u	% -1000u	% SLIME	% HEAVY MINERAL
Na 460W 1600N	0-1.5	5.00	0.0536	0.05	99.95	1.08	0.79
Na 460W 1600N	1.5-3.5	5.95	0.0104	0.03	99.97	2.91	0.64
Na 460W 1600N	3.5-5.5	4.10	0.3329	1.27	98.73	9.23	0.56
Na 460W 1600N	5.5-7.5	6.15	0.5366	5.25	94.75	26.98	1.42
Na 460W 1600N	7.5-9.5	10.90	0.0447	0.07	99.93	1.06	1.91
Na 460W 1600N	9.5-11.5	7.40	0.0058	1.07	98.93	7.84	0.46
Na 460W 1600N	11.5-13.5	9.35	1.7108	5.24	94.76	2.85	1.57
Na 480W 1600N	0-1.5	5.00	0.0410	0.05	99.95	1.39	0.57
Na 480W 1600N	1.5-3.5	7.70	0.0000	0.14	99.86	7.58	0.91
Na 480W 1600N	3.5-5.5	7.95	0.0000	0.02	99.98	3.63	0.87
Na 480W 1600N	5.5-7.5	1.95	3.4549	20.17	79.83	53.49	0.60
Na 480W 1600N	7.5-9.5	8.05	0.3620	1.02	98.98	3.62	4.46
Na 480W 1600N	9.5-11.5	6.65	0.3585	0.24	99.76	4.94	2.17
Na 480W 1600N	11.5-13.5	5.50	2.8891	0.83	99.17	3.41	1.21
Na 500W 1600N	0-1.5	4.45	0.0530	0.06	99.94	1.38	0.61
Na 500W 1600N	1.5-3.5	6.60	0.0000	0.20	99.80	6.38	0.40
Na 500W 1600N	3.5-5.5	6.95	0.0000	0.02	99.98	4.36	0.58
Na 500W 1600N	5.5-7.5	2.65	0.2453	7.96	92.04	17.29	0.36
Na 500W 1600N	7.5-9.5	3.80	0.7968	2.93	97.07	11.53	5.98
Na 500W 1600N	9.5-11.5	9.00	0.2448	0.15	99.85	3.77	1.54
Na 500W 1600N	11.5-13.5	5.50	2.3736	1.62	98.38	6.40	0.73
Na 500W 1600N	13.5-14.0	3.70	2.3886	3.26	96.74	9.76	2.02
Na 520W 1600N	0-1.5	4.95	0.0220	0.05	99.95	1.48	0.46
Na 520W 1600N	1.5-3.5	6.50	0.0000	0.23	99.77	5.62	0.55
Na 520W 1600N	3.5-5.5	9.25	0.0000	0.01	99.99	6.09	0.87
Na 520W 1600N	5.5-7.5	3.05	1.2623	6.19	93.81	16.92	0.52
Na 520W 1600N	7.5-9.5	5.40	2.8787	4.35	95.65	23.19	1.04
Na 520W 1600N	9.5-11.5	5.80	0.0043	0.06	99.94	4.94	0.41
Na 520W 1600N	11.5-13.5	6.90	2.0496	1.47	98.53	5.21	0.74
Na 300W 1780N	0-1.5	5.20	0.0840	0.07	99.93	1.10	0.51
Na 300W 1780N	1.5-3.5	8.30	0.0000	0.01	99.99	1.34	0.49
Na 300W 1780N	3.5-5.5	7.77	0.0000	0.00	100.00	0.64	0.32
Na 300W 1780N	5.5-7.5	8.20	0.0116	0.04	99.96	2.13	0.30
Na 300W 1780N	7.5-9.5	9.85	0.0276	0.11	99.89	2.10	0.18
Na 300W 1780N	9.5-11.5	6.65	2.9071	0.88	99.12	5.94	1.23
Na 320W 1780N	0-1.5	4.95	0.0097	0.10	99.90	2.21	0.56
Na 320W 1780N	1.5-3.5	8.30	0.0029	0.02	99.98	1.81	0.60
Na 320W 1780N	3.5-5.5	7.95	0.0000	0.03	99.97	2.02	0.48
Na 320W 1780N	5.5-7.5	8.60	0.0000	0.05	99.95	3.08	0.53
Na 320W 1780N	7.5-9.5	8.80	0.4245	0.12	99.88	4.01	0.30
Na 320W 1780N	9.5-11.5	6.15	4.4363	1.55	98.45	6.05	1.39

087

R.H.F. LABORATORY HEAVY MINERAL SEPARATION

HOLE NUMBER	DEPTH	TOTAL WEIGHT KG	% + 2mm	% +1000u	% -1000u	% SLIME	% HEAVY MINERAL
Na 340W 1800N	0-1.5	0.90	1.5422	0.19	99.81	2.79	0.30
Na 340W 1800N	1.5-3.5	8.40	0.0000	0.07	99.93	2.57	0.45
Na 340W 1800N	3.5-5.5	9.60	0.0068	0.03	99.97	5.19	0.46
Na 340W 1800N	5.5-7.5	9.10	0.0055	0.03	99.97	2.60	2.75
Na 340W 1800N	7.5-9.5	6.85	0.0939	0.12	99.88	6.95	0.34
Na 340W 1800N	9.5-11.5	6.65	3.9158	2.38	97.62	7.43	2.18
Na 360W 1800N	0-1.5	3.20	0.0300	0.05	99.95	1.99	0.58
Na 360W 1800N	1.5-3.5	7.55	0.0000	0.01	99.99	3.10	0.60
Na 360W 1800N	3.5-5.5	7.65	0.3025	0.11	99.89	7.18	0.95
Na 360W 1800N	5.5-7.5	7.60	0.0000	0.16	99.84	5.80	1.14
Na 360W 1800N	7.5-9.5	7.05	0.4813	0.08	99.92	5.94	0.73
Na 360W 1800N	9.5-11.5	7.75	2.0403	0.90	99.10	4.66	1.44
Na 400W 1800N	0-1.5	4.95	0.0424	0.10	99.90	1.80	0.55
Na 400W 1800N	1.5-3.5	7.20	0.0000	0.02	99.98	3.63	0.64
Na 400W 1800N	3.5-5.5	9.00	0.0013	0.02	99.98	5.79	1.56
Na 400W 1800N	5.5-7.5	8.45	0.0000	0.36	99.64	4.74	1.04
Na 400W 1800N	7.5-9.5	7.30	0.2190	0.04	99.96	4.53	0.53
Na 400W 1800N	9.5-11.5	7.20	1.5044	0.53	99.47	4.12	0.46
Na 400W 1800N	11.5-12.0	1.80	4.7644	3.08	96.92	2.95	3.80
Na 420W 1800N	0-1.5	5.60	0.0498	0.08	99.92	2.28	0.71
Na 420W 1800N	1.5-3.5	8.75	0.0000	0.22	99.78	7.80	0.33
Na 420W 1800N	3.5-5.5	8.85	0.1328	0.09	99.91	4.34	0.40
Na 420W 1800N	5.5-7.5	9.70	0.2039	0.48	99.52	8.11	0.72
Na 420W 1800N	7.5-9.5	8.35	0.0098	0.10	99.90	6.22	0.41
Na 420W 1800N	9.5-11.5	4.25	0.0000	0.15	99.85	5.90	0.27
Na 420W 1800N	11.5-13.0	5.25	9.7082	3.77	96.23	5.41	2.51
Na 440W 1800N	0-1.5	5.65	0.0269	0.07	99.93	1.52	0.39
Na 440W 1800N	1.5-3.5	7.30	0.0000	0.03	99.97	7.35	0.54
Na 440W 1800N	3.5-5.5	3.65	0.0000	0.73	99.27	11.34	0.80
Na 440W 1800N	5.5-7.5	4.45	1.3710	0.41	99.59	5.99	0.38
Na 440W 1800N	7.5-9.5	8.10	0.0000	0.04	99.96	6.91	0.30
Na 440W 1800N	9.5-11.5	7.60	0.0000	0.27	99.73	6.17	0.46
Na 440W 1800N	11.5-13.5	6.45	6.8513	3.77	96.23	6.85	1.44
Na 460W 1800N	0-1.5	5.15	0.0344	0.08	99.92	1.92	0.60
Na 460W 1800N	1.5-3.5	7.90	0.0000	0.08	99.92	3.34	0.53
Na 460W 1800N	3.5-5.5	6.25	0.0021	0.06	99.94	8.50	0.52
Na 460W 1800N	7.5-9.5	5.15	0.9746	2.62	97.38	9.45	0.81
Na 460W 1800N	9.5-11.5	7.85	0.0129	0.06	99.94	3.18	0.17
Na 460W 1800N	11.5-13.5	3.80	0.0550	0.19	99.81	4.92	0.26
Na 460W 1800N	13.5-14.5	2.70	11.7737	4.53	95.47	6.68	0.95

086

R.H.F. LABORATORY HEAVY MINERAL SEPARATION

HOLE NUMBER	DEPTH	TOTAL WEIGHT KG	% + 2mm	% +1000u	% -1000u	% SLIME	% HEAVY MINERAL
Na 480W 1800N	0-1.5	5.10	0.0065	0.23	99.77	5.30	0.79
Na 480W 1800N	1.5-3.5	7.85	0.0000	0.19	99.81	5.13	0.43
Na 480W 1800N	3.5-5.5	7.15	0.0000	0.04	99.96	7.28	0.55
Na 480W 1800N	5.5-7.5	5.80	0.0000	0.96	99.04	9.14	0.70
Na 480W 1800N	9.5-11.5	5.20	0.0048	0.24	99.76	4.75	0.63
Na 480W 1800N	11.5-13.5	3.25	0.0000	0.11	99.89	4.84	0.30
Na 480W 1800N	13.5-15.5	5.30	5.9819	2.62	97.38	7.90	0.69
Na 500W 1800N	0-1.5	3.80	0.0376	0.17	99.83	2.91	0.43
Na 500W 1800N	1.5-3.5	9.40	0.0000	0.35	99.65	6.93	0.52
Na 500W 1800N	3.5-5.5	6.70	0.0000	0.08	99.92	7.08	0.41
Na 500W 1800N	5.5-7.5	5.35	0.0665	1.77	98.23	12.51	0.69
Na 500W 1800N	9.5-11.5	7.15	0.0000	0.12	99.88	4.32	0.54
Na 500W 1800N	11.5-13.5	3.65	0.0148	0.19	99.81	4.30	0.38
Na 500W 1800N	13.5-14.75	5.30	5.1751	3.54	96.46	11.35	0.79
Na 520W 1800N	0-1.5	4.20	0.0605	0.27	99.73	4.03	0.71
Na 520W 1800N	1.5-3.5	8.80	0.0000	0.14	99.86	7.55	0.75
Na 520W 1800N	3.5-5.5	6.55	0.0000	0.02	99.98	5.78	0.66
Na 520W 1800N	9.5-11.5	7.75	0.0000	0.04	99.96	7.51	0.24
Na 520W 1800N	11.5-13.5	4.15	0.0769	0.86	99.14	8.04	0.47
Na 520W 1800N	13.5-14.5	4.25	4.1532	4.79	95.21	15.30	0.65
Na 380W 1800N	0-1.5	4.90	0.0404	0.08	99.92	1.32	0.56
Na 380W 1800N	1.5-3.5	8.05	0.0000	0.03	99.97	3.42	0.47
Na 380W 1800N	3.5-5.5	6.95	0.0000	0.04	99.96	6.49	1.06
Na 380W 1800N	5.5-7.5	5.90	0.5500	0.47	99.53	7.46	1.26
Na 380W 1800N	7.5-9.5	6.55	0.3577	0.04	99.96	4.00	0.23
Na 380W 1800N	9.5-11.5	5.05	2.3261	0.86	99.14	5.14	0.49
Na 380W 1800N	11.5-12.5	2.15	5.7372	3.00	97.00	6.31	3.45
Na TR26	0-1.5	3.35	0.0454	0.08	99.92	1.72	0.82
Na TR26	1.5-3.5	7.20	0.0000	0.04	99.96	1.42	0.69
Na TR26	3.5-5.5	6.15	0.0000	0.02	99.98	5.43	0.85
Na TR26	7.5-9.5	4.95	1.6095	4.92	95.08	13.35	4.08
Na TR26	9.5-11.5	3.75	0.1413	2.67	97.33	11.76	1.98
Na TR26	11.5-13.25	6.65	2.2256	3.14	96.86	4.47	1.24
Na TR30	0-1.5	3.60	0.0442	0.49	99.51	3.91	0.78
Na TR30	1.5-3.5	7.20	0.0000	0.19	99.81	5.28	1.12
Na TR30	3.5-5.5	6.00	0.0202	0.99	99.01	8.54	7.04
Na TR30	5.5-7.5	7.30	0.0711	0.06	99.94	2.06	6.83
Na TR30	9.5-11.5	8.90	2.4622	1.23	98.77	4.77	1.96
Na TR30	7.5-9.5	4.55	1.5631	1.83	98.17	14.83	1.31

039

R.H.F. LABORATORY HEAVY MINERAL SEPARATION

HOLE NUMBER	DEPTH	TOTAL WEIGHT KG	% + 2mm	% +1000u	% -1000u	% SLIME	% HEAVY (MINERAL)
Na TR34	0-1.5	4.80	0.0071	0.00	100.00	1.37	0.65
Na TR34	1.5-3.5	8.15	0.0000	0.02	99.98	0.88	0.54
Na TR34	3.5-5.5	8.50	0.0000	0.03	99.97	2.36	0.99
Na TR34	5.5-7.5	8.80	0.0000	0.02	99.98	2.86	4.25
Na TR34	7.5-9.5	6.25	0.2061	1.23	98.77	7.60	3.56
Na TR34	9.5-11.5	3.90	0.0000	0.74	99.26	9.48	0.49
Na TR34	11.5-13.5	7.15	3.0545	2.54	97.46	6.07	3.53
Na TR38	0-1.5	4.25	0.0351	0.02	99.98	1.36	0.73
Na TR38	1.5-3.5	7.35	0.0041	0.01	99.99	2.06	1.26
Na TR38	3.5-5.5	10.30	0.0000	0.06	99.94	5.09	1.60
Na TR38	5.5-7.5	6.90	0.2477	0.14	99.86	5.42	1.54
Na TR38	7.5-9.5	4.65	0.1890	0.30	99.70	9.69	0.33
Na TR38	9.5-11.5	7.05	1.8600	0.84	99.16	4.35	2.56
Na TR42	0-1.5	4.45	0.0169	0.02	99.98	0.78	0.55
Na TR42	1.5-3.5	9.10	0.0027	0.00	100.00	1.85	1.77
Na TR42	3.5-5.5	7.80	0.0000	0.02	99.98	2.70	0.60
Na TR42	5.5-7.5	5.80	0.3359	1.11	98.89	9.56	0.78
Na TR42	7.5-9.5	5.10	0.0000	0.14	99.86	4.04	0.11
Na TR42	9.5-11.5	8.25	4.2455	0.98	99.02	4.44	2.46
Na TR48	0-1.5	3.30	0.0152	0.04	99.96	1.24	0.55
Na TR48	1.5-3.5	5.85	0.0068	0.10	99.90	4.52	2.99
Na TR48	3.5-5.5	10.45	0.0000	0.14	99.86	2.65	6.43
Na TR48	5.5-7.5	7.70	2.5556	0.28	99.72	2.67	11.95
Na TR48	7.5-9.5	6.00	1.6550	1.35	98.65	5.11	5.57
Na TR48	9.5-11.5	5.20	0.7210	6.65	93.35	28.67	1.63
Na TR50	0-1.5	5.15	0.0132	0.08	99.92	2.78	0.67
Na TR50	1.5-3.5	6.30	0.0116	0.04	99.96	4.23	3.38
Na TR50	3.5-5.5	9.80	0.0556	0.07	99.93	2.43	4.84
Na TR50	5.5-7.5	9.35	0.2565	0.32	99.68	1.96	3.28
Na TR50	7.5-9.5	4.60	5.5328	2.57	97.43	9.80	2.13
Na 380W 1200N	0-1.5	3.15	1.5933	0.58	99.42	7.99	0.73
Na 380W 1200N	1.5-3.5	8.45	1.3702	1.07	98.93	1.79	1.93
Na 380W 1200N	3.5-5.0	8.55	1.7239	2.84	97.16	3.12	2.19
Na 380W 1400N	1.5-3.5	3.70	0.3381	0.21	99.79	2.68	1.73
Na 380W 1400N	3.5-5.5	5.00	0.1422	0.09	99.91	4.60	1.42
Na 380W 1400N	5.5-5.7	0.65	1.5277	1.02	98.98	2.87	5.72

090

R.H.F. LABORATORY HEAVY MINERAL SEPARATION

HOLE NUMBER	DEPTH	TOTAL WEIGHT KG	% + 2mm	% +1000u	% -1000u	% SLIME	% HEAVY MINERAL
Na 400W 1400N	3.5-5.5	2.45	0.6376	0.93	99.07	5.31	1.13
Na 46W 1600N	0-1.5	5.00	0.1284	0.03	99.97	1.46	0.43
Na 46W 1600N	1.5-3.5	8.40	0.0000	0.09	99.91	0.83	0.67
Na 46W 1600N	3.5-5.5	8.75	0.4216	2.13	97.87	1.83	0.34
Na 46W 1600N	5.5-7.5	10.60	4.7720	5.83	94.17	1.86	0.30
Na 46W 1600N	7.5-9.5	7.10	9.2982	12.02	87.98	2.32	0.37
Na 46W 1600N	9.5-11.5	5.90	0.0190	0.98	99.02	8.08	0.61
Na 46W 1600N	11.5-13.5	4.95	0.1069	1.51	98.49	9.55	0.81
Na 26W 1600N	0-1.5	5.00	0.0296	0.01	99.99	1.68	0.48
Na 26W 1600N	1.5-3.5	8.05	0.0000	0.03	99.97	1.26	0.98
Na 26W 1600N	3.5-5.5	8.15	0.0072	0.01	99.99	2.02	1.32
Na 26W 1600N	5.5-7.5	11.05	9.5061	8.04	91.96	2.19	0.68
Na 26W 1600N	7.5-9.5	8.95	11.3635	4.47	95.53	2.36	0.19
Na 26W 1600N	9.5-11.5	5.90	0.8361	2.42	97.58	10.48	0.84
Na 26W 1600N	11.5-12.6	2.75	0.0000	0.36	99.64	10.38	0.85
Na 6W 1600N	0-1.5	4.25	0.0614	0.07	99.93	1.68	0.29
Na 6W 1600N	1.5-3.5	7.65	0.0000	0.03	99.97	1.44	0.21
Na 6W 1600N	3.5-5.5	7.60	0.0000	0.04	99.96	2.22	0.45
Na 6W 1600N	5.5-7.5	8.05	0.1077	0.20	99.80	2.02	0.77
Na 6W 1600N	7.5-9.5	5.85	11.7872	11.18	88.82	2.64	0.27
Na 6W 1600N	9.5-11.5	8.80	0.3738	0.93	99.07	6.16	0.67
Na 6W 1600N	11.5-12.4	0.90	0.1122	1.62	98.38	9.15	0.68
Na SI	0-1.5	5.50	0.0391	0.07	99.93	3.63	1.20
Na SI	1.5-3.5	7.65	0.0132	0.12	99.88	4.19	0.56
Na SI	3.5-5.5	9.00	0.0000	0.09	99.91	5.40	0.40
Na SI	5.5-7.5	8.60	0.0000	0.05	99.95	5.28	0.67
Na SI	7.5-9.5	8.10	0.0372	0.08	99.92	2.81	0.44
Na SI	9.5-11.0	1.85	4.5076	10.18	89.82	13.67	1.52

091

APPENDIX 3

Readings of Lismore Ilmenite Beneficiation Treatment

093

2.

The testwork covered under this job number involved:

- i. Screening at 300 microns
- ii. High Tension/Plate separation to remove non conductors
- iii. Magnetic fractionisation into six magnetic fractions on a pilot induced roll magnet
- iv. The chemical assays of the six magnetics fractions obtained in (iii) above.

This work was reported to you by fax on 23 December 1988 and 4 January 1989. Please find attached copies of these two faxes.

Trust this letter formalises the testwork covered under the two RMS jobs mentioned.

Yours faithfully,
READINGS METALLURGICAL SERVICES PTY LTD



Eugene Dardengo
Project Metallurgist

enc



094

542095

90

READINGS OF LISMORE PTY. LTD.
(INCORPORATED IN NEW SOUTH WALES)
MINERAL PROCESSING EQUIPMENT & TECHNICAL SERVICES

Your Ref:

Our Ref: 2971

9 November 1988

Peter Stitt & Associates Pty Ltd
Mining and Geological Consultants
5th Floor
King York House
32 York Street
SYDNEY NSW 2000

ATTENTION: GRAHAM LEE

Dear Graham,

RE: THREE HEAVY MINERAL CONCENTRATES FROM KING ISLAND

Following your visit to Readings of Lismore on 14 October 1988, please find below a summary of testwork conducted on the three samples mentioned above as per your letter of 23 August 1988.

Testwork Procedure:

The three samples received were passed over our laboratory Semi-lift Induced Roll Magnet at increasing magnetic intensity to remove a magnetic fraction. The resulting non-magnetic fraction was then sent to G.C.A.S. for clerici separation at 2.85, 3.85, 4.05 and 4.22 S.G.

The density fractions $>3.85 <4.05$, $>4.05 <4.22$ and >4.22 were optically examined by David James (eyeball observation) and these grain counts should be treated with this in mind.

Testwork Results:

The results obtained from this testwork are attached in table form.

Yours faithfully,
READINGS OF LISMORE PTY LTD

A handwritten signature in cursive script that reads 'Eugene Dardengo'.

Eugene Dardengo
Project Metallurgist

095

SAMPLE 2

PRODUCT	MAGS	NON/MAGS				
		<2.85 S.G.	>2.85 <3.85 S.G.	>3.85 <4.05 S.G.	>4.05 <4.22 S.G.	>4.22 S.G.
% wt	79.39	0.44	7.31	0.86	0.98	11.02
Microscopic Observations		Presume Quartz	Presume Other Minerals	No Zircon 0.5% Rutile ? Anatase 80% Pale Brown & Medium Brown Leucoxene 19% Other Minerals (glassy minerals)	99% Rutile/Anatase/Rutile reporting Leucoxene - maybe a 92% TiO ₂ 1% Silicates	50% Zircon staining intermediate 50% Rutile - coarse

SAMPLE 5

PRODUCT	MAGS	NON/MAGS				
		<2.85 S.G.	>2.85 <3.85 S.G.	>3.85 <4.05 S.G.	>4.05 <4.22 S.G.	>4.22 S.G.
% wt	69.41	3.65	5.36	1.36	1.18	19.04
Microscopic Observations		Presume Quartz	Presume Other Minerals	No Zircon 1.0% Rutile ? Anatase 90% Leucoxene 9% Other Minerals	99% Rutile/Anatase/Rutile reporting Leucoxene ? Sulphides present 1% Silicates	55% Zircon Majority is clean 45% Rutile - coarse

E49096

095

SAMPLE 17

PRODUCT	MAGS	NON/MAGS				
		<2.85 S.G.	>2.85 <3.85 S.G.	>3.85 <4.05 S.G.	>4.05 <4.22 S.G.	>4.22 S.G.
% wt	87.33	0.85	2.33	0.60	0.44	8.45
Microscopic Observations		Presume Quartz	Presume Other Minerals	No Zircon 0.5% Rutile ? Anatase 80% Leucoxene 19% Other Minerals	99% Rutile/Anatase/Rutile reporting Leucoxene 1% Silicates	60% Zircon; most is heavily stained; stain looks internal, water attritioning not sufficient, need chemical attritioning. Some of the Zircon is coarse. 40% Rutile; majority is coarse. Looks clean.

542097 92



READINGS METALLURGICAL SERVICES PTY LTD
 MINERAL DRESSING CONSULTANTS AND LABORATORY SERVICES
 PO BOX 161, LISMORE, NSW 2480 AUSTRALIA
 PHONE (066) 21 7451 TELEX 166158 READG
 FACSIMILE (066) 21 9384

CLIENT FILE NATIONAL MINERAL SANDS (3048)
 TO DAVID GILLET NUMBER 02 262 4368
 FROM EUGENE DARDENGO DATE 4-1-89
 REF NO RL 4623 TOTAL OF 3 PAGES INCLUDING THIS ONE

Please call if any pages are not received.

MESSAGE:

David,
 Please find enclosed copy of fasc I sent
 to Graham Lee with regards to chemical
 assays I faxed to you today.

With regards to Cr_2O_3 levels it is felt
 (discussion with David James) that a bulk sample
 processed through a MKIV crossbelt might
 differentiate the Cr_2O_3 better. Food for thought
 as we have had experience with East Coast
 Ilmenites.

David, I'm off now, I'll ring you tomorrow.

Regards
 Eugene



READINGS OF LISMORE PTY. LTD.
 MINERAL PROCESSING EQUIPMENT & TECHNICAL SERVICES
 P.O. BOX 161, LISMORE NSW AUSTRALIA 2480
 PHONE (066) 21 7451 TELEX 166158 READG
 FACSIMILE (066) 21 9384

CLIENT FILE PETER STITT & ASSOCIATES (3048) /
 (2000) ✓
 TO GRAHAM LEE NUMBER 02 262 2395
 FROM EUGENE DARDENGO DATE 23.12.88
 REF NO RL 4577 TOTAL OF 2 PAGES INCLUDING THIS ONE

Please call if any pages are not received.

MESSAGE:

Further to your recent conversations with David James and myself, please find attached Treatment flowsheet of the testwork conducted on the combine magnetic fractions from Readings of Lismore Job 2971.

We have sent the six magnetic fractions for chemical assays (ie TiO_2 , Cr_2O_3 , SiO_2 , Al_2O_3 and Total Fe as per our telephone conversation 21 December 1988) to Gold Coast Assay Services, via Ipec.

No Assays results are available at this time as the samples were held up in Sydney (don't know how) and did not arrive as planned, to be assayed on 22 December 1988, with results being available today.

This delay is beyond Reading's control and assays will now be available in the first week of the New Year.

I hate to wish you a Merry Christmas and happy new year on a less than pleasant note, however all the best for the festive season.

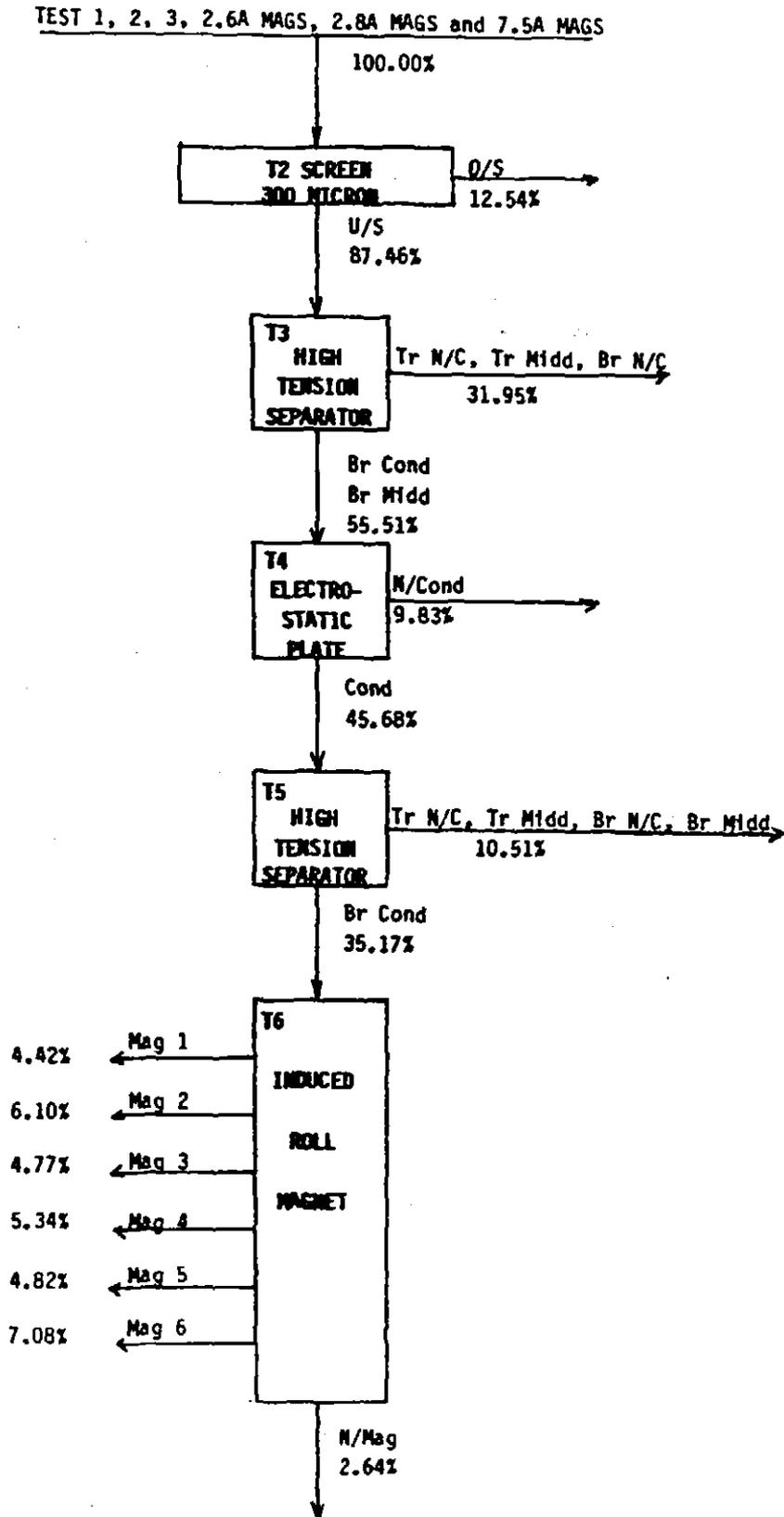
Regards,

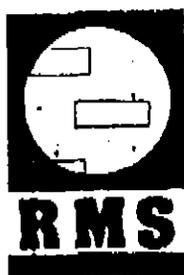
Eugene

Eugene Dardengo
 Project Metallurgist

TREATMENT FLOWSHEET

FEED: ROL JOB 2971





FACSIMILE SHEET

READINGS METALLURGICAL SERVICES PTY LTD
 MINERAL DRESSING CONSULTANTS AND LABORATORY SERVICES
 PO BOX 161, LISMORE. NSW 2480 AUSTRALIA
 PHONE (066) 21 7451 TELEX 166158 READG
 FACSIMILE (066) 21 9384

CLIENT FILE NATIONAL MINERAL SANDS PTY LTD (304a)

TO DAVID GILLET NUMBER 02 262 4368

FROM EUGENE DARDENGO DATE 4 JANUARY 1989

REF NO RMS 4613 TOTAL OF 1 PAGES INCLUDING THIS ONE

Please call if any pages are not received.

MESSAGE: RE: ASSAYS REQUESTED BY GRAHAM LEE

David,

1. Could you pass this information onto Graham. This information relates to a fax I sent to Graham on 23 December 1988.

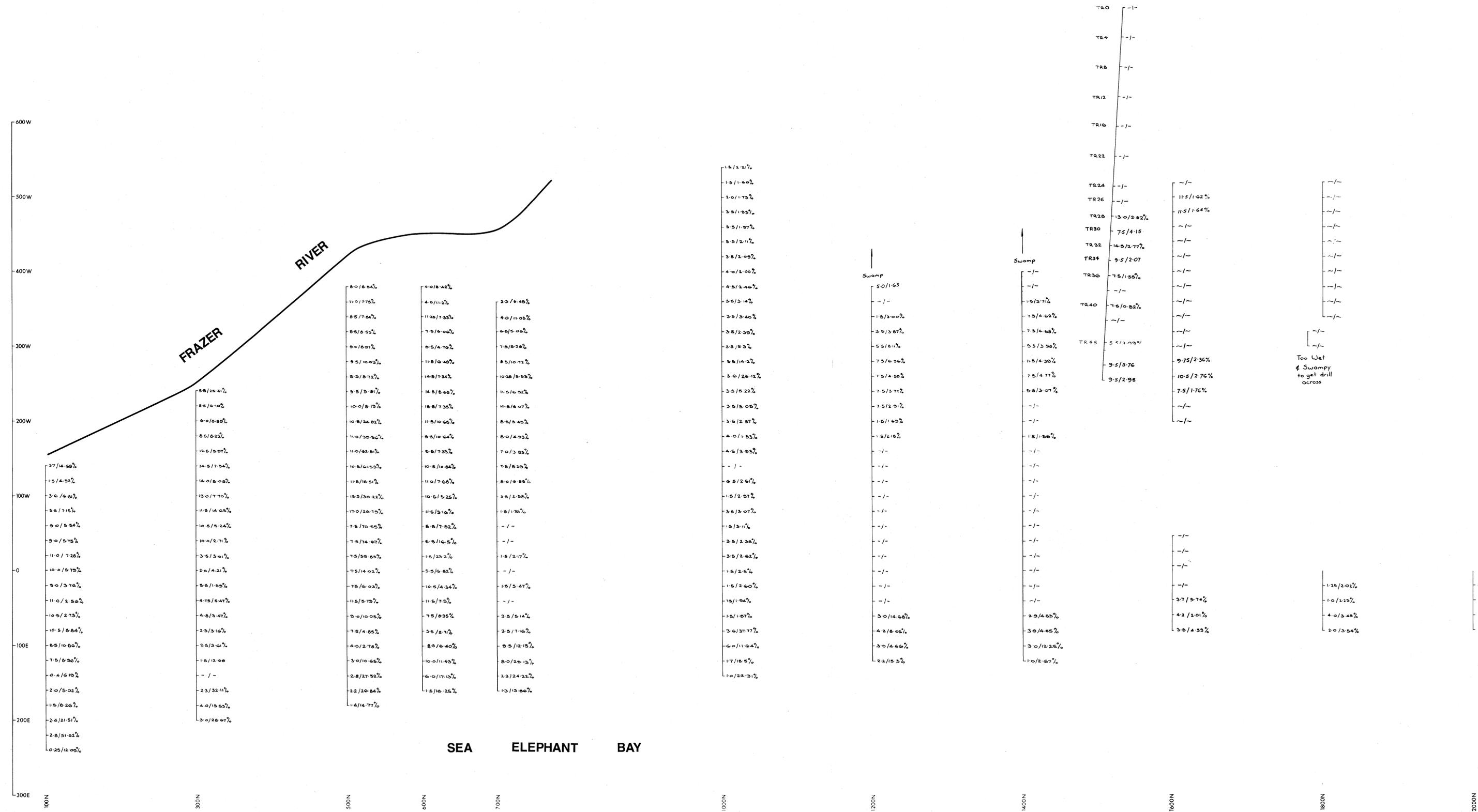
Product	% Assay				
	TiO ₂	Fe ₂ O ₃	SiO ₂	Cr ₂ O ₃	Al ₂ O ₃
T6 Mag 1	53.0	43.1	0.40	1.46	0.96
T6 Mag 2	56.4	38.6	1.01	1.37	1.12
T6 Mag 3	58.1	34.7	0.90	2.35	1.76
T6 Mag 4	58.0	31.5	0.92	3.38	2.44
T6 Mag 5	59.2	30.4	0.91	3.31	2.70
T6 Mag 6	59.1	29.7	1.12	3.10	3.21

2. The information you requested as per our telephone conversation 3 January 1989, ie brochures, are being dispatched to you today via Ansett Air Freight Consignment Note AP 412937.

Regards,

Eugene

Eugene Dardengo
 Project Metallurgist



LEGEND
 3.0/12.25%
 Depth in m. Grade to Depth.

5cm

SCALE 1:2000
 0 40 80 120 160m

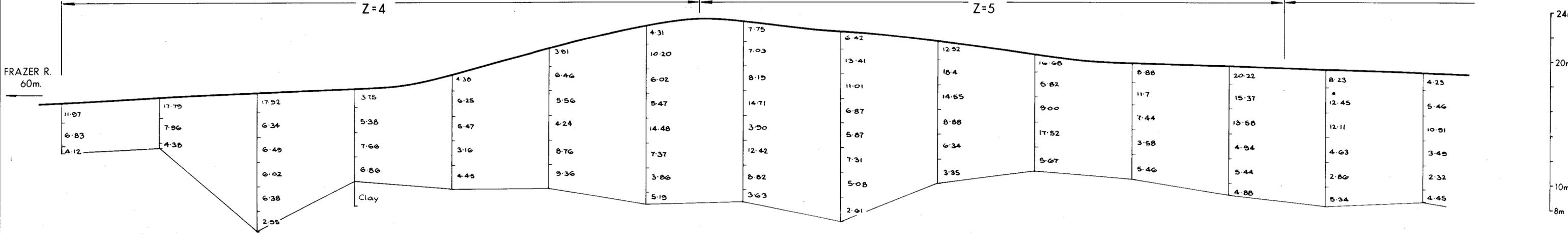
542102

NATIONAL MINERAL SANDS
 EL 28/85
NARACOOPA GRID
GRADES AT 1.5% H.M.
CUTOFF

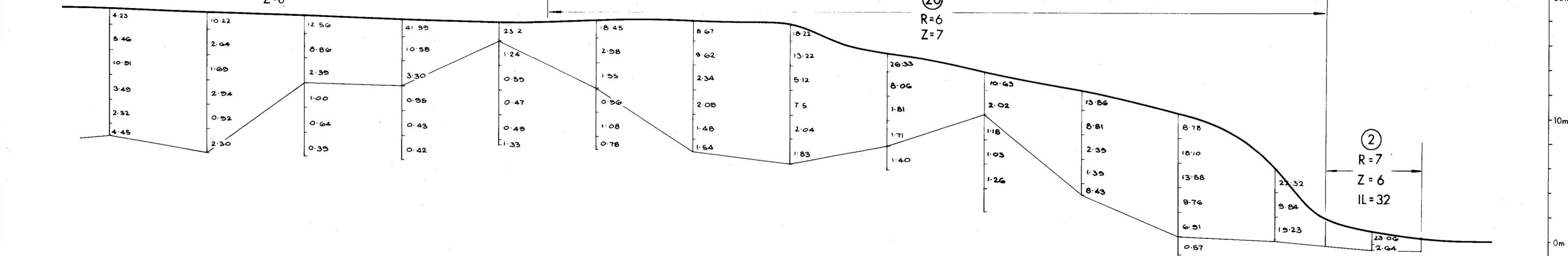
Author: G LEE Date: JUNE '88 Fig. No.: 3
 Revised MAY '89 DWG: 10.003R

WEST

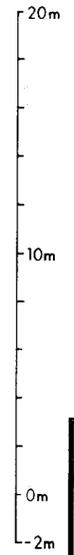
EAST



Clay 380w 4.0m 8.42%	Clay 360w 4.0m 11.2%	Clay 340w 11.25m 7.33%	Clay 320w 7.5m 6.06%	Clay 300w 9.5m 4.76%	Clay 280w 11.5m 6.49%	Clay 260w 14.5m 7.34%	Clay 240w 14.5m 8.65%	Clay 220w 15.5m 7.35%	Clay 200w 11.5m 10.65%	Clay 180w 9.5m 10.64%	Clay 160w 9.5m 7.33%	Clay 140w 10.5m 10.84%	Clay 120w 11.0m 7.68%	Clay 100w 10.5m 5.25%
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Clay 100w 10.5m 5.25%	Clay 80w 11.5m 3.16%	Clay 60w 5.5m 7.52%	Clay 40w 5.5m 16.5%	Clay 20w 1.5m 23.2%	Clay 000 5.5m 6.82%	Clay 20E 10.5m 4.34%	Clay 40E 11.5m 7.5%	Clay 60E 7.5m 8.35%	Clay 80E 3.5m 5.71%	Clay 100E 8.5m 6.40%	Rock 120E 10.0m 11.43%	Pebbles 140E 6.0m 17.13%	Pebbles 160E 1.5m 16.25%	Descr ⁿ end hole Drill hole no. Depth to 1.5% Cutoff Ave. Grade to 1.5% Cutoff
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LEGEND
 ① Mineralogical Sample No.
 R = 8 % Rutile
 Z = 8 % Zircon
 IL = 33 % Ilmenite

5 cm
SCALE
 HORIZONTAL 1:500
 VERTICAL 1:200

NATIONAL MINERAL SANDS
 EL 28/85
LINE 600N
CROSS SECTION
 Author: G. LEE Date: JUNE '88 Figure No. 7
 Revised March '89 DWG: 10-007R

WEST

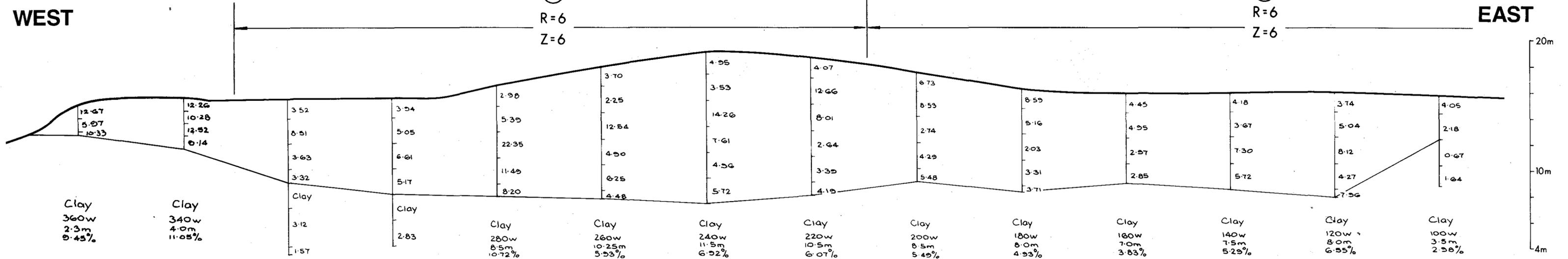
EAST

⑦

⑥

R=6
Z=6

R=6
Z=6

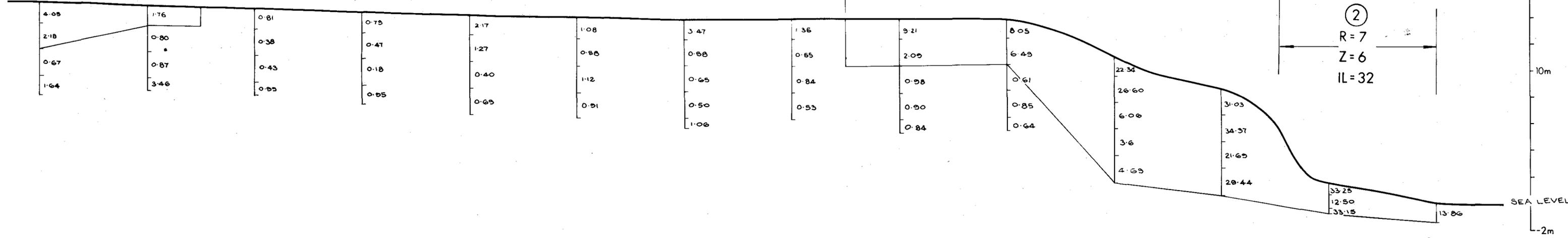


Desctⁿ end hole
Drill hole no. 320w
Depth to 1.5% H.H. Cutoff 6.5m
Ave. Grade to 1.5% Cutoff 5.06%

Clay
300w
7.5m
5.28%

③①

R=6
Z=6



②

R=7
Z=6
IL=32

Desctⁿ end hole
Drill hole no. 100w
Depth to 1.5% H.H. Cutoff 3.5m
Ave. Grade to 1.5% cutoff 2.98%

Clay
80w
1.5m
1.76%

Clay
60w
—

Clay
40w
—

Clay
20w
1.5m
2.17%

Clay
0
—

Clay
20E
1.5m
3.47%

Clay
40E
—

Clay
60E
3.5m
5.14%

Clay
80E
3.5m
7.16%

Clay
100E
9.5m
12.15%

Rock
120E
8.0m
29.13%

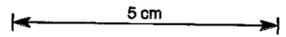
Rock
140E
2.3m
24.22%

Rock
160E
1.3m
13.86%

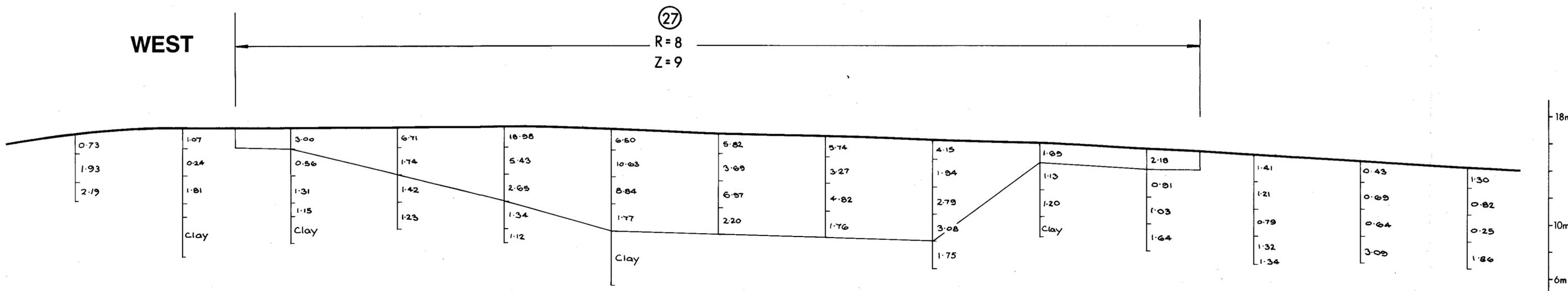
LEGEND

- ① Mineralogical Sample No.
- R=8 % Rutile
- Z=8 % Zircon
- IL=33 % Ilmenite

SCALE
HORIZONTAL 1:500
VERTICAL 1:200

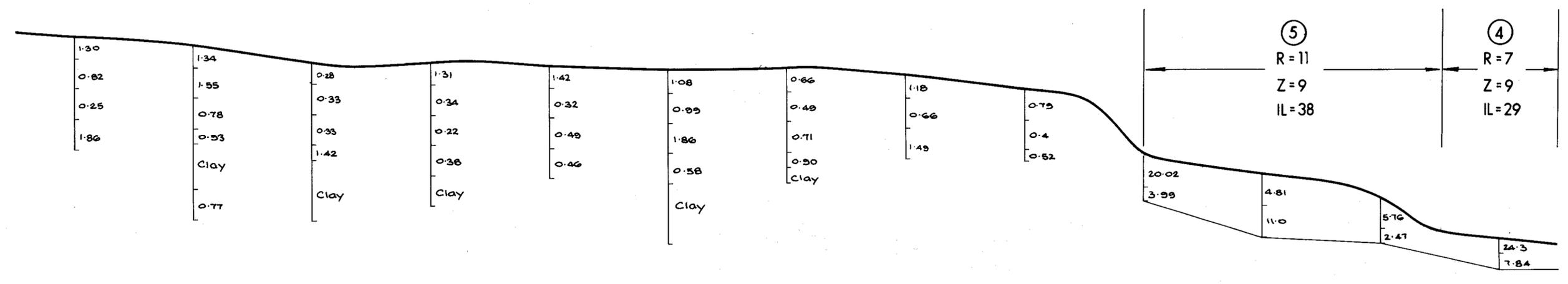


NATIONAL MINERAL SANDS
EL 28/85 542104
LINE 700N
CROSS SECTION
Author: G.LEE Date: JUNE '88 Figure No. 8
Revised March '89 DWG: 10-008R



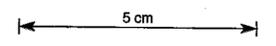
Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay
380w	360w	340w	320w	300w	280w	260w	240w	220w	200w	180w	160w	140w	120w	
—	—	1.5m	3.5m	5.5m	7.5m	7.5m	7.5m	7.5m	1.5m	1.5m	—	—	—	
—	—	3.00%	3.57%	8.11%	6.96%	4.55%	3.77%	2.91%	1.65%	2.18%	—	—	—	

Descⁿ end hole
 Drill hole no.
 Depth to 1.5% Cutoff
 Av. Grade to 1.5% Cutoff



Clay	Rock	Rock	Rock	Rock	Rock									
120w	100w	80w	60w	40w	20w	000	20E	40E	60E	80E	100E	120E		
—	—	—	—	—	—	—	—	—	—	3.0m	4.2m	3.0m	2.2m	
—	—	—	—	—	—	—	—	—	—	14.68%	8.05%	4.66%	15.3%	

LEGEND
 ① Mineralogical Sample No.
 R=8 % Rutile
 Z=8 % Zircon
 IL=33 % Ilmenite



SCALE
 HORIZONTAL 1:500
 VERTICAL 1:200

NATIONAL MINERAL SANDS
 EL 28/85 542105
LINE 1200N
CROSS SECTION

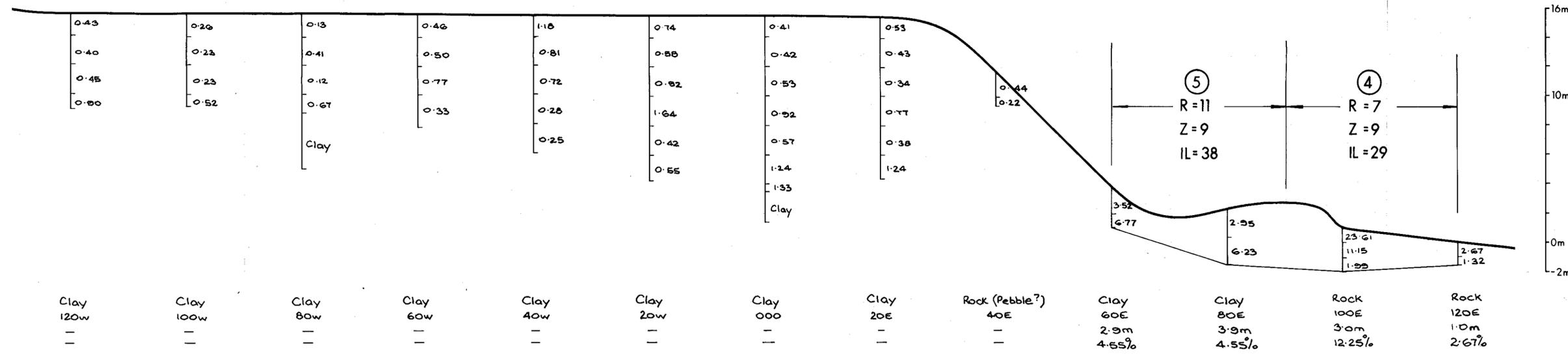
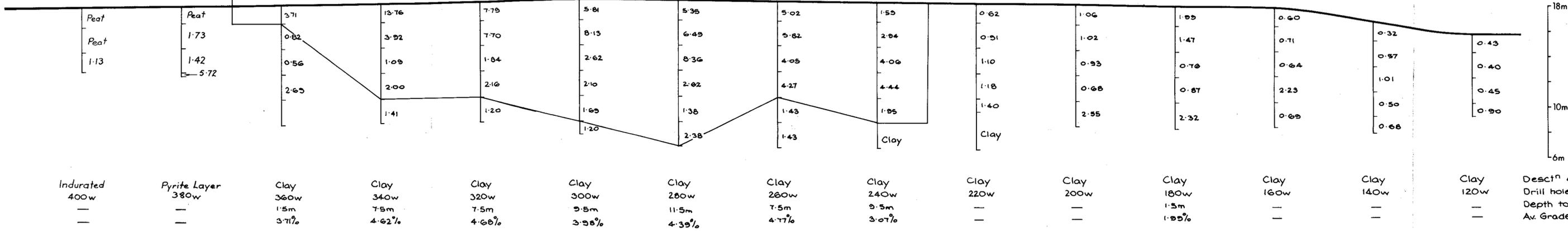
WEST

EAST

28

R=9

Z=12



5 cm

LEGEND

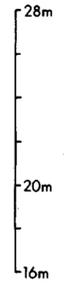
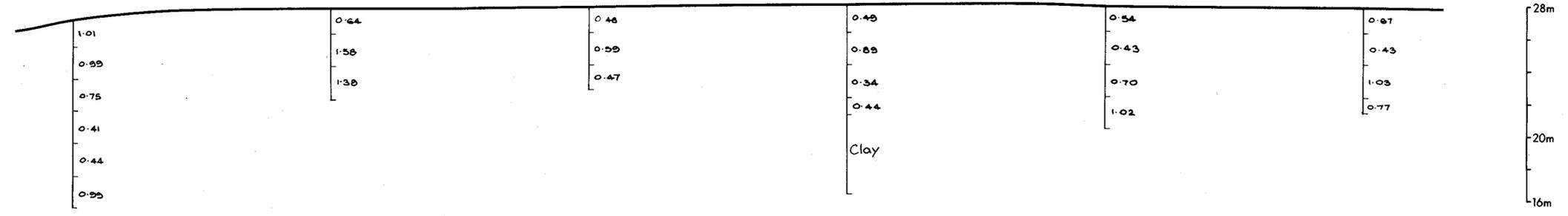
- ① Mineralogical Sample No.
- R = 8 % Rutile
- Z = 8 % Zircon
- IL = 33 % Ilmenite

SCALE
HORIZONTAL 1:500
VERTICAL 1:200

NATIONAL MINERAL SANDS
EL 28/85
LINE 1400N
CROSS SECTION

WEST

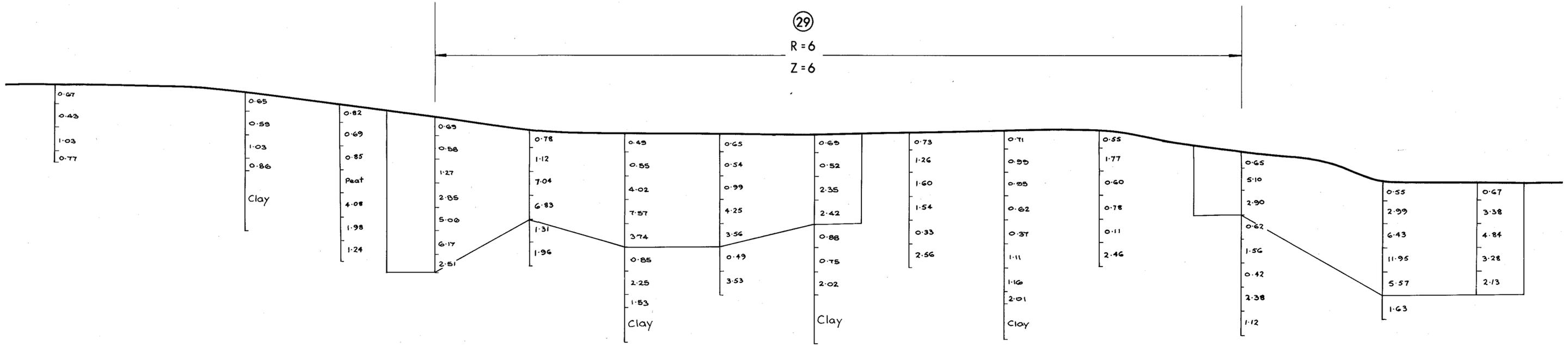
EAST



Clay TR0
 Peat & Mud TR4
 Clay TR8
 Clay TR12
 Clay TR16
 Clay TR20

Descⁿ end hole
 Drill hole no.
 Depth to 1.5% Cutoff
 Av. Grade to 1.5% Cutoff

29
 R = 6
 Z = 6



Clay TR20
 Clay TR24
 Clay TR26
 Clay TR28 13.0m 2.82%
 Clay TR30 7.5m 4.15%
 Clay TR32 12.5m 2.72%
 Clay TR34 9.5m 2.07%
 Clay TR36 7.5m 1.55%
 Clay TR38
 Clay TR40 7.5m 0.82%
 Clay TR42
 Clay TR45 3.5m 3.09%
 Clay TR48 9.5m 5.76%
 Clay TR50 9.5m 2.98%

LEGEND

① Mineralogical Sample No.
 R = 8 % Rutile
 Z = 8 % Zircon
 IL = 33 % Ilmenite

5cm

SCALE
 HORIZONTAL 1:500
 VERTICAL 1:200

NATIONAL MINERAL SANDS
 EL 28/85
TIP ROAD CROSS SECTION

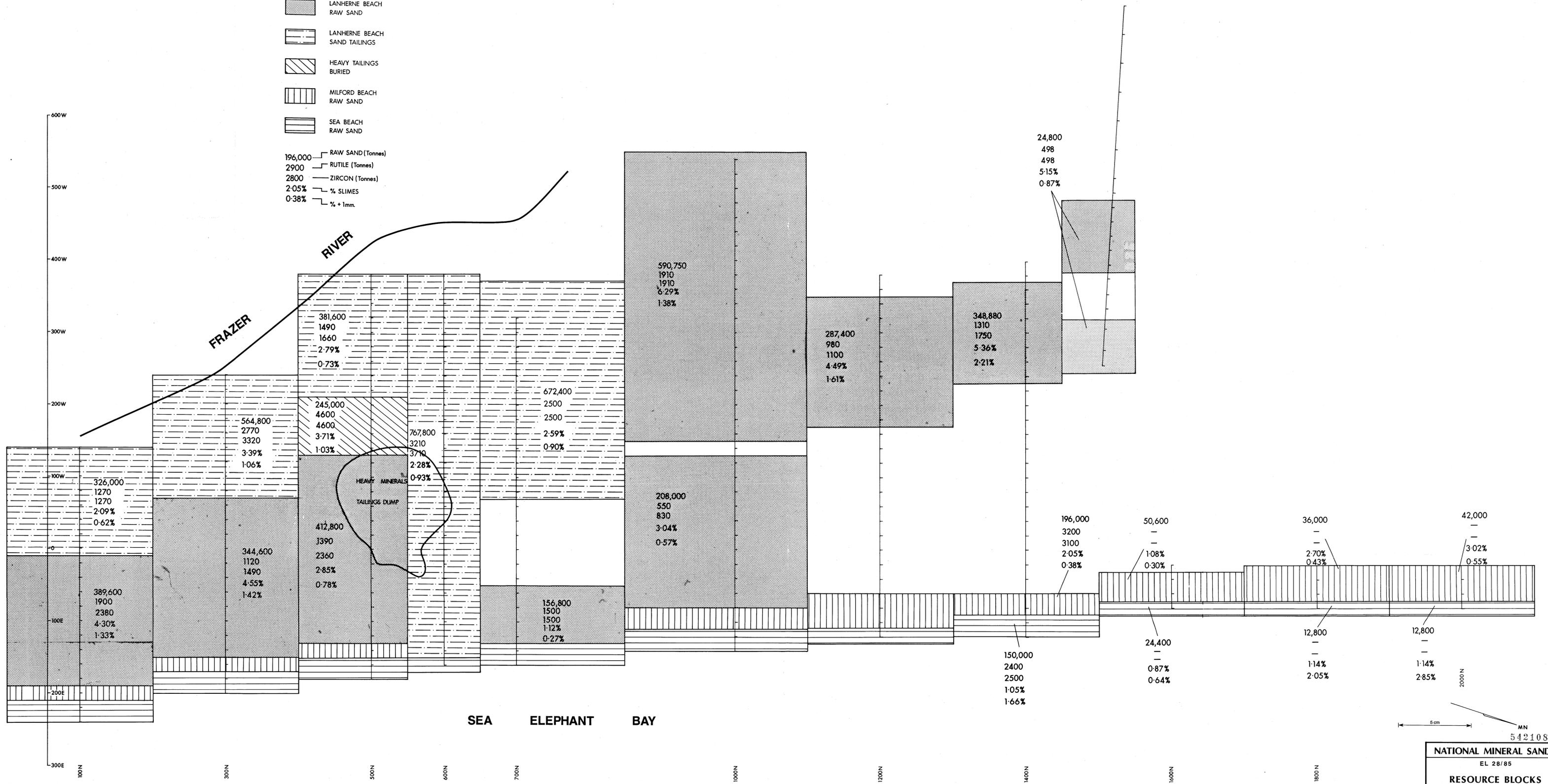
Author: G. LEE Date: JUNE '88 Figure No. 12
 Revised May '89 DWG: 10-012R

542107

LEGEND

-  LANHERNE BEACH RAW SAND
-  LANHERNE BEACH SAND TAILINGS
-  HEAVY TAILINGS BURIED
-  MILFORD BEACH RAW SAND
-  SEA BEACH RAW SAND

- 196,000 — RAW SAND (Tonnes)
- 2900 — RUTILE (Tonnes)
- 2800 — ZIRCON (Tonnes)
- 2.05% — % SLIMES
- 0.38% — % + 1mm.



SEA ELEPHANT BAY

542108

NATIONAL MINERAL SANDS

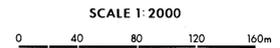
EL 28/85

RESOURCE BLOCKS

AT 1.5% CUTOFF

Author: G. LEE Date: JULY '88 Fig. No: 14

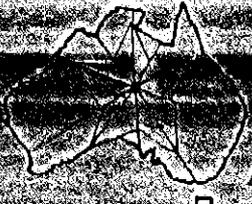
Revised MAY '89 DWG: 10-014R



5cm

100

3.001



ANMTEL

AUSTRALIAN METALLURGICAL AND
MINERAL TESTING CONSULTANTS PTY LTD.

METALLURGICAL TESTING
OF
A HEAVY MINERAL CONCENTRATE
PREPARED FROM
LANHERNE RAW SAND DRILL SAMPLES

FOR

NATIONAL MINERAL SANDS PTY LTD

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(i)

SUMMARY

1. A total of 1400 kg of Lanherne raw sand drill samples were composited for metallurgical testing.
2. The head grade was determined to be 5.3% heavy mineral.
3. A heavy mineral concentrate was prepared using a combination of spiral and wet table concentration.
4. The heavy mineral concentrate was then separated using high tension and magnetic separation techniques to prepare ilmenite, rutile and zircon products.
5. The rutile product contained excessive sulphur (1.19%) and the initial flotation response was poor, possibly due to organic coatings on the mineral surfaces. Excellent flotation results were achieved after the product had been attritioned in caustic soda solution.
6. Product analyses are given below :

	TiO ₂ %	Fe ₂ O ₃ %	MnO %	^{Cr₂O₃} Cr ₂ O ₃ %	Al ₂ O ₃ %	S %	SnO ₂ ppm
Ilmenite	57.2	32.5	1.55	1.46	-	-	-
Rutile	96.9	0.585	-	-	0.198	<0.005	2750
Zircon	0.4	0.308	-	-	2.79	-	44

7. The high tin content (SnO₂ = 2750ppm) in the final rutile product is of some concern, although it is believed that it can be resolved in plant operations, because of its high SG, by using a wet gravity technique.
8. Although the zircon product is off grade, the contaminants do not pose long term production problems.
9. The chrome in ilmenite is in the form of a chrome spinel (chromite).

- 1 -

1. INTRODUCTION

A request was received from the client, National Mineral Sands Pty Ltd, for an initial metallurgical test programme to be undertaken upon a composite sample prepared from drill hole samples taken from the Lanherne Beach Deposit.

The required metallurgical testwork programme was outlined in a letter from National Mineral Sands Pty Ltd, and included the production of mineral samples suitable for initial marketing purposes and an indication of expected product quality.

2. SAMPLES RECEIVED

All the drill hole samples taken during the drilling campaign carried out in the southern (Naracoopa) deposits were forwarded by the client.

These samples included :

1. Heavy mineral tailing
2. Sand tailing
3. Raw sand - Lanherne Beach
4. Sea and Milford beaches

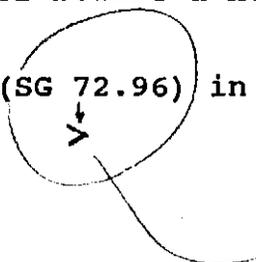
However, only the Lanherne raw sand samples were to be composited for the initial metallurgical test programme and these samples are listed in Table 1.

The total weight of the composite sample was 1400kg.

3. HEAD SAMPLE

The samples were composited and then thoroughly blended using a rotary splitter before a head sample was split from the bulk.

The percentage heavy mineral (SG 72.96) in the sample was determined to be 5.3%.



- 2 -

The particle sizing distribution was determined for both the heavy liquid sink product (SG >2.96) and the float product (SG <2.96). These data are given in Table 2 and illustrated by Figure 1.

4. ANALYTICAL

Samples arising from the testwork were forwarded to Analabs (Balcatta) laboratory for analysis.

5. PRODUCTION OF HEAVY MINERAL CONCENTRATE

The following two stages of concentration were used to prepare a heavy mineral concentrate for dry plant testwork :

1. single stage spiral rougher concentration; and
2. cleaning on a laboratory wet table.

Insufficient material was available for cleaner spiral concentration.

5.1. Spiral Concentration

A Mineral Deposits MG5 wash waterless spiral was used for the initial concentration. Preliminary spiral testwork to determine the weight to concentrate/heavy mineral recovery relationship was not included in the scope of work and a nominal selection of 25% weight to concentrate was made. Spiral middlings were recycled with concentrate and tailing as final product.

Spiral products were not dried or weighed, but the product split was one 200 litre drum of concentrate and four 200 litre drums of tailings.

The percentage heavy mineral in the tailing was determined to be 1.1% indicating low heavy mineral recovery with insufficient weight recovery to concentrate.

5.2. Wet Table Concentration

The wet spiral concentrate was then further concentrated using a laboratory sized Wilfley table. Three products were recovered, concentrate, middling and tailing.

Both the concentrates and middling products were then water attritioned and deslimed by washing and decantation before the solids were dried for the dry separation testwork.

5.3. Attritioning

A laboratory unit with an active volume of 5 litres was used for the testwork. The attritioner has two four blade turbines and is powered by a variable speed 0.75 kw motor.

It was necessary to wash the damp wet table concentrates into the attritioner so the pulp density could not be accurately controlled to the usual 80% solids. Attritioning time was 10 minutes and no chemical additions were made.

After being discharged from the attritioner, the solids were deslimed by repeated washing and decantation and then dried.

6. HEAVY MINERAL CONCENTRATE

The dry deslimed table products were screened using a 500 μ m aperture sieve to remove oversize before the <500 μ m solids were riffle split to provide a head sample for the determination of the percentage heavy mineral :

Product	Weight (kg)	Weight (%)	Heavy Mineral (%)
Table Concentrate (>500 μ m)	0.195	0.6	ND
Table Concentrate (<500 μ m)	30.956	99.4	97.5
Total	31.151	100.0	-

- 4 -

Product	Weight (kg)	Weight (%)	Heavy Mineral (%)
Table Middling (>500 μ m)	0.514	3.6	ND
Table Middling (<500 μ m)	13.858	96.4	86.0
Total	14.372	100.0	-

The <500 μ m concentrates and middlings were then composited for the dry plant testwork with the percentage heavy mineral in the composite sample given below.

Product	Weight (kg)	HM (%)	Units
Concentrate	30.956	97.5	3018.21
Middling	13.858	86.0	1191.79
Total	44.814	(93.9)	4210.00

7. INITIAL DRY PLANT TESTWORK

7.1. Procedure

The initial testwork was conducted according to the general procedure detailed in Figure 2 and consisted of high tension roughing and cleaning stages followed by electrostatic plate cleaning and magnetic separation.

7.2. Results - Weight Recoveries

The weight recoveries for the various unit operation are given in flowsheet form as listed in the Table of Contents.

7.3. Results - Analysis

Only three products were selected for analysis, rutile, zircon and one of the ilmenite products.

Analyses are given in Table 3.

7.4. Discussion

The ilmenite was confirmed to be high in chrome (1.46% Cr₂O₃) and a sample was forwarded to Mintek Services for mineralogical and electron probe analysis so as to determine the mineralogical occurrence of the chrome. The chrome was determined to be present as discrete grains (chromite). See Mintek report, Appendix I, for details.

The low percentage TiO₂ in rutile was due to the very high sulphide content (1.19% S) while the SnO₂ (>0.1%) was not unexpectedly high considering the previous history of the deposit. The percentage sulphur in rutile is very high compared with some other deposits and indicated the need for flotation to be included in the plant treatment circuit.

The zircon was offgrade with respect to TiO₂, Fe₂O₃ and Al₂O₃. The high Al₂O₃ would be due, in part, to the concentration procedure used; ie spiral concentration followed by laboratory wet tabling with the aim to maximise heavy mineral recovery. No data is as yet available on the difference in weight recovery to concentrate for heavy mineral recovery and economic heavy mineral recovery. A percentage of the trash minerals such as kyanite can be expected to be rejected in the spiral concentration stage.

8. FOLLOW-UP TESTWORK

8.1. Rutile

The rutile product was then wet tabled using a multi-product offtake in an attempt to take a top table cut to remove the high SG cassiterite. This operation was not successful as there was a tendency for the top material to wash down the table into the bulk of the material at the discharge end of the table.

Some of the rutile table product was then floated using sodium ethyl xanthate as a collector.

However, the low sulphide concentrate weight indicated that less than half of the sulphide floated despite additional xanthate addition and the use of copper sulphate as an activator. A considerable quantity of sulphide was observed in the rutile under the binocular microscope.

A possible reason for the poor flotation response was surface organic coatings so the rutile was then attritioned with caustic soda addition (1kg/tonne) to clean the mineral surfaces.

Sulphide flotation response with sodium ethyl xanthate was then excellent.

Test details are given in Figure 6.

8.2. Zircon

The zircon product (Sample 3) was also wet tabled using the multi-product offtake and, in an attempt to reduce the Al_2O_3 content, the two lower products were excluded from the zircon product. The black solution decanted from the rutile product was visible evidence of slime removal by caustic attritioning and a similar treatment was then given to the zircon wet table product. The dry zircon product, with a much whiter appearance, was then subjected to additional electrostatic plate cleaning. Quartz was removed from the sample submitted for analysis by heavy liquid separation.

8.3. Analyses

Rutile and zircon analytical results are given in Table 4.

8.4. Discussion

Caustic soda attritioning appears to have enhanced the appearance of the zircon and allowed the production of low sulphur $<300\mu m$ rutile product. Some coarse sulphides were observed in the $>300\mu m$ product.

The tin content of the rutile remains high at 2750 ppm SnO_2 , and the high level is some concern, although it is expected that, because of the high SG differential a plant wet table using a top cut to discard the cassiterite will successfully reduce the tin in rutile.

The zircon grade with respect to TiO_2 and Fe_2O_3 , was somewhat disappointing as, under the binocular microscope the zircon appeared to be better grade than the reported 0.4% TiO_2 and 0.308% Fe_2O_3 . The Al_2O_3 remained high at 2.79% and a combination of both wet and air tabling may be required. However, there appears to be no reason why the specification for TiO_2 , Fe_2O_3 and Al_2O_3 cannot be met in plant operations.

9. RADIOACTIVITY

Following a request from the client selected samples were submitted for thorium and uranium analysis.

Test results are given in Table 5.

The implication of these results will be reported at a later date.

TABLES

TABLE 1
SAMPLES USED IN PREPARATION OF LANHERNE RAW SAND COMPOSITE SAMPLE

[Data Supplied by Client]

20E	100N	0 - 9.0	60E	700N	0 - 3.5
40E	"	0 - 11.0	80E	"	0 - 3.5
60E	"	0 - 10.5	100E	"	0 - 9.5
80E	"	0 - 10.5	120E	"	0 - 8.0
100E	"	0 - 8.5			
120E	"	0 - 7.5	540W	1000N	0 - 1.5
140E	"	0 - 0.4	520W	"	0 - 1.5
160E	"	0 - 2.0	500W	"	0 - 2.0
180E	"	0 - 1.5	480W	"	0 - 3.5
			460W	"	0 - 5.5
60W	300N	0 - 10.5	440W	"	0 - 5.5
40W	"	0 - 10.0	420W	"	0 - 3.5
20W	"	0 - 10.0	400W	"	0 - 4.0
000	"	0 - 2.0	380W	"	0 - 4.5
20E	"	0 - 5.5	360W	"	0 - 3.5
40E	"	0 - 4.75	340W	"	0 - 3.5
60E	"	0 - 4.8	320W	"	0 - 3.5
80E	"	0 - 2.3	300W	"	0 - 3.5
100E	"	0 - 2.5	280W	"	0 - 6.5
120E	"	0 - 4.0	260W	"	0 - 3.5
140E	"	0 - 1.0	240W	"	0 - 3.5
			220W	"	0 - 3.5
20E	500N	0 - 7.5	200W	"	0 - 3.5
40E	"	0 - 11.5	180W	"	0 - 4.0
60E	"	0 - 9.0	160W	"	0 - 4.5
80E	"	0 - 7.5			
100E	"	0 - 4.0	120W	1000N	0 - 6.5
120E	"	0 - 3.0	100W	"	0 - 1.5
000	"	1.5 - 7.5	80W	"	0 - 3.5
20W	"	5.5 - 7.5	60W	"	0 - 1.5
40W	"	5.5 - 7.5	40W	"	0 - 3.5
60W	"	5.5 - 7.5	20W	"	0 - 3.5
80W	"	5.5 - 17.0	000	"	0 - 1.5
100W	"	5.5 - 15.5	20E	"	0 - 1.5
120W	"	1.5 - 11.5	40E	"	0 - 1.5
			60E	"	0 - 1.5

.../Continued

TABLE 1 ... Continued
SAMPLES USED IN PREPARATION OF LANHERNE RAW SAND COMPOSITE SAMPLE

[Data Supplied by Client]

340W	1200N	0 - 1.5	360W	1400N	0 - 1.5
320W	"	0 - 3.5	340W	"	0 - 7.5
300W	"	0 - 5.5	320W	"	0 - 7.5
280W	"	0 - 7.5	300W	"	0 - 7.5
260W	"	0 - 7.5	280W	"	0 - 7.5
240W	"	0 - 7.5	260W	"	0 - 7.5
220W	"	0 - 7.5	240W	"	0 - 9.5
200W	"	0 - 1.5			
180W	"	0 - 1.5			
TR 28		0 - 13.0 (tIP ROND)			
TR 32		0 - 14.5			
TR 36		0 - 7.5			
TR 40		0 - 5.5			
TR 45		0 - 5.5			

- Average heavy mineral grade 3 - 6%
- Rutile and zircon contained not known but from previous raw sand mineralogy rutile should be in the range 7 - 8% and zircon 10 - 12% of the heavy mineral suite
- Heavy grains are likely to be coated

- 11 -

TABLE 2
THE PARTICLE SIZING DISTRIBUTION FOR HEAVY LIQUID SINK AND FLOAT PRODUCTS

Aperture (μm)	Sink		Float	
	Weight, %		Weight, %	
	Retained	Passing	Retained	Passing
+500	3.0	97.0	4.8	95.2
-500 +355	6.4	90.6	13.9	81.3
-355 +250	17.8	72.8	38.6	42.7
-250 +180	21.1	51.7	25.2	17.5
-180 +125	29.5	22.2	12.2	5.3
-125 + 90	11.7	10.5	2.0	3.3
- 90 + 63	9.1	1.4	1.7	1.6
- 63 + 45	0.7	0.7	0.5	1.1
- 45	0.7		1.1	
	100.0		100.0	

TABLE 3
ANALYTICAL DATA FOR SELECTED PRODUCTS - INITIAL TESTWORK

[All Data %]

<u>Product</u>	<u>Sample No</u>	<u>TiO₂</u>	<u>Fe₂O₃</u>	<u>MnO</u>	<u>Cr₂O₃</u>	<u>Al₂O₃</u>	<u>SnO₂</u>	<u>S</u>
Ilmenite	1	57.2	32.5	1.55	1.46	-	-	-
Rutile	2	92.9	1.86	-	-	0.355	>0.1	1.19
Zircon	3	1.28	0.62	-	-	5.12	<0.005	-

TABLE 4
ANALYTICAL DATA FOR FINAL PRODUCTS

[Data % Except Where Noted]

<u>Product</u>	<u>Sample No</u>	<u>TiO₂</u>	<u>Fe₂O₃</u>	<u>Al₂O₃</u>	<u>S</u>	<u>SnO₂</u> <u>(ppm)</u>
Rutile	23	96.9	0.585	0.198	<0.005	2750
Zircon	24	0.4	0.308	2.79	-	44

TABLE 5
THORIUM AND URANIUM ANALYSES SELECTED SAMPLES

[Data in ppm]

<u>Product</u>	<u>Sample No</u>	<u>Th</u>	<u>U</u>
Bulk Spiral Tailing	18	1.96	0.41
Ilmenite (1)	19	13.50	2.85
Rutile (2)	20	10.50	15.80
Nol N/C IRM Mags (10)	21	765	52.80
Head Heavy Mineral (Combinea Table Conc & Mid)	22	138	17.70

FIGURES

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FIGURE 1
NARACOOPA PROJECT - GENERAL PROCEDURE FOR INITIAL TESTWORK

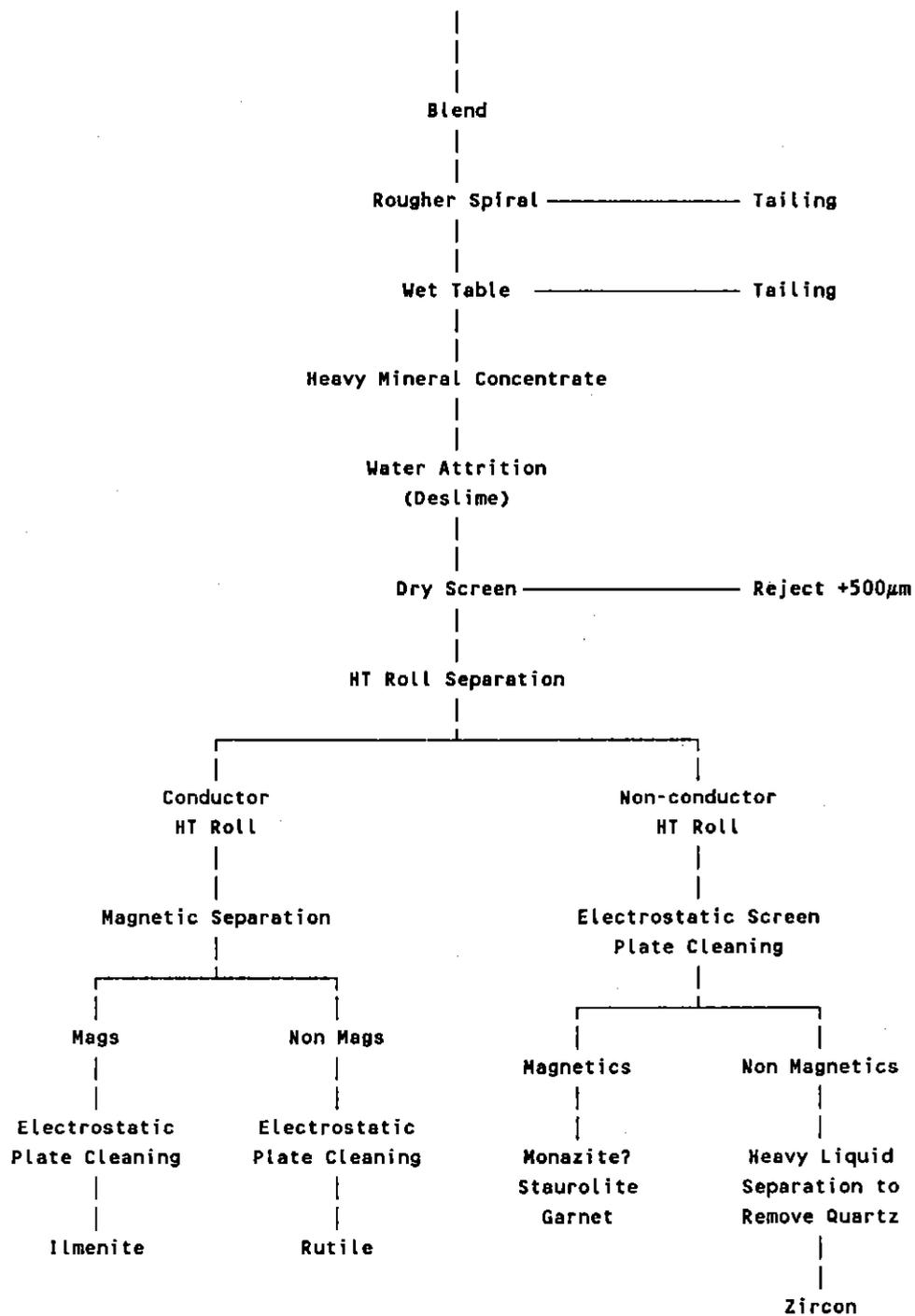


FIGURE 2

HEAD SAMPLE - PARTICLE SIZING DISTRIBUTION FOR HEAVY MINERAL AND QUARTZ

119

National Mineral Sands Pty. Ltd.
Sizing Distribution Data

Weight Percent Passing

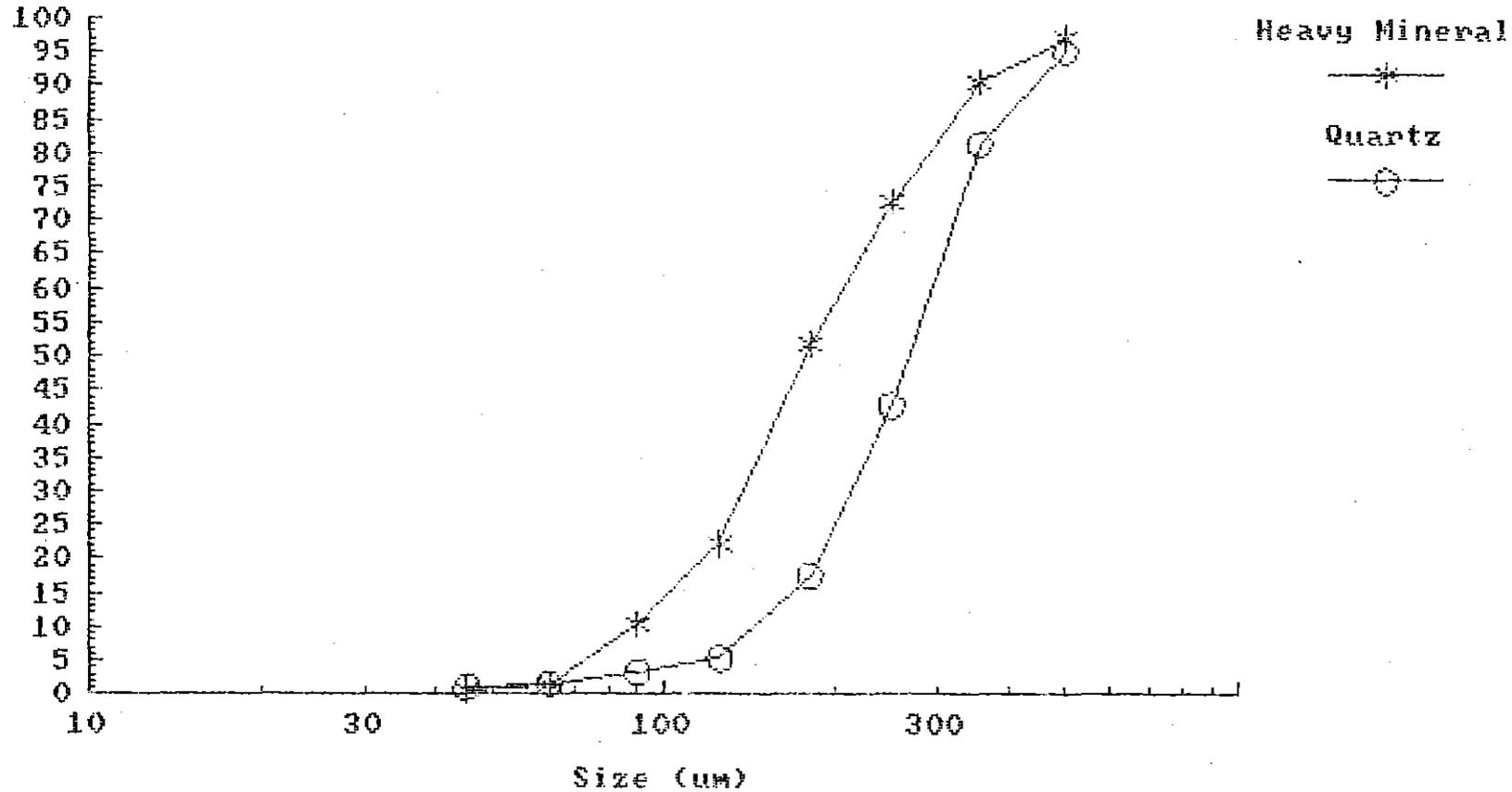


FIGURE 3
HIGH TENSION ROLL TESTWORK

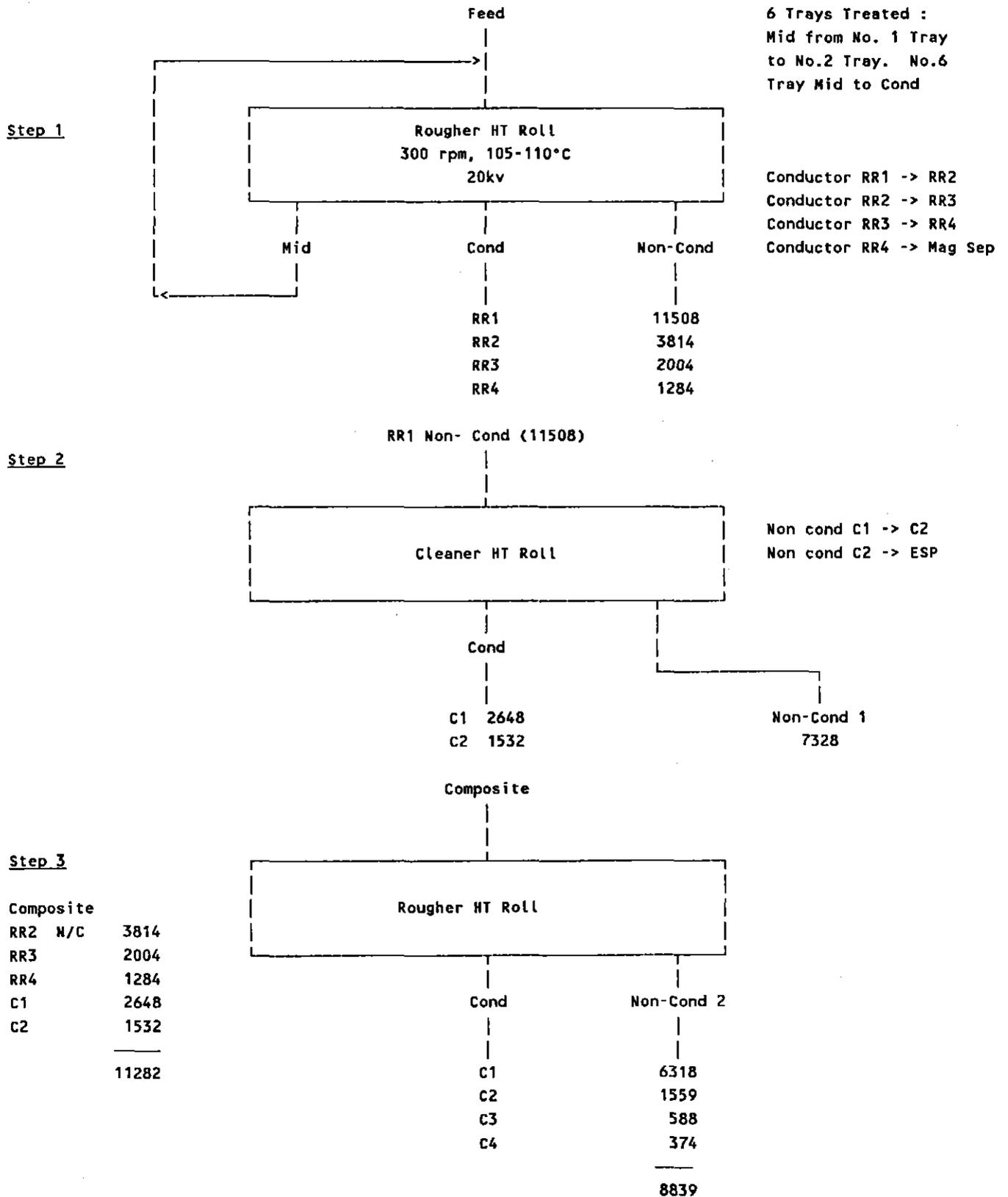
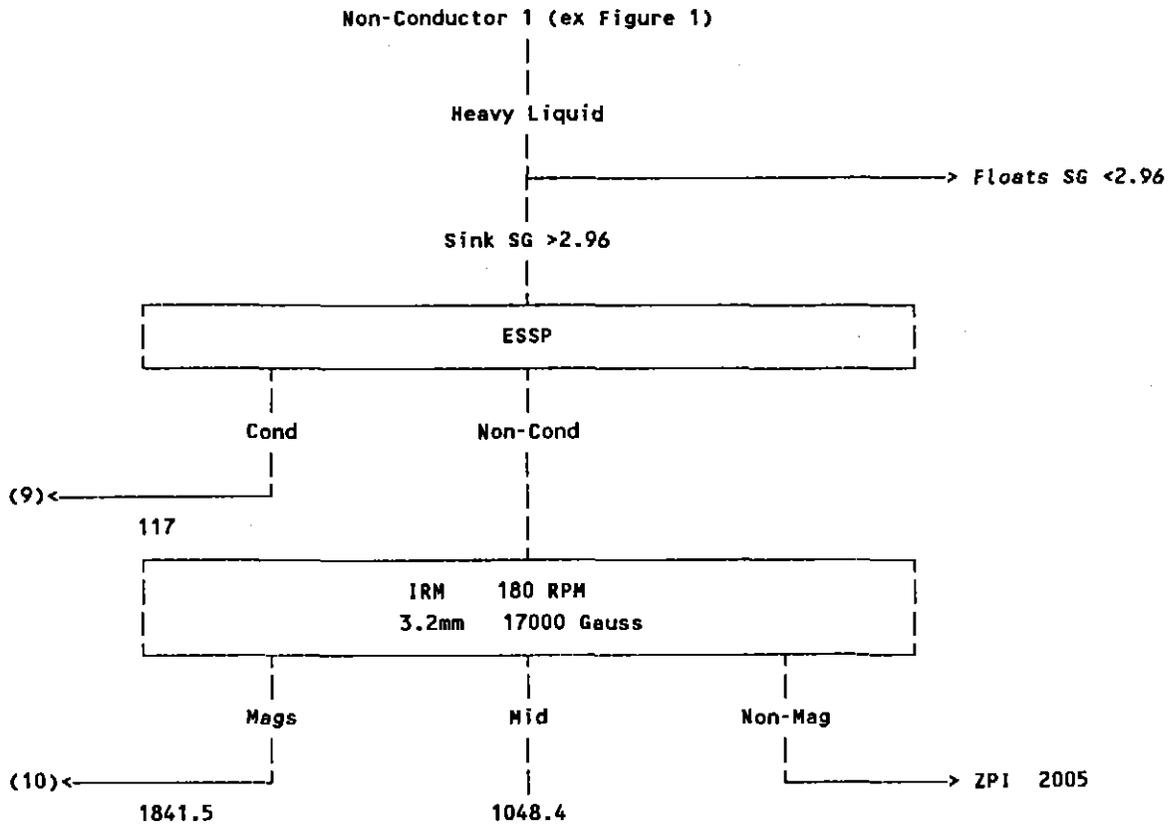
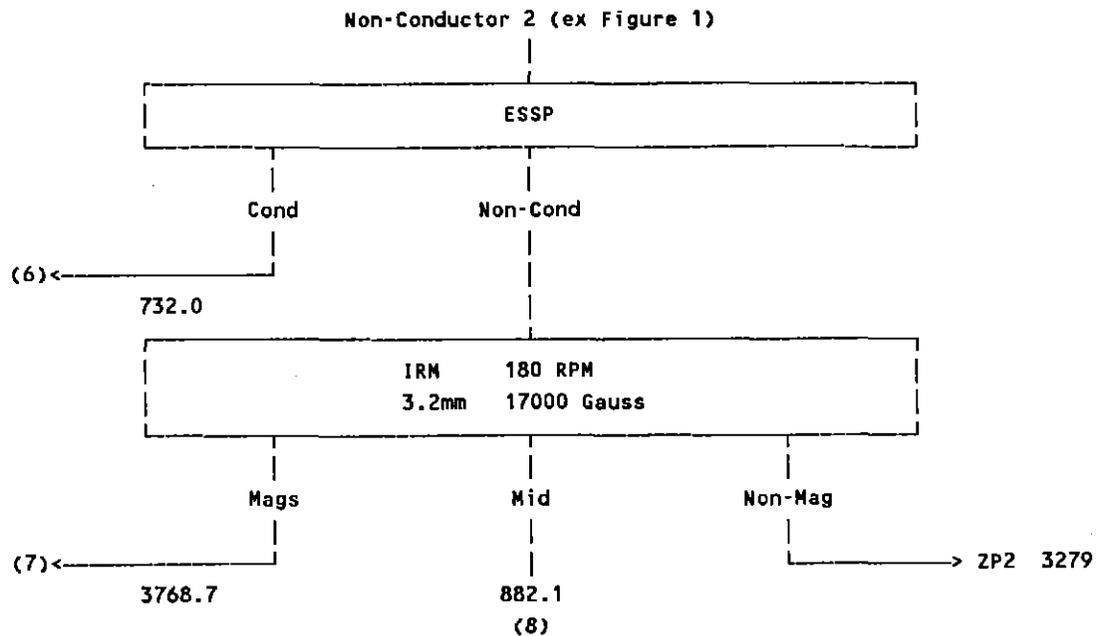


FIGURE 4
ELECTROSTATIC SCREEN PLATE CLEANING OF NON-CONDUCTORS

Step 4



Step 5

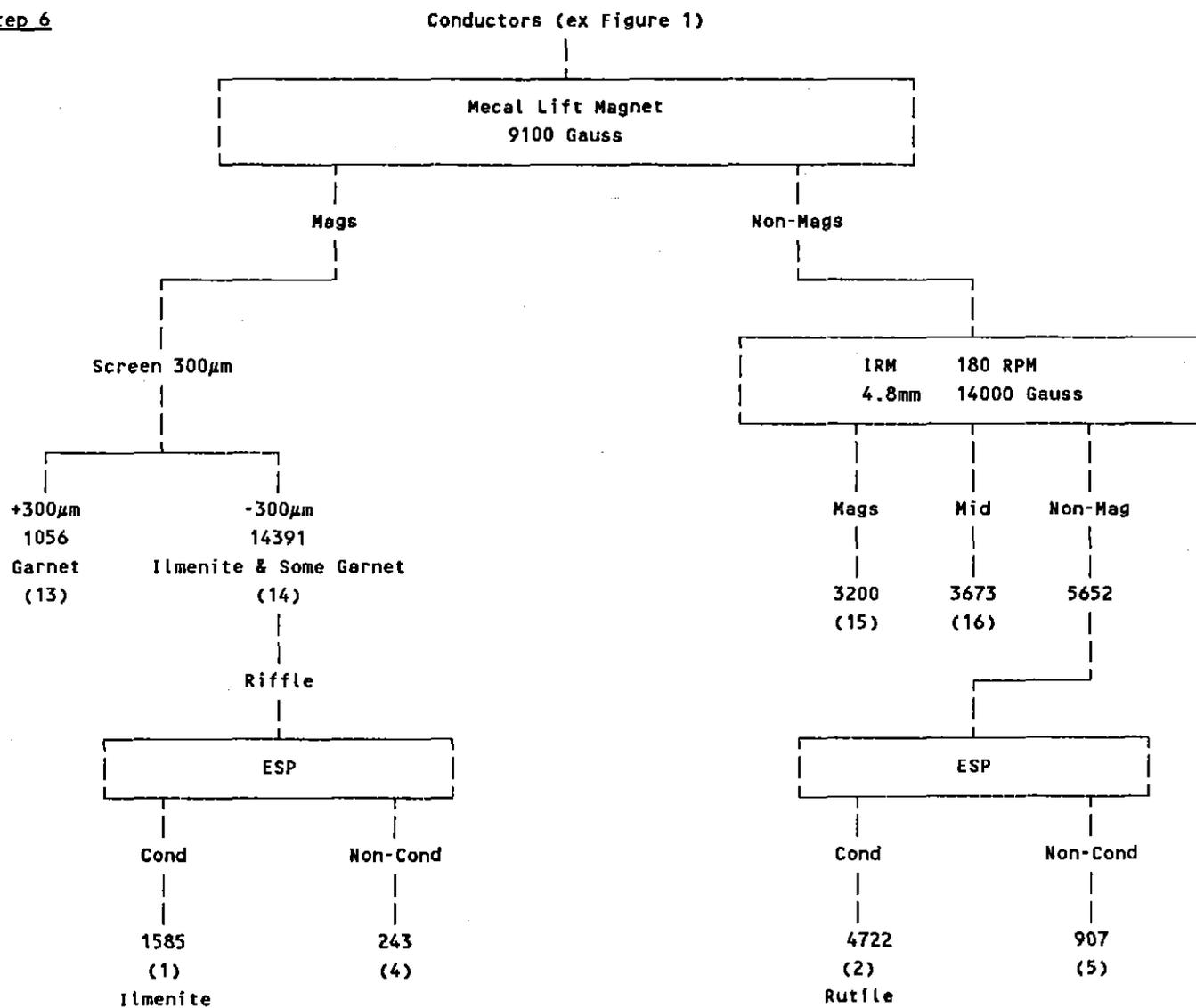


Note: Composite ZP1 and ZP2 = 5284g. Riffle 164.4g to TBE. Sink = 154.4g (3)

12c

FIGURE 5
MAGNETIC SEPARATION AND ELECTROSTATIC PLATE CLEANING OF CONDUCTORS

Step 6



Legend: Weights in grams
() = Sample No.

FIGURE 6
FOLLOW-UP TESTWORK - RUTILE

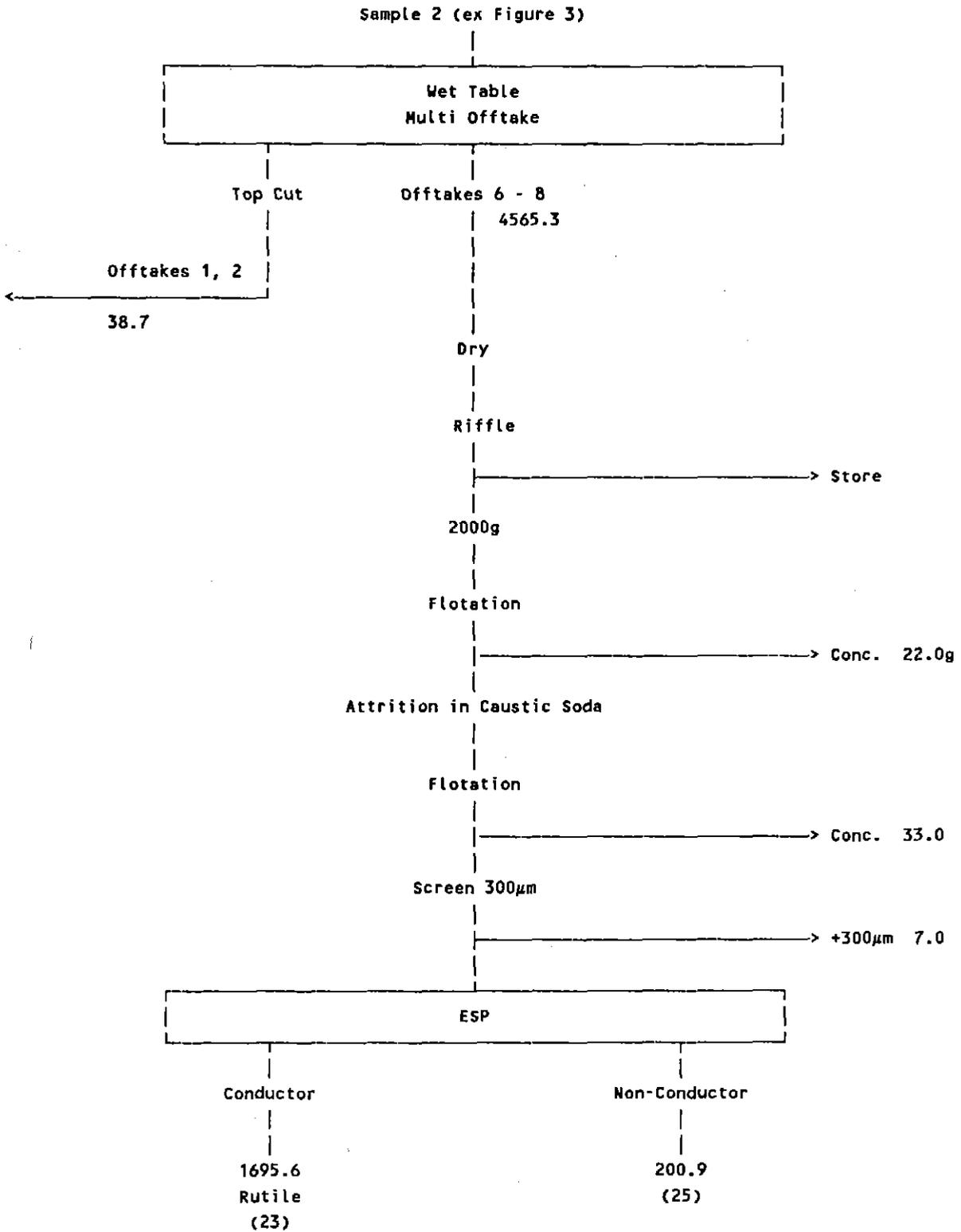
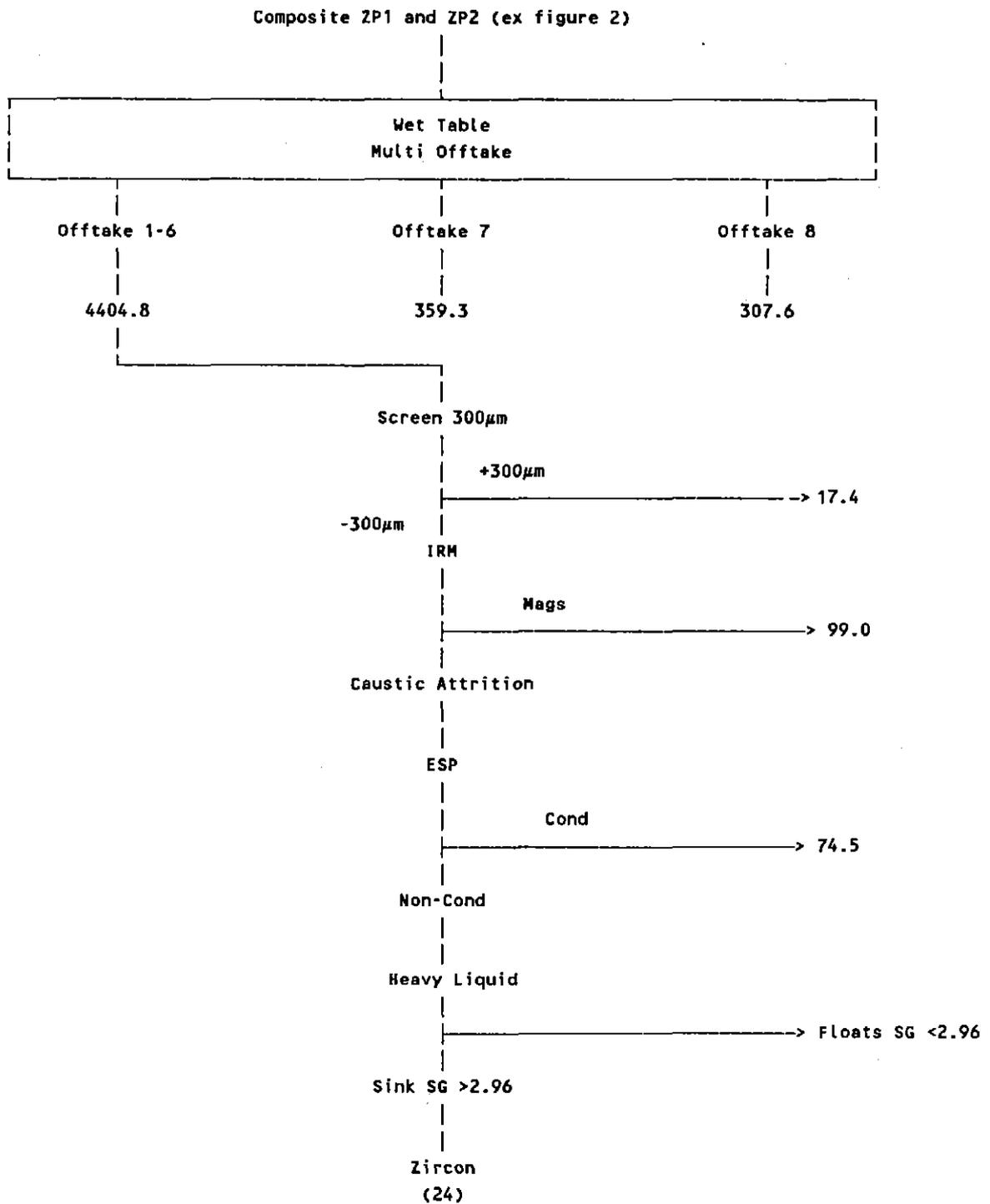


FIGURE 7
FOLLOW-UP TESTWORK - ZIRCON



APPENDIX I
MINTEK SERVICES - MINERAGRAPHIC REPORT

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Mintek
Services



542136

27 Burma Road Lesmurdie Western Australia 6076
PO Box 242 Kalamunda Western Australia 6076

Telephone: (09) 291 7491

14th April, 1989

Mr. D.R. Moyses
Ammtec
6 MacAdam Place
BALCATTWA WA 6021

Mineragraphic Report IL 29605

A2046/1

Order No. 5980
27th February, 1989


J.E. Borner

MINTEK SERVICESMINERAGRAPHIC DESCRIPTION

Sample No. A2046/1 AMMTEC
Polished section

Registered No. IL 29605

MEGASCOPIIC CHARACTERISTICS

Nature of Sample: Ilmenite sample A2046/1, Assay 1.46% Cr₂O₃
Minerals Visible: Fine ilmenite.
Texture: Finely granular and porous.
Colour: Grey and dark grey.
Grain Size: Very fine and fine-grained.
Other Comments: Many of the ilmenite grains are seen under a binocular microscope to be finely porous, possibly due to the effects of leaching. Zoned grains could also be present. The polished grain mount will be examined with the SEM in order to determine if chromite is present. Leucoxene is a general term for the alteration products of ilmenite.

MICROSCOPIC CHARACTERISTICSMINERAGRAPHY

Constituents: (Percent visual estimate)

99% Ilmenite occurs as very fine and fine-grained, often finely porous and translucent subangular to rounded detrital grains that when examined with the aid of the SEM revealed that chromium is absent. Trace Mn was detected in many of the ilmenite grains examined. Two of the ilmenite grains enclosed very fine zircon grains, and rarely very fine quartz and pyrite grains and clusters. All phases of titanium enrichment can be seen in most of the ilmenite grains examined. This is reflected by the variation in colour at the grain boundaries, and zoning. Secondary rutile appears to have been developed at the grain boundaries during weathering and leaching processes that depleted iron from the ilmenite. Magnetite and hematite rims are absent.

1% Chromite occurs as four fine subangular and subrounded grains that show no evidence of alteration or leaching at the grain boundaries.

Texture: Finely granular.

Surficial Alteration: Weathering, leaching and supergene enrichment of ilmenite.

Mineralogy: Fine leached and supergene enriched ilmenite grains with minor chromite (chrome spinel).

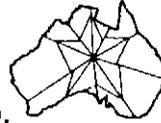
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-2-

Sample No. A2046/1 AMMTEC
Polished section

Remarks: No chromium was detected in the ilmenite grains when these were examined in some detail with the SEM. Chromite is present as four detrital grains that would account for the 1.46% Cr₂O₃ content of the ilmenite concentrate.

MINERALOGY: FINE LEACHED AND SUPERGENE ENRICHED ILMENITE
GRAINS WITH MINOR CHROMITE (CHROME SPINEL).



ANNTEC

AUSTRALIAN METALLURGICAL AND MINERAL TESTING CONSULTANTS PTY LTD.

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.....
D.R. MOYSES
SENIOR METALLURGIST


.....
G.W. LLOYD
MANAGING DIRECTOR

130

3-004
copy 1



ANNTEC

AUSTRALIAN METALLURGICAL AND
MINERAL TESTING CONSULTANTS PTY LTD.

METALLURGICAL TESTWORK CONDUCTED UPON

A THREE TONNE BULK SAMPLE FROM THE

LANHERNE DEPOSIT

FOR

NATIONAL MINERAL SANDS PTY LTD

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(i)

SUMMARY

1. A three tonne bulk sample from the Lanherne deposit (from line 1400N) was supplied for metallurgical testing.
2. It was determined that the material contained :

	<u>% Weight</u>	<u>% HM</u>
>2mm Rock	4.50	
Sand	90.09	5.13
Slime	5.41	
Feed	100.00	4.63

3. Slime and table concentration recovered 98.0 kg of heavy mineral concentrate, at a grade of 81% heavy mineral, which was forwarded to Readings Metallurgical Services Pty Ltd, for WHIMS testwork.
4. Single stage WHIMS recovered 31.50% of the feed to magnetics which contained 0.41% non-magnetic.
5. Three options for second stage WHIMS were investigated.
6. Single stage WHIMS is the preferred option.
7. The WHIMS non-magnetics were returned for dry plant testwork.
8. Final rutile and zircon products were forwarded for chemical analysis.
9. Cassiterite was shown to concentrate at the top of the wet table.

(ii)

10. The percentage rutile and zircon in the head heavy mineral were determined to be :

	RX	Z%
Line 1400N	9	12
Bulk Sample Modal Analysis	12.1	8.5
Bulk Sample Testwork	8.7	8

11. There is a major loss of leucoxene in the primary wet concentrate, based on modal analysis.
12. Modal analysis is not overly accurate.
13. The overall rutile and zircon recovery based on the testwork is probably over-optimistic.
14. Allowing for increased primary concentrate grade and further elimination of trash "light heavies" in a secondary wet plant, the overall rutile and zircon recovery are each estimated to be 85%.
15. The testwork appears to have emphasised the need for efficient attritioning, and the number of electrostatic plate stages used to clean the rutile may have been influenced by inadequate attritioning. A final attritioning stage was required after flotation before a satisfactory rutile product was recovered.

1. INTRODUCTION

A request was received from Mr. David Gillett, acting on behalf of National Mineral Sands Pty Ltd., for a programme of metallurgical testwork to be conducted upon a three tonne bulk sample from the Lanherne, King Island, heavy mineral deposit.

The required testwork included spiral concentration testwork and the preparation of a bulk heavy mineral concentrate for WHIMS testing followed by dry plant testwork, to be conducted upon the WHIMS non-magnetics.

The rougher spiral testwork was to be conducted upon a representative portion taken from the bulk sample supplied and with scavengers and cleaner spiral testwork to be conducted upon the appropriate products produced during the spiral concentration stages of the bulk sample.

Previous plant operations at the site had stockpiled an ilmenite product and as the earlier laboratory testwork (Ammtec Report A2046) had indicated high chrome (1.46% Cr O₃) in ilmenite, wet magnetic separations to discard a magnetic product was a priority in the development of a plant flowsheet.

Subsequent to the spiral concentration the recovered heavy mineral concentrate was accordingly forwarded to Readings Metallurgical Services Pty Ltd for WHIMS testwork. After an assessment of the RMS test results all single stage test products were recombined and repassed at the selected conditions to remove a magnetic fraction (ilmenite) before three second stage options were investigated. Apart from selected product samples, the second stage option products were then dried and returned to Ammtec for the dry plant testwork.

2. TESTWORK - SCOPE OF WORK

Details of the scope of work, as indicated by the client, is given in Appendix I with the overall test procedure illustrated by Figure 1.

- 2 -

3. SAMPLE SUPPLIED

A total of 20 x 120 litre drums of material were received. the drums were emptied and the material spread over a concrete floor and allowed to air dry. The solids were then blended using a rotary splitter and a 1/12 portion split for the rougher spiral testwork and a head sample.

4. HEAD SAMPLE

One drum of solids (1/12 portion of the total sample) was screened to remove the >2mm rock (4.5%) and the <2mm then split into 12 fractions using a rotary splitter. A head sample was then split from one of the fractions. The head sample was water attritioned and then deslimed by repeated washing and decantation with the sand fraction then separated in heavy liquid (TBE SG = 2.96) with the following results :

	(g)	
Weight <2mm head sample	1283.8	
Weight attritioned deslimed sand	1211.1	
Weight slime	72.7	= 5.66 slime in <2mm ore = 5.41 % slime in feed
Weight sand to TBE	1211.1	
Weight sink (SG >2.96)	62.2	= 5.13% HM in sand = 4.84% HM in <2mm ore = 4.63% HM in feed

The particle sizing distribution for the heavy liquid (SG = 2.96) sink and float products are given below for the sand fractions :

Aperture (μ m)	Sink (SG >2.96)		Float (SG <2.96)	
	Weight % Retained	Weight % Passing	Weight % Retained	Weight % Passing
+500	1.5	98.5	1.8	98.2
-500+355	4.3	94.2	12.4	85.8
-355+250	12.2	82.0	36.5	49.3
-250+180	21.8	60.2	26.1	23.2
-180+125	25.9	34.3	14.4	8.8
-125+90	30.3	4.0	7.8	1.0
-90 +63	3.2	0.8	0.7	0.3
-63 +45	0.6	0.2	0.2	0.1
-45	0.2		0.1	
	100.0		100.0	

In the closed circuit tests, a total of 25-30 kg of solids are charged to the pump hopper and pumped to a eightway distributor above the spiral. Usually 2-3 distributor pipes are directed to the spiral with the remaining material returned to the pump hopper. A high rate of circulation is maintained in an attempt to avoid segregation in the pump hopper.

Automatic samplers are used to cut the product streams at the same time for a set period to allow calculations of feed rate etc. Water is maintained at the same level and an equivalent weight of dry solids added to the pump hopper after each test.

Comparative spiral tests between different makes were not conducted and each series was restricted to one make of spiral. A Mineral Deposits 7 Turn MG5 spiral was used for both the rougher and scavenger tests with a Mineral Deposits HG5 used for the cleaner testwork.

6.1. Closed Circuit Rougher Spiral Testwork (MG5)

Test data are given in Table 1, with the weight to concentrate/heavy mineral recovery illustrated by Figure 2 and the weight to concentrate/grade by Figure 3.

6.2. Closed Circuit Cleaner Spiral Testwork (HG5)

Test data are given in Table 2 with the weight to concentrate/heavy mineral recovery/grade illustrated by Figure 4.

6.3. Closed Circuit Scavenger Spiral Testwork (MG5)

During the rougher open circuit spiral operation (see Section 6.4) the middlings were normally returned to the pump hopper (closed circuit) with rougher concentrate and rougher tailing the two outflow.

However, for a short period, in order to collect material for the scavenger testwork, the middling pipe was diverted and a total of 74 kg (dry weight basis) of rougher middling collected.

- 5 -

All cleaner tailing was collected and air dried before rougher middling and cleaner tailing were blended in the ratio of 2.5:1 respectively.

Test data are given in Table 3 with the weight to concentrate/heavy mineral recovery/grade illustrated by Figure 5.

6.4. Open Circuit Bulk Concentrate Production

In the bulk rougher testwork the ore was fed at a controlled rate using a vibrating feeder onto a conveyor belt and transported to and slurried with water in a scrubber trommel. Rock >2mm was discharged from the end of the trommel screen, while the slurry passed through the screen into a pump hopper and was pumped to the spiral pump feed hopper. Concentrate and tailing products were diverted to 200 litre drums while the middlings were recycled.

The rougher concentrate was air dried to a sufficiently low moisture level so that the material would flow freely using a vibrating feeder, approximately 60 kg was then split for cleaner spiral testwork, and the remainder pumped to the cleaner spiral. Cleaner concentrate was handled in a similar manner.

Product samples, concentrate and tailings were taken at regular intervals 10, 5 and 3 minutes for the rougher, cleaner and recleaner tests respectively.

The products were handled wet and apart from the feed were not weighed, hence the weight recovery to concentrate for each run was determined using the standard formula :

$$C = F \frac{f - t}{c - t}$$

Where: C = Weight of concentrate (kg)
 F = Weight of feed (kg)
 f = % Heavy mineral in feed
 t = % Heavy mineral in tail
 c = % Heavy mineral in concentrate

All calculations were based on a "sand only" basis as all products were deslimed before being dried for % heavy mineral determination.

The following weight recoveries were determined:

Spiral	Feed*	HM	Concentrate		Weight to Concentrate (%)	Heavy Mineral Recovery (%)
			(kg)	(%)		
Rougher	2724	5.13	1039	12.18	38.1	90.60
Cleaner	979**	12.18	434	24.38	44.3	88.71
Recleaner	434	24.38	201.6	48.10	46.5	91.65

Notes: * Rock and slime free basis
 ** 60 kg rougher conc to closed circuit cleaner tests

6.5. Wet Table Upgrading

Recleaner concentrate was much too low for dry plant testwork, so the material was further upgraded to 81.1% using a laboratory wet table.

Overall spiral and table results are given in Figure 6.

Calculated recleaner concentrate was 201.6 kg containing 97.0 kg of heavy mineral. As previously discussed, this material was not weighed, and was not air dried, but fed wet to the wet table. Based on the wet table products, the weight of table feed was 175.5 kg containing 90.5 kg of heavy mineral.

A comparison of the procedures is given below :

	Heavy Mineral Concentrate Balance	
	Based on Spirals	Based on Wet Table Products
Weight Concentrate (kg)	201.6	175.5
Heavy Mineral (%)	48.1	51.6
Heavy Mineral (kg)	97.0	90.5

6.6. Concentrate to RMS

A total of 98 kg of concentrate, at a grade of 81.1% HM, was forwarded to Readings Metallurgical Services Pty Ltd.

6.7. Mineralogy

Information regarding the mineralogical composition of the heavy mineral was not available at the commencement of the program, but information later provided by the client indicated a high percentage (27%) of tourmaline in line 1400N representing the bulk sample. Tourmaline has a reasonably low specific gravity 2.98-3.2, and the presence of the large amount of this mineral could explain the need to take a large percentage weight to concentrate, and resulting low concentrate grades, to recover a reasonable percentage of heavy mineral. However, such a high percentage weight cut is probably not required to recover a high percentage of HM. Details of the mineralogical assessment, by Applied Petrographic Services, of line 1400N are given in Table 4.

Samples of the heavy mineral for the head sample and wet concentration products were forwarded to Analabs for modal analysis and these data, Table 5, show that the light heavies, tourmaline (SG 2.98-3.2) and amphibole (SG 3-3.2) are close to a greater than 50% of the so called heavy mineral (SG >2.96) in the rougher, cleaner and recleaner tailing; ie 52.2, 55.1 and 49.7% respectively, with 66.1% and 72.7% tourmaline in the wet table middling and wet table tailing respectively.

6.8. Wet Concentration - Recovery of Selected Heavy Minerals

Although the procedure probably does not have high accuracy, based on the weight of heavy mineral in the samples and the modal analysis, the recovery of selected heavy minerals is given in Table 6 with a summary given below, including a comparison of the data for the concentrate forwarded for WHIMS testwork :

Mineral	Wet Conc Recovery %	Weight to WHIMS	
		Based On Wet Conc Products	Based On Conc to RMS
Rutile	97.3	16.44	11.36
Zircon	97.8	11.61	9.46
Leucoxene	67.1	9.26	8.93
Tourmaline	44.1	15.84	3.50

Although there are discrepancies in the data, eg the percentage rutile of 12.1% may actually be closer to the 9% indicated for line 1400N, the data probably indicate that a high recovery of rutile and zircon can be expected while it is likely that there will be significant loss of leucoxene in the primary wet concentration.

6.9. Discussion

The concentration curves from the closed circuit spiral tests appeared flatter than expected and the need to cut a high percentage weight to concentrate to ensure a reasonably high percentage heavy mineral recovery, with associated lower concentrate heavy mineral grades, seems to be explained by the high percentage of trash "light heavy" minerals present in the mineral suite.

A facility for heavy liquid analysis (TMF) may be required for plant operations to ensure maximum recovery of VHM.

7. WET HIGH INTENSITY MAGNETIC SEPARATION (WHIMS) TESTWORK

The scope of work for the Readings wet magnetic separation testwork was to :

1. Determine the relationship for the weight to magnetic/non-magnetic loss for a single WHIMS stage.
2. Investigate a second WHIMS stage to determine the feasibility of producing a clean rutile/zircon mixed concentrate.
3. Recombine test products and process through WHIMS using selected conditions. Return non-magnetic product to Ammtec for dry plant testwork.

The sample supplied had a heavy mineral content, as determined by RMS using bromoform analysis, as follows:

<u>Product</u>	<u>% Weight</u>
Sinks	80.76
Floats	19.24
<u>Total</u>	<u>100.00</u>

The RMS "in house" analysis of the heavy mineral gave an ilmenite content of approximately 35% ilmenite. For procedure see Appendix II.

7.1. Single Stage WHIMS Testwork

The following is a summary of the details of the testwork provided by Readings Metallurgical Services Pty Ltd.

The "as received" sample was split into six portions with the portions being subjected to WHIMS treatment at increasing magnetic field strengths. This involved the removal of a highly susceptible magnetic fraction first, followed by WHIMS treatment. The results of the six WHIMS tests are given in Table 7.

7.2. Metallurgical Analysis of WHIMS Magnetics

Each of the WHIMS magnetic fractions was assessed for non-mag losses in the magnetics using the RMS "in house" analysis technique with the following results :

<u>Field Strength (Amps)</u>	<u>Magnetics % Weight</u>	<u>% Non-Mags in Magnetics</u>
70	12.23	0.57
80	15.85	0.55
90	20.58	0.47
100	24.76	0.37
110	26.73	0.44
120	29.07	0.41

The objective of the WHIMS was to reject the maximum weight of material to magnetics consistent with low non-magnetic (ir rutile and zircon) losses in the magnetics. This criteria seems to have been met by the 120 Amp test and consequently all single stage products were recombined and repassed at 120 Amps before the second stage testwork.

It was also reported that the non-magnetics from the six WHIMS passes contained between 20 and 30% quartz and further upgrading by spiral concentration was required before further testwork.

7.3. RMS Second stage Testwork (Three Options)

The first stage WHIMS non-magnetics were spiral concentrated and the spiral middlings then subjected to three options as to further upgrading steps. Bromoform analysis results for the spiral products are given below :

Product (Test 27)	Weight %	HM %	HM Dist %
Conc	29.40	93.05	54.76
Mid	27.98	66.81	37.42
Tail	10.96	35.67	7.82
Total	68.34	73.10	100.0

Note: Visual inspection of the tail heavy mineral fractions showed that it contained light heavy trash minerals.

Because of the limited weight of Test 27 middlings, it was decided by RMS that option 1, spiral testwork, be conducted first and product splits be taken. The spiral products were then split into two, to facilitate options 2 and 3.

Option 1

This involved taking the middling product and retreating this flow on another spiral to make a further reject tail and a concentrate to, presumably, join the concentrate from Test 27.

Option 2

This involved the passing of test 27 middlings over a WHIMS at 120 Amps, followed by the retreatment of the non-magnetics over a wet table. The use of a wet table was to simulate a spiral as there was insufficient material to conduct an actual spiral test.

Option 3

This involved the passing of Test 27 middlings over a WHIMS at 150 Amps, followed by the retreatment of the non-magnetics over a wet table. Again the use of the wet table was to simulate a spiral as there was insufficient material to conduct an actual spiral test.

Samples of all outflows from the three options were forwarded to Gold Coast Assay services for TMF analysis so as to determine the distribution of the various minerals. However, samples of the spiral concentrate and spiral middling from Test 27 were not forwarded so that an overall balance for the WHIMS testwork is not available.

7.4. Second Stage Test Results

The general test procedure, and weight balance, for the three options are illustrated by Figure 7. Detailed test data, TMF Analysis results for the outflows, are given in Table 8.

7.5. Discussion

The first stage WHIMS testwork effectively removed an appreciable percentage of the feed weight (29%) with the loss of only 0.41% of non-magnetics in the magnetics.

Examinations of the data for the second stage WHIMS Options 2 and 3, Tests 32 and 33, indicates a further recovery of magnetics of 4.74% and 6.22% weight respectively. However, the apparent improved recovery of the >4.05, <4.38 and the >4.38 non-magnetic fractions in Tests 32 and 33 (Table 8) probably reflects the difference in wet concentration table performance Vs spiral performance rather than an overall improvement due to the second stage of WHIMS and probably indicates the need for wet tables within the secondary circuit to treat spiral middlings.

Also, the use of the second stage WHIMS is unlikely to decrease the equipment units required for the dry plant. ie HT Rolls and induced roll magnetic machines.

The preferred option seems to be a wide rotor single stage WHIMS as this will allow an increase in feed tonnage or allow the second stage option to be installed at a later date after operator confidence in the machine has been established.

It is assumed that RMS will discuss the merits of a wide rotor Vs a normal width rotor in their report.

7.6. Disposal of WHIMS Products

The following products were returned to Ammtec :

Test 27 Conc
Test 27 Tail
Test 32 Mags
Test 34 Conc
Test 34 Tail
Test 33 Mags
Test 35 Conc
Test 35 Tail

The following samples from the treatment flowsheet were not returned :

1. Low intensity magnet pass HS
2. Test 26 mags
3. Test 31 conc (part)
4. Test 31 tail (part)

The above samples were not returned for the following reasons :

1. Highly susceptibles only
2. Retained by RMS for chrome differentiation
3. Test 31 conc sample split retained
4. Test 31 tail sample split retained

8. DRY PLANT TESTWORK

The total weight of material returned by RMS was 61 kg and all material returned was attritioned for 10 minutes with the addition of 1 kg/tonne caustic soda.

8.1. Laboratory Attritioning

A laboratory unit with an active volume of 5 litres was used for the testwork. The attritioner has two four blade turbines and is powered by a variable speed 0.75 kw motor.

After being discharged from the attritioner the solids were deslimed by repeated washing and decantation and then dried. The slime content was determined as follows :

	<u>Weight (kg)</u>
Feed	61.0
Deslimed Sand	59.78
<hr/>	
Weight Slime	1.25 = 2.0%

*Further
slime
ie 4.5%
plus?*

8.2. High Tension and Magnetic Separation

The initial stage of high tension separation was to split the feed into conductor and non-conductor fractions. However, because the material was being processed batchwise, and not continuously as in plant operations, some ilmenite and rutile were recovered from the non-conductor circuit.

8.3. Ilmenite

Details of the test procedure for ilmenite recovery are given in Figure 8.

A number of essentially ilmenite products were produced, Samples 3/1, 3/2, 3/3 and 3/4. Samples were not submitted for either analysis or mineralogy.

8.4. Rutile and Leucoxene

Details of the test procedure are given in Figures 9 and 10.

The conductor, after recovery of the ilmenite, were further cleaned by electrostatic plate cleaning and magnetic separation to remove the ilmenite/leucoxene (sample 3/7).

Sample 3/7 was screened at (300µm) to remove tourmaline and a sample submitted for analysis with the following results (all data in %):

	TiO ₂	Fe ₂ O ₃	FeO	ZrO ₂	Al ₂ O ₃	SiO ₂
Sample 3/26	75.7	11.5	1.30	0.10	2.63	2.50

The high Al₂O₃ and SiO₂ may be due to tourmaline indicating the need for additional high tension cleaning. It was also reported, verbally by the analyst, that the sample had a loss on ignition of >4% and this does not seem to be explained by any need for additional attritioning to remove organic material.

After removal of the magnetic ilmenite/leucoxene fraction, the non-magnetics were further cleaned by electrostatic plate cleaning and then wet tabled using the multi-product offtake to produce 10 fractions. The dry products were inspected and products 8-10, which may have contained some quartz, were reserved while products 1-7 were composited for flotation to remove sulphides.

*Flotation
using
water*

The rutile product was riffle split to provide 2 kg lots for flotation and these were floated in a laboratory agitair cell using potassium amyl xanthate as the collector with TEB added as a frother. Typical flotation conditions were as follows:

Feed = 2000 grms
 Natural pH = 6.5 (Perth Tap Water)
 Collector (PAX) 100 g/t —> Condition 3 minutes
 TEB 10 drops —> Condition 2 minutes
 Flotation 3 min 30 secs

The tailings (rutile) were attritioned, deslimed and dried, concentrates (sulphides) were filtered and dried.

Flotation testing indicated the presence of considerable slime and, because of the problems in obtaining a clean conductor product from the electrostatic plate cleaning, the rutile product

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was again attritioned with caustic soda to remove slime before a final high tension roll cleaning stage. Product analyses and sizing data are given in Table 9.

8.5. Tin in Rutile

Literature relating to the previous plant operations reported that tin in rutile was controlled by a wet table operation with the top cut from the wet table directed to a second wet table to recover cassiterite and the rutile returned to the circuit. This seems a reasonable approach because of the variation in specific gravity for the two minerals, 6.8 - 7.1 for cassiterite compared with 4.2 for rutile.

Small samples (10 grams each) were taken from the first seven products from the top of the table, before the preparation of the composite sample, and submitted for SnO₂ analysis. Analytical results and the distribution of SnO₂ in the table products are given in Table 10.

8.6. Zircon

The non-conductor, non-magnetic fraction from the zircon circuit (Figure 11) was wet tabled using a multi-product offtake to remove some silica as an elutriator was not available to remove fine quartz from the non-conductor product.

The wet table results follow :

Product	Weight (g)	Weight (%)	HM (%)
Conc 1	178.9	0.9	
Conc 2	735.9	3.6	
Conc 3	1353.6	6.6	
Conc 4	1795.7	8.7	
Conc 5	1797.9	8.7	
Conc 6	1367.9	6.7	97.9
Conc 7	2314.5	11.2	60.3
Conc 8	2254.0	10.9	
Mid	4473.1	21.7	7.0
Tail	4328.5	21.0	
Total	20600.0	100.0	

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The dry products were visually examined and the high quartz products, Conc 8, mid and tailing, which represented 53.6 of the feed weight to the table and contained 7.0% HM, were excluded from the composite.

Insufficient product was available for air table testwork to remove quartz and alumina from the zircon product and, because of a need to recover a reasonable quantity of zircon product the quartz was removed from concentrates 6 and 7 by heavy liquid separation before the sinks were composited with concentrates 1 - 5.

The composite sample was then attritioned and magnetically cleaned before the non-magnetics (Sample 3/22) were submitted for analysis. These results and the particle sizing distribution for the product (3/22) are given in Table 11.

The zircon product was offgrade with respect to TiO_2 (1.94%), Alumina (4.0%) and free quartz (2.5%) and these figures explain the low percentage ZrO_2 in the sample (58.8%).

The product (3/22) was then further cleaned using both electrostatic plates and high tension rolls to remove the TiO_2 bearing material, see Figure 12.

The only practical means of removing both quartz and alumina from the product was by heavy liquid separation, and after removal of the quartz using TBE (SG = 2.96) the TiO_2 and Fe_2O_3 for sample 3/24 were determined to be 0.17 and 0.06% respectively.

The sinks from 3/24 were then forwarded for TMF separation at SG = 3.85 to remove the alumina and to recover a zircon sample for detailed chemical analysis as required by the client.

Heavy liquid separation data are given below :

	Weight (g)	Weight (%)
<2.96	1.1	1.7
<2.96 <3.85	1.1	1.7
>3.85	63.5	96.6
<hr/>	<hr/>	<hr/>
	65.7	100.0

A detailed chemical analysis of the sink product is given in Table 12.

8.7. Mineralogy

Only a limited number of dry plant products were submitted for modal analysis and these data are given in Table 13.

9. RECOVERY OF SELECTED MINERALS

9.1. Rutile and Zircon

Dry plant outflows with their rutile and zircon content, based on assumed figures for ilmenite, modal analyses and visual estimates using a binocular microscope are given in Tables 14 and 15 for rutile and zircon respectively.

Comparative product weights based on the concentrate forwarded to RMS and the dry plant products and outflows are given below :

	Weight (kg)	
	Rutile	Zircon
Conc to RMS	11.61	9.26
Dry Plant Testwork	11.6	10.8

Rutile and zircon loss in dry plant ilmenite is minor and is about 0.1% of the total input. Most of the intermediate products; eg non-conductors in the rutile circuit really represent recirculating material and not actual losses.

Non-conductor wet table losses are also minor, trace for rutile and 0.3% for zircon, but these figures probably do not reflect the actual losses which would be experienced in plant operation.

Considering the worst case scenario, from RMS Option 1, retreatment of the spiral middlings, the retreat spiral tailing is 13.46% of the feed weight and contains 3.2% rutile and 1.75% zircon (assuming the non-mag >4.05 <4.38 fraction is rutile and the >4.38 fraction is zircon).

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The rutile and zircon loss to tailings are determined to be :

Rutile : $98.0 \times 0.1346 \times 0.032 = 0.422 \text{ kg}$
 Zircon : $98.0 \times 0.1346 \times 0.0175 = 0.231 \text{ kg}$

The overall rutile balance is given by :

	Weight (kg)	Weight (%)
Primary Wet Tailings	0.460	3.8
WHIMS Magnetics	0.064	0.5
Option 2 Spiral Tailing	0.422	3.5
Dry Plant Ilmenite	0.016	0.1
Product and Recirculating Cond	11.130	92.1
Total	12.092	100.0

The overall ^{Zircon} balance is given by :

	Weight (kg)	Weight (%)
Primary Wet Tailings	0.260	2.3
WHIMS Magnetics	0.062	0.6
Option 2 Spiral Tailing	0.231	2.1
Dry Plant Ilmenite	0.016	0.1
Product and Recirculating Cond	10.601	94.5
Total	11.17	100.0

9.2. Ilmenite and Leucoxene

According to modal analyses (by Analabs) the percentage of these minerals were :

	%
Ilmenite	3.4
Alt Ilmenite	32.1
Leucoxene	11.3

} 35.5

Therefore: the weight of ilmenite/alt ilmenite in the concentrate forwarded to RMS is :

$$79.5 \times 0.355 = 28.2$$

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WHIMS ilmenite recovery was :

93 x 0.315 = 29.3 kg

Recovered from dry
plant testwork (3/1-3/4) = 5.4

Total ilmenite = 34.7 kg (+6.5 kg)

Leucoxene (offgrade) screened was only 1.8 kg, hence it seems possible that some of the material reported as leucoxene may have been recovered as ilmenite/altered ilmenite.

9.3. Tourmaline

The estimated tourmaline input to the dry plant, based on the concentrate to RMS, was only 3.50 kg and this was low compared with the 15.84 kg from the wet plant data.

The weight of tourmaline in two dry plant products is determined below :

Product	Sample No.	Weight kg	Tourmaline	
			%	Wt (kg)
N/C Magnetics	3/8	8649.9	59.6	5.16
N/C Conductors	3/11	6280.3	20.4	1.28
				6.44

The N/C magnetics may be a discard fraction but the N/C cond require further treatment to discard the tourmaline, possibly electrostatic plates before a fraction is returned to the secondary wet plant.

10. AN ESTIMATE OF PLANT RUTILE AND ZIRCON RECOVERY

The testwork rutile and zircon recovery figures are probably too high for an operating plant for the following reasons :

1. Heavy mineral concentration was only 81% HM whereas at least 90% is probably required as feed to an elutriator.

2. A considerable quantity of tourmaline and other aluminium silicates entered the non-conductor circuit; eg 4% Al₂O₃ in zircon which would be required to be discarded through the secondary wet circuit.
3. Wet magnetic testwork was conducted under ideal laboratory conditions and with clean plate boxes. Losses will increase if plate boxes become affected by scale build-up etc.

More realistic losses may be :

	<u>%</u>
Primary Wet Plant	6
WHIMS	2
Secondary Wet Plant	6
Dry Plant, Windage etc.	1
<hr/>	
Estimated overall loss	15
Expected recovery	85
<hr/>	
Total	100

11. MISCELLANEOUS TESTS

11.1. Head sample (Heavy Mineral)

Following a request from the client, a sample of the head feed heavy mineral was submitted for gold and tantalum analyses. Data are given below :

	<u>ppm</u>	
	<u>(1)</u>	<u>(2)</u>
Gold	0.020	0.074
Ta	70	
Sn	198	

11.2. Radioactivity

As previously reported in Ammtec report A2046, thorium and uranium analyses for selected samples were determined to be :

Product	Sample No.	ppm	
		Th	U
Bulk Spiral Tailing	18	1.96	0.41
Ilmenite (1)	19	13.50	2.85
Rutile (2)	20	10.50	15.80
MONAZITE -> No 1 N/C IRM Mags (10)	21	765	52.80
HM Ex HM Conc	22	139	17.70

The above materials would not be classed as radioactive substances with the ilmenite and rutile clean products.

The IRM mags, in which the monazite has been concentrated, would require some management; ie should not be dumped and used for building landfill.

11.3. Lanherne Deposit - Indicated Resources

A request was received from the client for a comparison to be made between the percentage rutile and zircon in heavy mineral from the preliminary drill hole bulk sample (Ammtec Report A2046) with the figures given in the Peter H. Stilt & Associates Pty Ltd report No. 20/88 on the Evaluation of Mineral Sand Resources at Naracoopa, King Island.

The Lanherne Beach indicated resource from the above report is 156000 tonnes of heavy mineral containing 11300 tonnes of rutile and 14000 tonnes of zircon, or 7.2% rutile and 9.0% zircon in heavy mineral.

It would be a major investigation to determine the rutile and zircon for all outflow from the testwork for Job A2046. However, considering the final products only and the dry plant feed heavy mineral the percentage rutile and zircon are determined below :

Product	Weight (kg)	% Dry Plant Feed HM
Feed	42.08	
Rutile	4.014	9.5
Zircon	4.129	9.8

These figures compare favorably with the Peter H. Stilt report and indicate that the report figures are not overly optimistic.

12. DISCUSSION

12.1. Calculating Mineral Recovery

The procedure adopted for the determination of mineral recovery, modal analysis and weights of products, is probably not high and improved values could be obtained if it were possible to use heavy liquid separation at different SG's (TMF separations). However, following the closure of the only commercial laboratory in Western Australia performing such analyses, the number of samples which can be tested is limited.

12.2. Rutile and Zircon in Bulk Sample Heavy Mineral

The percentage rutile and zircon determined for line 1400N, and the bulk sample as determined by two different procedures are given below :

	Percentage	
	Rutile	Zircon
Line 1400N - Modal analysis	9	12
Bulk Sample - Modal analysis	12.1	8.5
Bulk Sample - Test Results	8.7	8

TABLES

TABLE 1

TEST DATA FOR CLOSED CIRCUIT ROUGHER SPIRAL TESTWORK

A2094/01 MDL M65 7T		03/89	33A:A2094 Nat Min Sands Rougher				A2094/01 MDL M65 7T		03/89	33A:A2094		
Wet Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %	
Conc.	2046	347	1699	1130.0	11.75	66.51	0.48	Conc.	38.67	11.75	454.40	82.16
Mid.	1261	276	985	695.1	2.68	70.57	0.30	Mid.	23.79	2.68	63.75	11.53
Tail	5771	512	5259	1096.9	0.93							
			7943	2922.0		68.00	0.78	C + M	62.46	8.30	518.15	93.69
						20.86	0.47	Tail	37.54	0.93	34.91	6.31
						36.79	1.25	Calc. F	100.00	5.53	553.06	100.00

A2094/02 MDL M65 7T		03/89	33A:A2094 Nat Min Sands Rougher				A2094/02 MDL M65 7T		03/89	33A:A2094		
Prod. Wet Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %	
Conc.	2114	347	1767	1230.2	15.08	69.62	0.53	Conc.	29.81	15.08	449.55	80.17
Mid.	1238	276	962	680.5	3.65	70.74	0.29	Mid.	16.49	3.65	60.19	10.73
Tail	10280	512	9768	2216.0	0.95							
			12497	4126.7		70.01	0.82	C + M	46.30	11.01	509.74	90.90
						22.69	0.95	Tail	53.70	0.95	51.01	9.10
						33.02	1.77	Calc. F	100.00	5.61	560.75	100.00

A2094/03 MDL M65 7T		03/89	33A:A2094 Nat Min Sands Rougher				A2094/03 MDL M65 7T		03/89	33A:A2094		
Prod. Wet Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %	
Conc.	2447	347	2100	1467.2	12.18	69.87	0.53	Conc.	41.04	12.18	499.83	90.05
Mid.	2050	276	1774	1289.1	1.38	72.67	0.55	Mid.	36.06	1.38	49.76	8.96
Tail	8910	512	8398	819.0	0.24							
			12272	3575.3		71.15	1.18	C + M	77.09	7.13	549.59	99.01
						9.75	0.35	Tail	22.91	0.24	5.50	0.99
						29.13	1.53	Calc. F	100.00	5.55	555.09	100.00

A2094/04 MDL M65 7T		03/89	33A:A2094 Nat Min Sands Rougher				A2094/04 MDL M65 7T		03/89	33A:A2094		
Prod. Wet Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %	
Conc.	2363	347	2016	1395.9	13.51	69.24	0.60	Conc.	35.17	13.51	475.21	87.08
Mid.	2448	276	2172	1558.0	1.62	71.73	0.67	Mid.	39.26	1.62	63.60	11.65
Tail	10388	512	9876	1014.6	0.27							
			14064	3958.5		70.53	1.27	C + M	74.43	7.24	538.81	98.74
						10.27	0.43	Tail	25.57	0.27	6.90	1.26
						28.22	1.70	Calc. F	100.00	5.46	545.71	100.00

TABLE 1 - Continued

A2094/05 MDL M65 7T		03/89	33A:A2094		Nat Min Sands	Rougher	A2094/05 MDL M65 7T		03/89	33A:A2094		
Prod.	Net Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %
Conc.	2046	347	1699	1176.2	13.94	69.23	0.50	Conc.	33.13	13.94	461.84	85.00
Mid.	1081	276	805	546.6	3.02	67.90	0.23	Mid.	15.40	3.02	46.50	8.56
Tail	10531	512	10019	1827.4	0.68							
			12523	3550.2		68.80	0.74	C + M	48.53	10.48	508.34	93.56
						18.24	0.78	Tail	51.47	0.68	35.00	6.44
						28.35	1.52	Calc. F	100.00	5.43	543.34	100.00

A2094/06 MDL M65 7T		03/89	33A:A2094		Nat Min Sands	Rougher	A2094/06 MDL M65 7T		03/89	33A:A2094		
Prod.	Net Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %
Conc.	1347	347	1000	682.0	22.45	68.20	0.29	Conc.	17.33	22.45	389.15	75.57
Mid.	987	276	711	494.2	4.49	69.51	0.21	Mid.	12.56	4.49	56.40	10.95
Tail	12400	512	11888	2758.2	0.99							
			13577	3934.4		68.74	0.50	C + M	29.90	14.90	445.55	86.52
						23.20	1.19	Tail	70.10	0.99	69.40	13.48
						28.93	1.69	Calc. F	100.00	5.15	514.96	100.00

A2094/07 MDL M65 7T		03/89	33A:A2094		Nat Min Sands	Rougher	A2094/07 MDL M65 7T		03/89	33A:A2094		
Prod.	Net Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %
Conc.	1527	347	1180	811.6	19.05	68.78	0.35	Conc.	21.85	19.05	416.27	77.62
Mid.	1885	276	1609	1150.8	2.99	71.52	0.49	Mid.	30.98	2.99	92.64	17.28
Tail	9982	512	9470	1751.8	0.58							
			12259	3714.2		70.36	0.84	C + M	52.84	9.63	508.91	94.90
						18.50	0.75	Tail	47.16	0.58	27.36	5.10
						30.30	1.59	Calc. F	100.00	5.36	536.26	100.00

A2094/08 MDL M65 7T		03/89	33A:A2094		Nat Min Sands	Rougher	A2094/08 MDL M65 7T		03/89	33A:A2094		
Prod.	Net Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %
Conc.	1901	347	1554	1081.0	14.78	69.56	0.46	Conc.	29.93	14.78	442.35	82.93
Mid.	1245	276	969	678.6	3.10	70.03	0.29	Mid.	18.79	3.10	58.24	10.92
Tail	10190	512	9678	1852.3	0.64							
			12201	3611.9		69.74	0.75	C + M	48.72	10.29	500.59	93.85
						19.14	0.79	Tail	51.28	0.64	32.82	6.15
						29.60	1.55	Calc. F	100.00	5.33	533.41	100.00

TABLE 1 - Continued

A2094/09 MDL M65 7T		03/89	33A:A2094 Nat Min Sands Rougher			A2094/09 MDL M65 7T		03/89	33A:A2094			
Wet Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %	
Conc.	1709	347	1362	949.8	15.38	69.74	0.41	Conc.	27.60	15.38	424.48	80.66
Mid.	1444	276	1168	820.6	3.23	70.26	0.35	Mid.	23.84	3.23	77.02	14.64
Tail	9852	512	9340	1671.0	0.51							
			11870	3441.4		69.98	0.76	C + M	51.44	9.75	501.50	95.29
						17.89	0.72	Tail	48.56	0.51	24.76	4.71
						28.99	1.47	Calc. F	100.00	5.26	526.26	100.00

A2094/10 MDL M65 7T		03/89	33A:A2094 Nat Min Sands Rougher			A2094/10 MDL M65 7T		03/89	33A:A2094			
Prod.	Wet Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %
Conc.	2197	347	1850	1276.6	13.59	69.01	0.55	Conc.	33.89	13.59	460.60	87.06
Mid.	1454	276	1178	838.5	2.15	71.18	0.36	Mid.	22.26	2.15	47.86	9.05
Tail	9981	512	9469	1651.5	0.47							
			12497	3766.6		69.85	0.91	C + M	56.15	9.05	508.46	96.10
						17.44	0.71	Tail	43.95	0.47	20.61	3.90
						30.14	1.61	Calc. F	100.00	5.29	529.07	100.00

TABLE 2
TEST DATA FOR CLOSED CIRCUIT CLEANER SPIRAL TESTWORK

A2094/11 MDL M65 7T		7/04/89		34A:A2077 Nat Min Sands Cleaner			A2094/11 MDL M65 7T		7/04/89		34A:A2077	
Prod.	Wet Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %
Conc.	1510	390	1120	730.6	46.15	65.23	0.31	Conc.	16.84	46.15	776.98	62.57
Mid.	1476	280	1196	772.5	14.87	64.59	0.33	Mid.	17.90	14.87	264.71	21.32
Tail	10853	512	10341	2836.4	3.06							
			12657	4339.5		64.90	0.64	C + M	34.64	30.07	1041.69	83.89
						27.43	1.22	Tail	65.36	3.06	200.01	16.11
						34.29	1.86	Calc. F	100.00	12.42	1241.70	100.00

A2094/12 MDL M65 7T		7/04/89		34A:A2077 Nat Min Sands Cleaner			A2094/12 MDL M65 7T		7/04/89		34A:A2077	
Prod.	Wet Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %
Conc.	2258	390	1868	1233.3	36.1	66.02	0.53	Conc.	28.82	36.10	1040.29	77.21
Mid.	1439	280	1159	776.4	9.15	66.99	0.33	Mid.	18.14	9.15	165.99	12.32
Tail	9445	512	8933	2270.1	2.66							
			11960	4279.8		66.39	0.86	C + M	46.96	25.69	1206.28	89.53
						25.41	0.97	Tail	53.04	2.66	141.09	10.47
						35.78	1.83	Calc. F	100.00	13.47	1347.37	100.00

A2094/13 MDL M65 7T		7/04/89		34A:A2077 Nat Min Sands Cleaner			A2094/13 MDL M65 7T		7/04/89		34A:A2077	
Prod.	Wet Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %
Conc.	2793	390	2403	1606.9	29.56	66.87	0.69	Conc.	36.55	29.56	1074.49	92.77
Mid.	1236	280	956	627.7	6.87	65.66	0.27	Mid.	14.20	6.87	97.55	7.51
Tail	9476	512	8964	2186.1	2.55							
			12323	4420.7		66.53	0.96	C + M	50.55	23.19	1172.04	90.29
						24.39	0.94	Tail	49.45	2.55	126.10	9.71
						35.87	1.89	Calc. F	100.00	12.98	1298.14	100.00

A2094/14 MDL M65 7T		7/04/89		34A:A2077 Nat Min Sands Cleaner			A2094/14 MDL M65 7T		7/04/89		34A:A2077	
Prod.	Wet Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %
Conc.	2822	390	2432	1635.2	25.96	67.24	0.70	Conc.	48.68	25.96	1263.80	91.23
Mid.	1337	280	1057	697.8	4.01	66.02	0.30	Mid.	20.77	4.01	83.31	6.01
Tail	6082	512	5570	1025.9	1.25							
			9059	3358.9		66.87	1.00	C + M	69.46	19.39	1347.11	97.24
						18.42	0.44	Tail	30.54	1.25	38.18	2.76
						37.08	1.44	Calc. F	100.00	13.85	1385.29	100.00

TABLE 2 - Continued

A2094/15 MDL M65 7T		7/04/89		34A:A2077 Nat Min Sands Cleaner			A2094/15 MDL M65 7T		7/04/89		34A:A2077	
Net Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %	
Conc.	2165	390	1775	1198.5	29.31	67.52	0.51	Conc.	39.96	29.31	1171.13	88.68
Mid.	1841	280	1561	1064.6	3.55	68.20	0.46	Mid.	35.49	3.55	126.00	9.54
Tail	4960	512	4448	736.4	0.96							
			7784	2999.5		67.84	0.97	C + M	75.45	17.19	1297.13	98.22
						16.56	0.32	Tail	24.55	0.96	23.57	1.78
						38.53	1.29	Calc. F	100.00	13.21	1320.70	100.00

A2094/16 MDL M65 7T		7/04/89		34A:A2077 Nat Min Sands Cleaner			A2094/16 MDL M65 7T		7/04/89		34A:A2077	
Prod.	Net Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %
Conc.	1644	390	1254	863.9	37.57	68.88	0.37	Conc.	22.64	37.57	850.44	70.43
Mid.	1395	280	1115	738.8	12.03	66.26	0.32	Mid.	19.36	12.03	232.91	19.29
Tail	8277	512	7765	2213.4	2.14							
			10134	3816.0		67.65	0.69	C + M	42.00	25.80	1093.35	89.72
						28.50	0.95	Tail	58.00	2.14	124.13	10.28
						37.66	1.64	Calc. F	100.00	12.07	1207.48	100.00

TABLE 3 - Continued

A2094/21 MDL M65 7T		21/04/89 34A:A2077		Nat Min Sands Scavenger			A2094/21 MDL M65 7T		21/04/89 34A:A2077			
Wet Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %	
Conc.	2108	390	1718	1118.6	4.32	65.11	0.48	Conc.	30.57	4.32	132.08	68.56
Mid.	1340	280	1060	728.1	1.70	68.69	0.31	Mid.	19.90	1.70	33.83	17.56
Tail	10098	512	9586	1812.0	0.54							
			12364	3656.7		66.48	0.79	C + M	50.47	3.29	165.91	86.12
						18.90	0.78	Tail	49.53	0.54	26.74	13.88
						29.59	1.57	Calc. F	100.00	1.93	192.65	100.00

A2094/22 MDL M65 7T		21/04/89 34A:A2077		Nat Min Sands Scavenger			A2094/22 MDL M65 7T		21/04/89 34A:A2077			
Wet Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %	
Conc.	1996	390	1606	1082.9	4.45	67.43	0.46	Conc.	27.31	4.45	121.52	62.03
Mid.	1427	280	1147	806.1	1.83	70.28	0.35	Mid.	20.33	1.83	37.20	18.99
Tail	9850	512	9338	2076.6	0.71							
			12091	3965.6		68.65	0.81	C + M	47.63	3.33	158.72	81.02
						22.24	0.89	Tail	52.37	0.71	37.18	18.98
						32.80	1.70	Calc. F	100.00	1.96	195.90	100.00

A2094/23 MDL M65 7T		21/04/89 34A:A2077		Nat Min Sands Scavenger			A2094/23 MDL M65 7T		21/04/89 34A:A2077			
Wet Weight	Bucket	Slurry	Dry Weight	HM %	% Solids	tph (Tonnes)	Prod.	Weight %	% HM	HM Units	HM Dist. %	
Conc.	1445	390	1055	769.4	6.08	72.93	0.33	Conc.	19.07	6.08	115.92	58.49
Mid.	1393	280	1113	694.8	2.04	62.43	0.30	Mid.	17.22	2.04	35.12	17.72
Tail	11289	512	10777	2571.3	0.74							
			12945	4035.5		67.54	0.63	C + M	36.28	4.16	151.04	76.21
						23.86	1.10	Tail	63.72	0.74	47.15	23.79
						31.17	1.73	Calc. F	100.00	1.98	198.19	100.00

TABLE 4
MINERALOGICAL ASSESSMENT OF LINE 1400N

[Applied Petrographic Services]

240W 0 - 9.5m 320W 0 - 5.5m
 260W 0 - 7.5m 240W 0 - 3.5m
 280W 0 - 7.5m 360W 0 - 1.5m
 300W 0 - 7.5m

	Total	Hand Mags	0.5A Mags	0.9A Mags	1.2A Mags	1.2A Non Mags
Magnetite	<1	100	-	-	-	-
Ilmenite	21	-	98	56	-	-
Leucoxene, Ilmenite	9	-	-	15	14	-
Iron Oxides	<1	-	1	<1	-	-
Chromite	-	-	-	-	-	-
Garnet	4	-	1	13	-	-
Tourmaline	27	-	-	11	71	8
Staurolite	4	-	-	2	12	-
Epidote	1	-	-	3	2	-
Rock Fragments	-	-	-	-	-	-
Alumino-Silicates	3	-	-	-	-	9
Other Silicates	-	-	-	-	-	-
Rutile	9	-	-	-	<1	25
Leucoxene	7	-	-	-	-	18
Zircon	12	-	-	-	-	33
Quartz	1	-	-	-	-	2
Pyrite	2	-	-	-	1	5
Corundum	<1	-	-	-	-	<1
Spinel	-	-	-	-	-	-
Apatite	-	-	-	-	-	-
Monazite	<1	-	-	-	-	<1
Scheelite	<1	-	-	-	-	<1
Cassiterite	-	-	-	-	-	-
Weight (g)	11.1138	0.0054	0.5368	3.2489	3.2603	4.0624
%	100	0.1	4.8	29.2	29.3	36.6
No. of Points			516	504	568	668

TABLE 5
LANHERNE CONCENTRATION PRODUCTS MODAL ANALYSES OF HEAVY MINERAL

[Data by Analabs - R. Townend]

Mineral	Head	Conc to RMS	Rougher Tail	Cleaner Tail	Recleaner Tail	Wet Table Mid	Wet Table Mid
Ilmenite	2.6	3.4	-	0.3	-	0.3	-
Alt Ilmenite	24.8	32.1	1.5	6.5	16.5	4.9	4.6
Leucoxene	9.9	11.3	13.7	8.0	9.5	8.4	8.2
Rutile	12.1	14.3	0.4	1.1	2.4	0.4	1.1
Limonite	0.7	0.2	2.4	1.7	1.5	-	0.7
Chromite	0.1	0.4	-	-	-	-	-
Zircon	8.5	11.9	0.3	0.7	1.5	-	-
Monazite	0.6	1.4	0.8	0.3	1.8	-	-
Staurolite	4.8	7.0	10.9	8.7	7.2	5.9	3.3
Tourmaline	25.7	4.4	28.4	42.5	45.4	66.1	72.7
Amphibole	-	5.4	23.8	12.6	4.7	-	-
Garnet	2.9	3.7	-	1.9	1.9	-	-
Corundum	-	1.5	0.4	-	-	-	-
Al Sil	-	0.3	3.9	4.9	3.0	5.5	6.8
Others	0.4	0.6	3.1	1.6	2.3	5.1	2.2
Pyrite	3.4	2.1	4.7	8.5	0.5	3.4	0.4
Quartz	-	-	5.7	0.7	2.2	-	-
Kyanite	3.5	-	-	-	-	-	-

TABLE 6
WET CONCENTRATION - RECOVERY OF SELECTED HEAVY MINERALS

Product HM	Weight (kg)	Percentage				Weight, Kg			
		R	Z	L	T	R	Z	L	T
Feed	139.7	12.1	8.5	9.9	25.7	16.90	11.87	13.80	35.90
Rougher Tail	13.1	0.4	0.3	13.7	28.4	0.05	0.04	1.79	3.72
Cleaner Tail	13.5	1.1	0.7	8.0	42.5	0.15	0.09	1.08	5.74
Recleaner Tail	8.8	2.4	1.5	9.5	45.4	0.21	0.13	0.84	4.00
Table Mid	9.1	0.4	-	8.4	66.1	0.04	-	0.76	6.02
Table Tail	0.8	1.1	-	8.2	72.7	0.01	-	0.07	0.58
Total in Tailings						0.46	0.26	4.54	20.06
Recovery to Concentrate						97.3	97.8	67.1	44.1
Calculated Weight to Concentrate						16.44	11.61	9.26	15.84
Conc to RMS	79.5	14.3	11.9	11.3	4.4	11.36	9.46	8.93	3.50

R = Rutile
 Z = Zircon
 L = Leucoxene
 T = Tourmaline

TABLE 7
TEST DATA - SINGLE STAGE WHIMS TESTWORK

1. Test Conditions 70 AMPS (Test 10)

Product	Wt %
H/S	0.15
Mags	12.23
N/Mags	87.62
TOTAL	100.00

4. Test Conditions 100 AMPS (Test 13)

Product	Wt %
H/S	0.18
Mags	24.76
N/Mags	75.06
TOTAL	100.00

2. Test Conditions 80 AMPS (Test 11)

Product	Wt %
H/S	0.16
Mags	15.85
N/Mags	83.99
TOTAL	100.00

5. Test Conditions 110 AMPS (Test 14)

Product	Wt %
H/S	0.14
Mags	26.73
N/Mags	73.13
TOTAL	100.00

3. Test Conditions 90 AMPS (Test 12)

Product	% Wt
H/S	0.14
Mags	20.58
N/Mags	79.28
TOTAL	100.00

6. Test Conditions 120 AMPS (Test 15)

Product	Wt %
H/S	0.16
Mags	29.07
N/Mags	70.77
TOTAL	100.00

TABLE 8
 DETAILED TEST RESULTS FOR SECOND STAGE WHIMS TESTWORK

Product	Wt%	Quartz	Assay %								Quartz	Distribution %								
			N/Mags				Mags					N/Mags				Mags				
			>2.85 <3.79	>3.79 <4.05	>4.05 <4.38	>4.38	>2.85 <3.85	>3.85 <4.05	>4.05 <4.38	>4.38		>2.85 <3.79	>3.79 <4.05	>4.05 <4.38	>4.38	>2.85 <3.85	>3.85 <4.05	>4.05 <4.38	>4.38	
GRAVITY ONLY OPTION 1																				
Test 31																				
Conc	14.52	26.96	9.13	3.45	7.32	3.57	45.01	2.03	2.33	0.20	43.01	53.47	60.99	71.16	68.75	54.74	36.37	63.26	60.67	
Tail	13.46	38.53	8.57	2.38	3.20	1.75	40.14	3.83	1.46	0.14	56.99	46.53	39.01	28.84	31.25	45.26	63.63	36.74	39.33	
Total	27.98	32.53	8.86	2.94	5.34	2.69	42.67	2.89	1.91	0.17	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
120A WHIMS + GRAVITY OPTION 2																				
Test 32																				
Mags	4.74	0.92	0.41	0.11	0.22	0.11	69.06	21.12	7.66	0.39	0.47	0.82	0.64	0.67	0.73	29.94	57.30	64.30	37.45	
Conc	9.36	15.01	15.07	8.07	16.34	7.46	28.31	7.42	2.05	0.27	15.21	59.42	92.72	98.62	98.48	24.23	39.76	33.98	51.21	
Tail	13.88	56.10	6.80	0.39	0.08	0.04	36.11	0.37	0.07	0.04	84.32	39.76	6.64	0.71	0.79	45.83	2.94	1.72	11.34	
Total	27.98	33.01	8.48	2.91	5.54	2.53	39.09	6.24	2.02	0.18	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
150A WHIMS + GRAVITY OPTION 3																				
Test 33																				
Mags	6.22	0.97	0.46	0.13	0.20	0.09	76.56	14.82	6.48	0.29	0.65	1.20	1.05	0.80	0.74	42.37	63.69	70.88	48.91	
Conc	8.74	13.27	17.59	8.30	17.48	8.51	27.25	5.58	1.85	0.17	12.58	64.32	94.05	98.36	98.40	21.19	33.70	28.43	40.49	
Tail	13.02	61.43	6.33	0.29	0.10	0.05	31.45	0.29	0.03	0.03	86.77	34.48	4.90	0.84	0.86	36.44	2.61	0.69	10.60	
Total	27.98	32.95	8.54	2.76	5.55	2.70	40.17	5.17	2.03	0.13	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	

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TABLE 9
RUTILE PRODUCT - CHEMICAL ANALYSIS AND PARTICLE SIZING DISTRIBUTION

[Analytical Data from Analabs Report 675661]

Chemical Analysis

[Data in % Except Where Noted]

TiO ₂	97.2
Fe ₂ O ₃	1.10
MnO	0.02
Cr ₂ O ₃	0.21
Nb ₂ O ₅	0.366
V ₂ O ₅	0.53
MgO	0.015
CaO	<0.01
ZrO ₂	0.22
SiO ₂	0.65
Al ₂ O ₃	0.37
Sn	0.083
S	0.025
U (ppm)	40
Th (ppm)	30

Particle Sizing Distribution

Aperture μm	Weight, %	
	Retained	Passing
+500	-	-
-500 +355	-	-
-355 +250	-	-
-250 +180	1.3	98.7
-180 +125	43.2	55.5
-125 +90	51.6	3.9
-90 +63	3.6	0.3
-63 +45	0.3	-
-45	-	-
Total	100.0	

TABLE 10
THE DISTRIBUTION OF CASSITERITE IN SEVEN RUTILE WET TABLE PRODUCTS

Product	Sample			Cumulative		
	Weight %	SnO ₂		Weight %	SnO ₂	
		Assay, %	Dist, %		Assay, %	Dist, %
Conc 1	1.82	2.41	32.1	1.82	2.41	32.1
Conc 2	6.11	0.76	34.0	7.93	1.14	66.1
Conc 3	11.24	0.155	12.7	19.17	0.56	78.8
Conc 4	19.34	0.051	7.2	38.51	0.31	86.0
Conc 5	19.51	0.038	5.4	58.02	0.22	91.4
Conc 6	17.93	0.028	3.7	75.95	0.17	95.1
Conc 7	24.05	0.028	4.9	100.00	0.14	100.0
Total	100.00	(0.14)	100.0			
Assay		0.083				

TABLE 11
ZIRCON OFFGRADE PRODUCT - CHEMICAL ANALYSIS AND PARTICLE SIZING DISTRIBUTION FOR SAMPLE 3/22

[Analytical Data from Analabs Report 67592]

Chemical Analysis

[Data in %]

ZrO ₂	58.8
TiO ₂	1.94
Fe ₂ O ₃	0.10
Al ₂ O ₃	4.0
ThO ₂	0.013
Free Quartz	2.5

Particle Sizing Distribution

Aperture μm	Weight, %	
	Retained	Passing
+500	-	-
-500 +355	-	-
-355 +250	0.6	99.4
-250 +180	3.0	96.4
-180 +125	13.3	83.1
-125 +90	64.9	18.2
-90 +63	16.2	2.0
-63 +45	1.9	0.1
-45	0.1	-
Total	100.0	

TABLE 12
ZIRCON PRODUCT - ANALYSIS OF TMF SINK PRODUCT

[Data in %]

ZrO ₂	66.2
TiO ₂	0.08
Fe ₂ O ₃	0.06
Al ₂ O ₃	0.19
Cr ₂ O ₃	0.002
P ₂ O ₅	0.163
S	0.06
CaO	0.02
MgO	0.01
U	0.027
Th	0.025
LOI	0.24

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TABLE 13
MODAL ANALYSES FOR FOUR DRY PLANT TESTWORK SAMPLES

Mineral	Zircon Circuit IRM Mags 3/8	Zircon Circuit Conductors 3/11	N/Cond Wet Table Mid 3/29*	N/Cond Wet Table Tail 3/30**
Ilmenite	-	-	0.9	
Alt Ilmenite	1.6	0.3	2.7	
Leucoxene	4.8	14.7	6.2	5.3
Rutile	-	16.0	5.2	1.0
Limonite	-	-	1.8	0.2
Pyrite	-	0.3	0.2	-
Zircon	2.5	26.3	48.5	0.5
Tourmaline	59.6	20.4	19.1	81.0
Al Silicates	0.6	1.8	2.9	5.8
Staurolite	24.3	8.7	9.2	3.0
Quartz	1.5	10.2	-	-
Others	5.1	1.3	3.3	3.2
Others includes garnet, epidote, spinel, quartz etc.				

Note: * 2.8% HM in Table Mid
** 2.7% HM in Table Tail

TABLE 14
DISTRIBUTION OF RUTILE IN PRODUCTS AND TEST OUTFLOWS

Figure	Product	Sample No.	Product Weight (g)	Rutile %	Weight Rutile in Product (g)	% of Total Rutile
	Ilmenite	3/1	2532.0	0.3A	7.6	0.1
	Ilmenite	3/2	1520.0	0.3A	4.6	
	Ilmenite	3/3	1037.9	0.3A	3.1	
	Ilmenite	3/4	321.4	0.3A	1.0	
	N/C	3/6	1305.3	10V	130.5	
	N/C	3/9	222.5	25V	55.6	
	N/C	3/10	298.9	60V	179.3	
	N/C	3/12	156.4	70V	109.5	
	N/C	3/13	142.9	60V	85.7	
	Rutile Table	3/15	940.7	85V	799.6	
	Rutile Table	3/16	225.8	85V	191.9	
	Rutile Table	3/17	14.6	30V	4.4	
	Rutile	3/18	8585.2	100A	8585.2	
	N/C	3/19	267.7	85V	227.5	
	N/C Table Mid	3/29	79.5 *	5.2M	4.1	
	N/C Table Tail	3/30	31.6 *	1.0M	0.3	
	N/C	3/11	6280.3	16.0M	1004.8	
	Mags	3/8	8649.7	-M	-	
	Zircon Comp 1-7		8597.8	2.0A	172.0	
	Sub-total				11566.7	
	WHIMS Mags		30870	0.21	64.8	0.5
	Wet Conc Tailings - See Table				460	3.8
	Total				12091.5	
	Total Weight Heavy Mineral in Feed =				139.7 Kg	
	% Rutile in Feed HM =				8.7	

* = Heavy Mineral
V = Visual Estimate (binocular microscope)

A = Assumed
M = Mineralogy

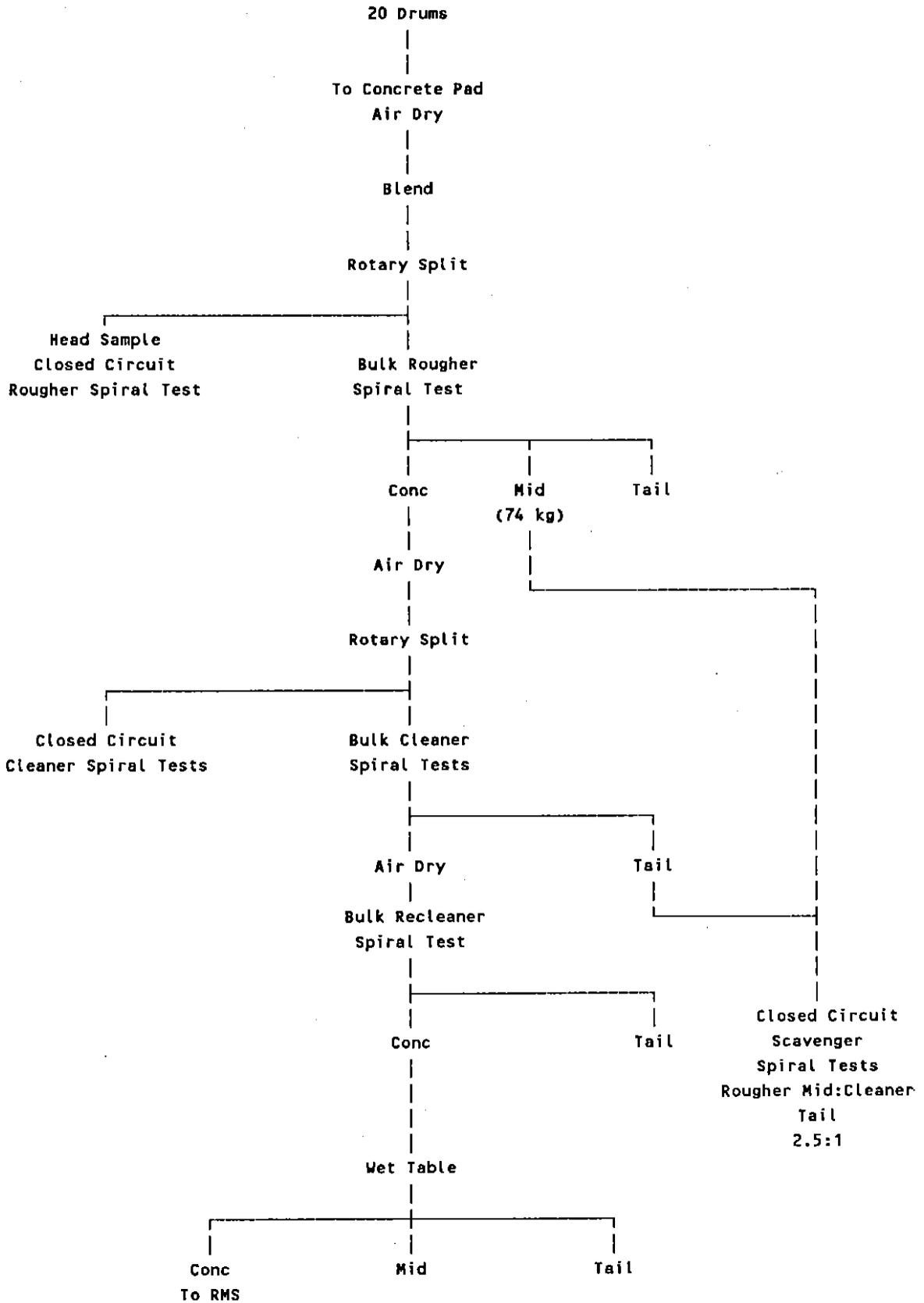
TABLE 15
DISTRIBUTION OF ZIRCON IN PRODUCTS AND TEST OUTFLOWS

Figure	Product	Sample No.	Product Weight (g)	Zircon %	Weight Zircon in Product (g)	% of Total Zircon
	Ilmenite	3/1	2532.0	0.3A	7.6	
	Ilmenite	3/2	1520.0	0.3A	4.6	
	Ilmenite	3/3	1037.9	0.3A	3.1	
	Ilmenite	3/4	321.4	0.3A	1.0	
	N/C	3/6	1305.3	10V	130.5	
	N/C	3/9	222.5	75V	155.8	
	N/C	3/10	298.9	40V	119.6	
	N/C	3/12	156.4	30V	46.9	
	N/C	3/13	142.9	40V	57.2	
	Rutile Prod N/C	3/19	267.7	15V	40.2	
	N/C Table Mid	3/29	79.5 *	48.5M	38.6	0.2
	N/C Table Tail	2/30	31.6 *	0.5M	15.8	0.1
	N/C	3/11	6280.3	26.3	1651.7	
	Mags	3/8	8649.7	2.5M	216.2	
	Zircon Comp 1-7		8597.8	89.1C	7660.6	
	Zircon Table 8-10		773.9 *	90V	696.5	
	Sub-total				10845.9	
	*Heavy Mineral					
	WHIMS Mags		30870	0.2	61.7	0.5
	Wet Conc Tailings (See Table)				260	2.3
	Total				11167.6	
	Total Weight Heavy Mineral in Feed			=	139.7 Kg	
	% Zircon in Feed HM			=	8.0%	

Zircon Comp 1-7, Less Quartz 2.5
 Rutile 2.0
 Kyanite 6.1 (Al₂O₃ = 4.0%)
 10.9
 Zircon 89.1

FIGURES

FIGURE 1
OVERALL TEST PROCEDURE FOR LANHERNE THREE TONNE BULK SAMPLE



Continued...

FIGURE 1 - Continued

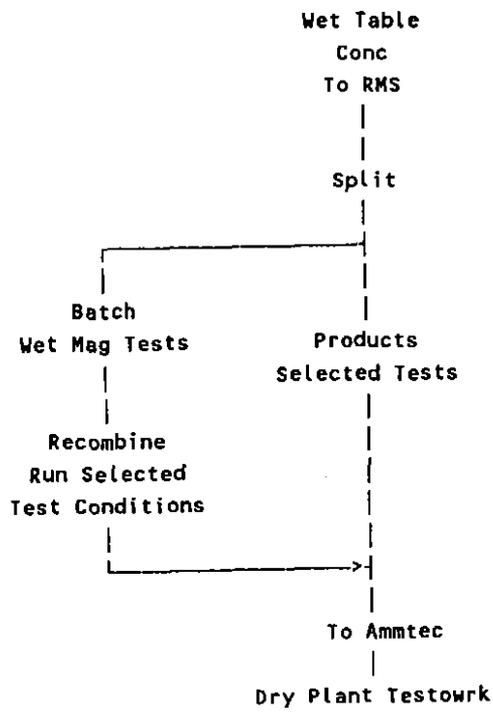
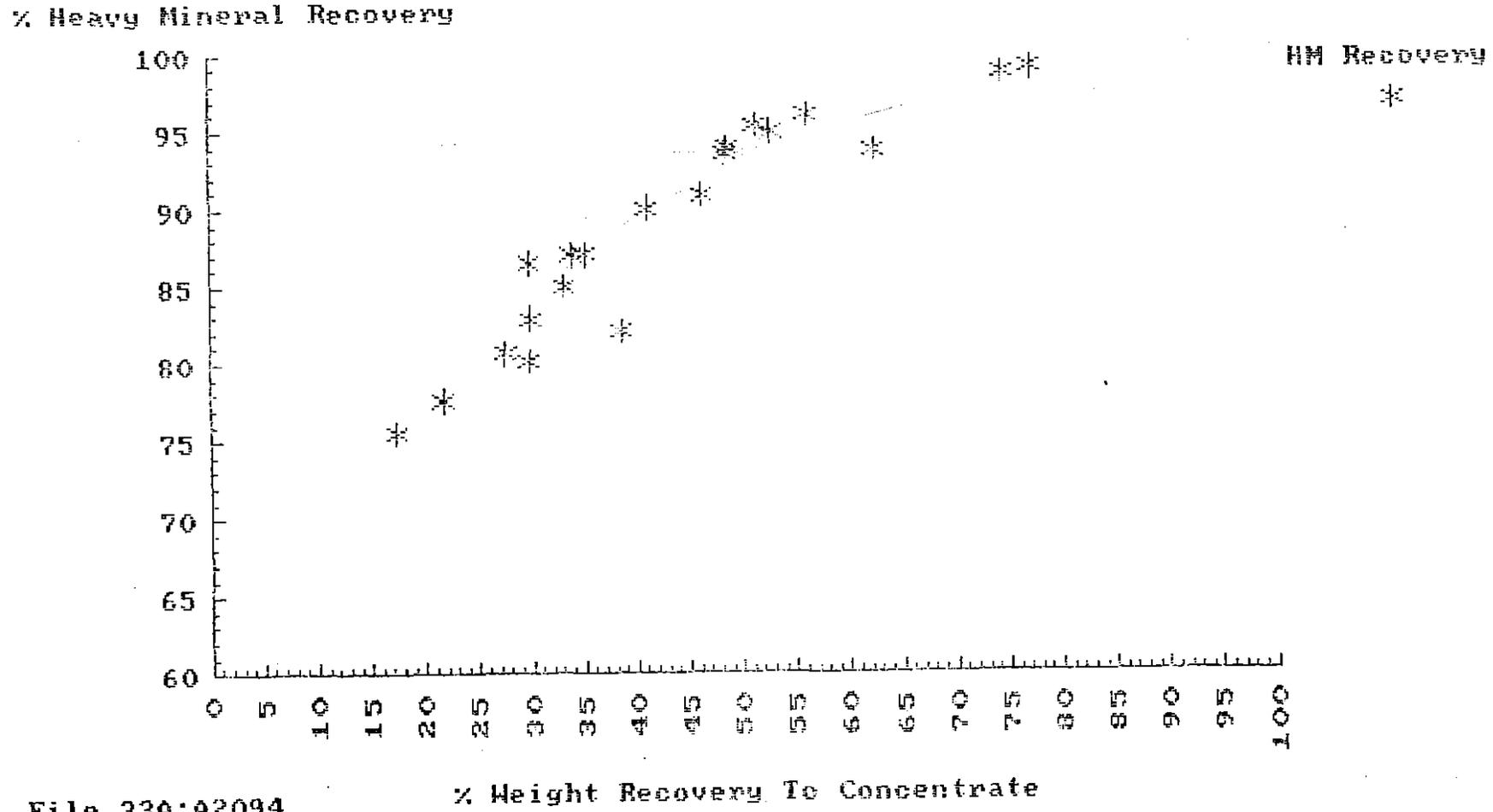


FIGURE 2
National Mineral Sands Pty. Ltd. (MDL MG5 7T)
Rougher Weight/Heavy Mineral Recovery
Feed <2mm Ore - Tests-1-10

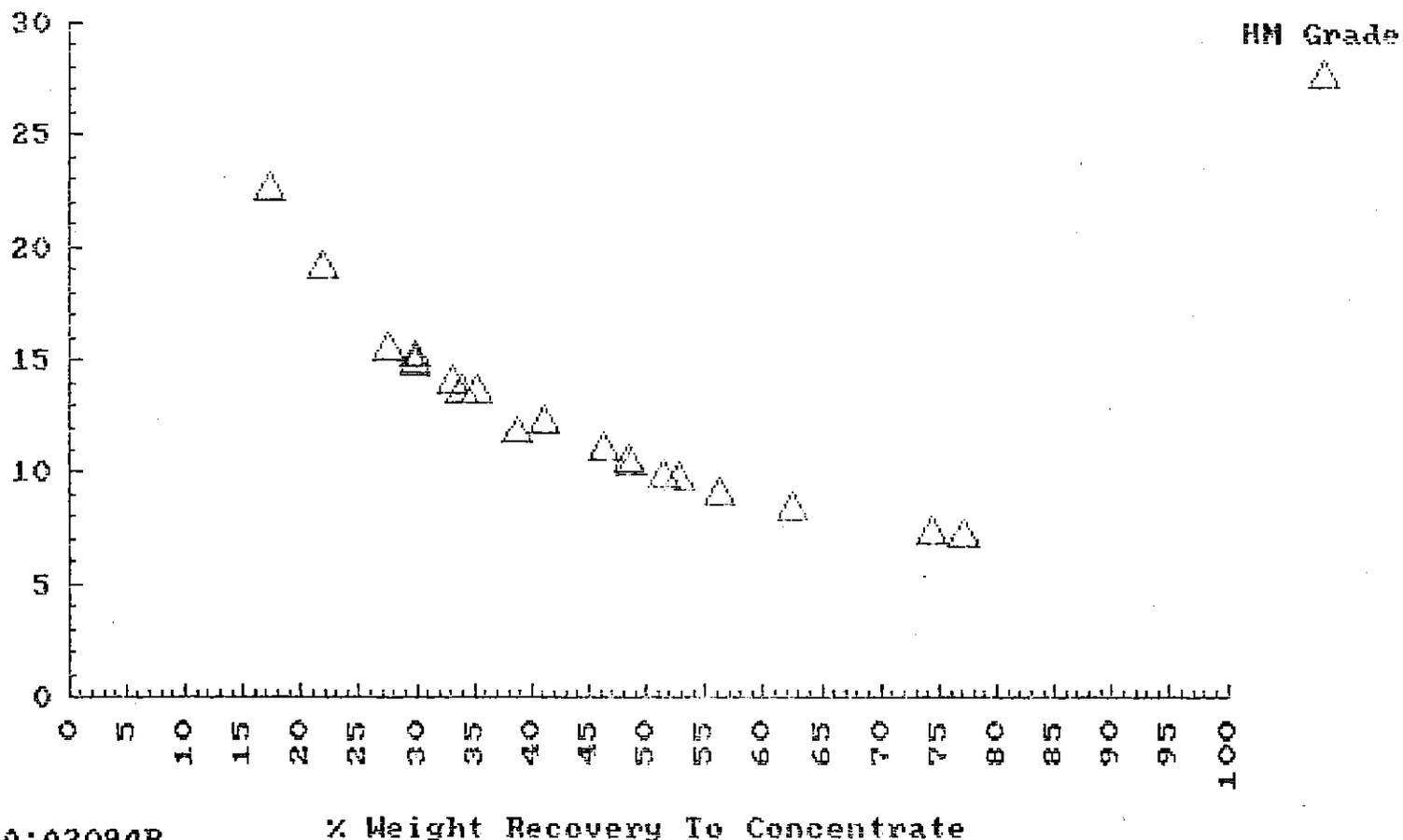


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 AMMTEC Pty Ltd

FIGURE 3

National Mineral Sands Pty. Ltd. (MDL MG5 7T)
Rougher Weight/Heavy Mineral Recovery
Feed <2mm Ore - Tests 1-10

% Heavy Mineral Grade



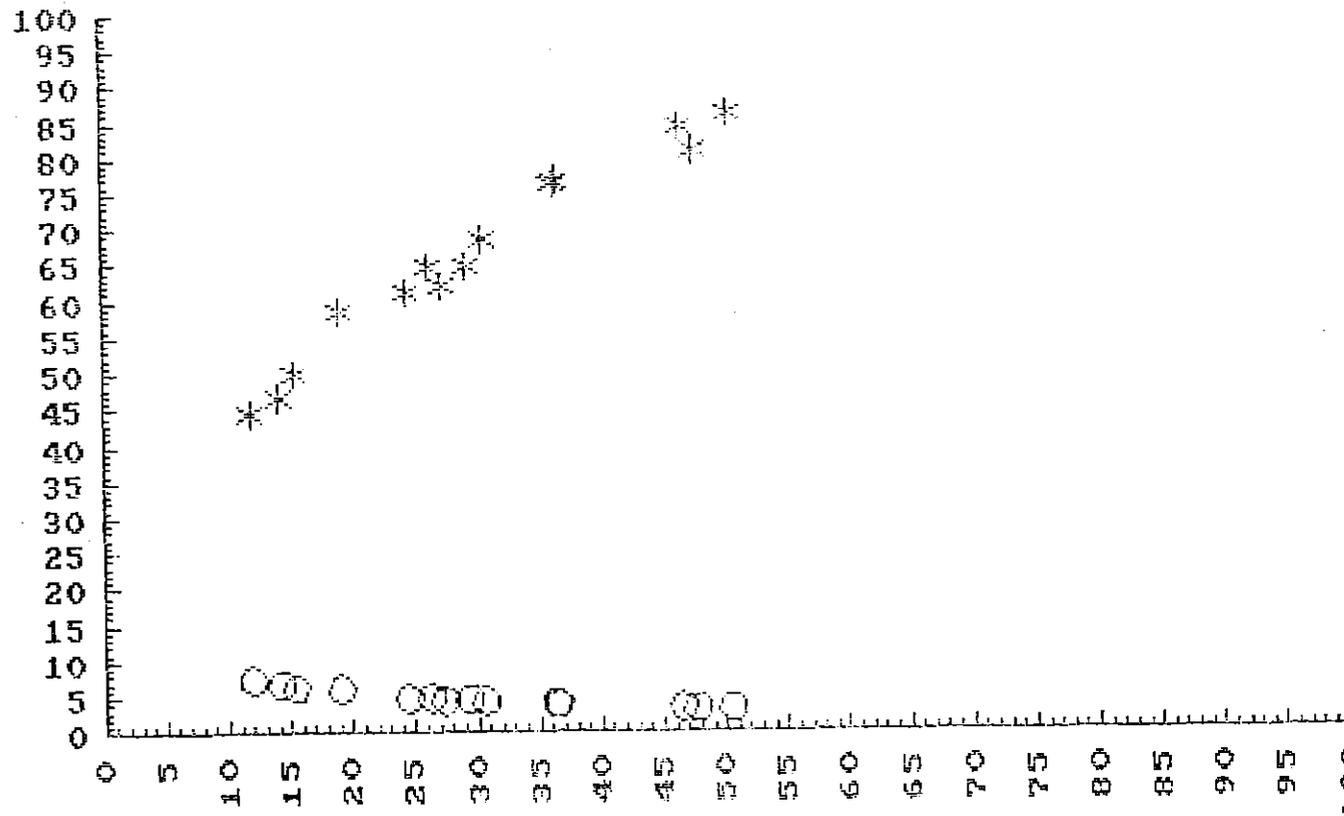
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AMMTEC Pty Ltd

% Weight Recovery To Concentrate

FIGURE 4

National Mineral Sands Pty. Ltd. (MDL MG5 71)
 Scavenger Weight/Heavy Mineral Recovery
 Rghr Mid Clar Tail (Ratio 2.5:1) Tests 17-23

% Heavy Mineral Recovery



HM Recovery

*

HM Grade

○

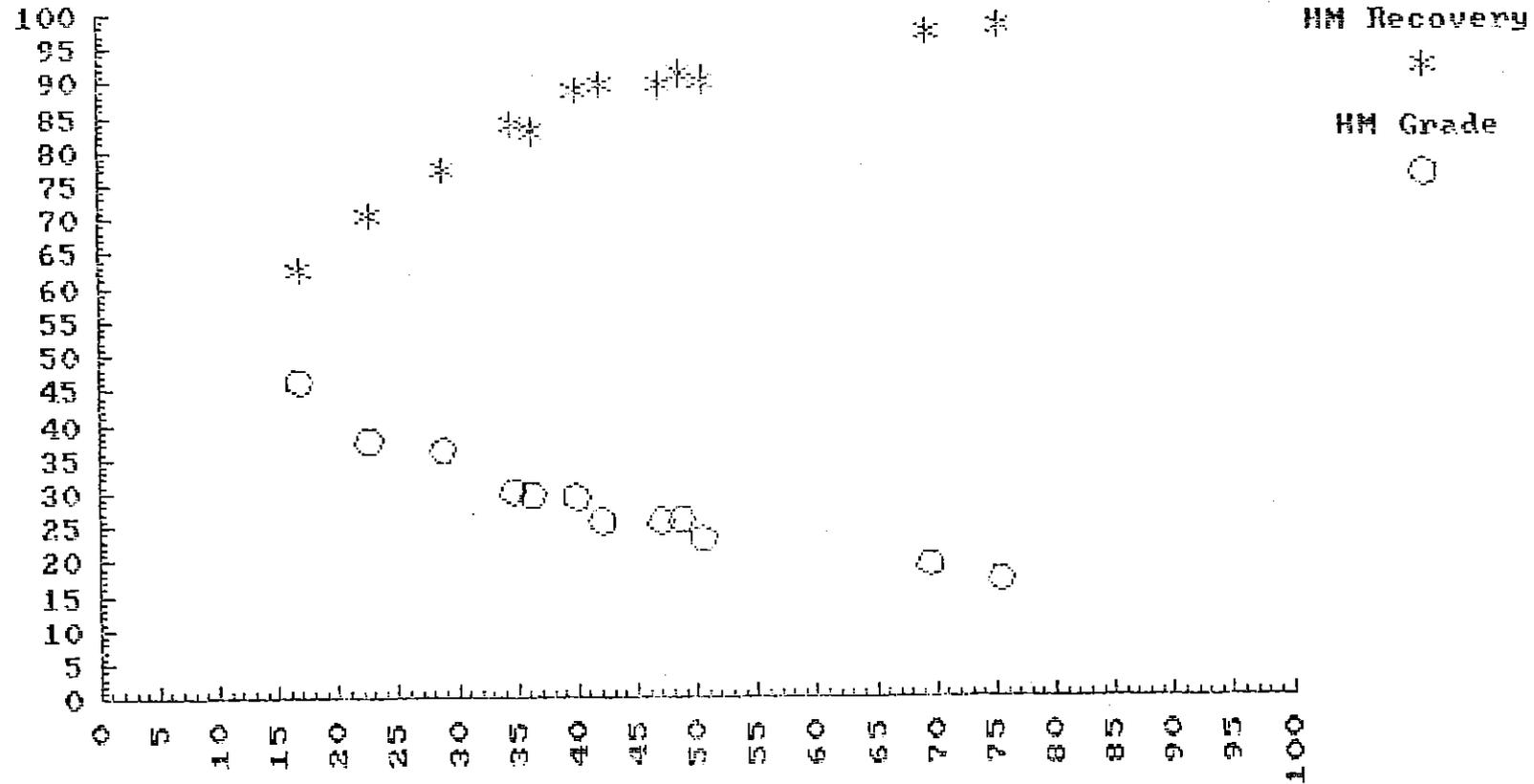
% Weight Recovery To Concentrate

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FIGURE 5

National Mineral Sands Pty. Ltd. (MDL HG5 7t)
 Cleaner Weight/Heavy Mineral Recovery
 Bulk Rougher Concentrate - Tests 11-16

% Heavy Mineral Recovery



File34A:A2094C
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% Weight Recovery To Concentrate

FIGURE 6
OVERALL TEST PROCEDURE AND RESULTS FOR SPIRAL, WET TABLE CONCENTRATION

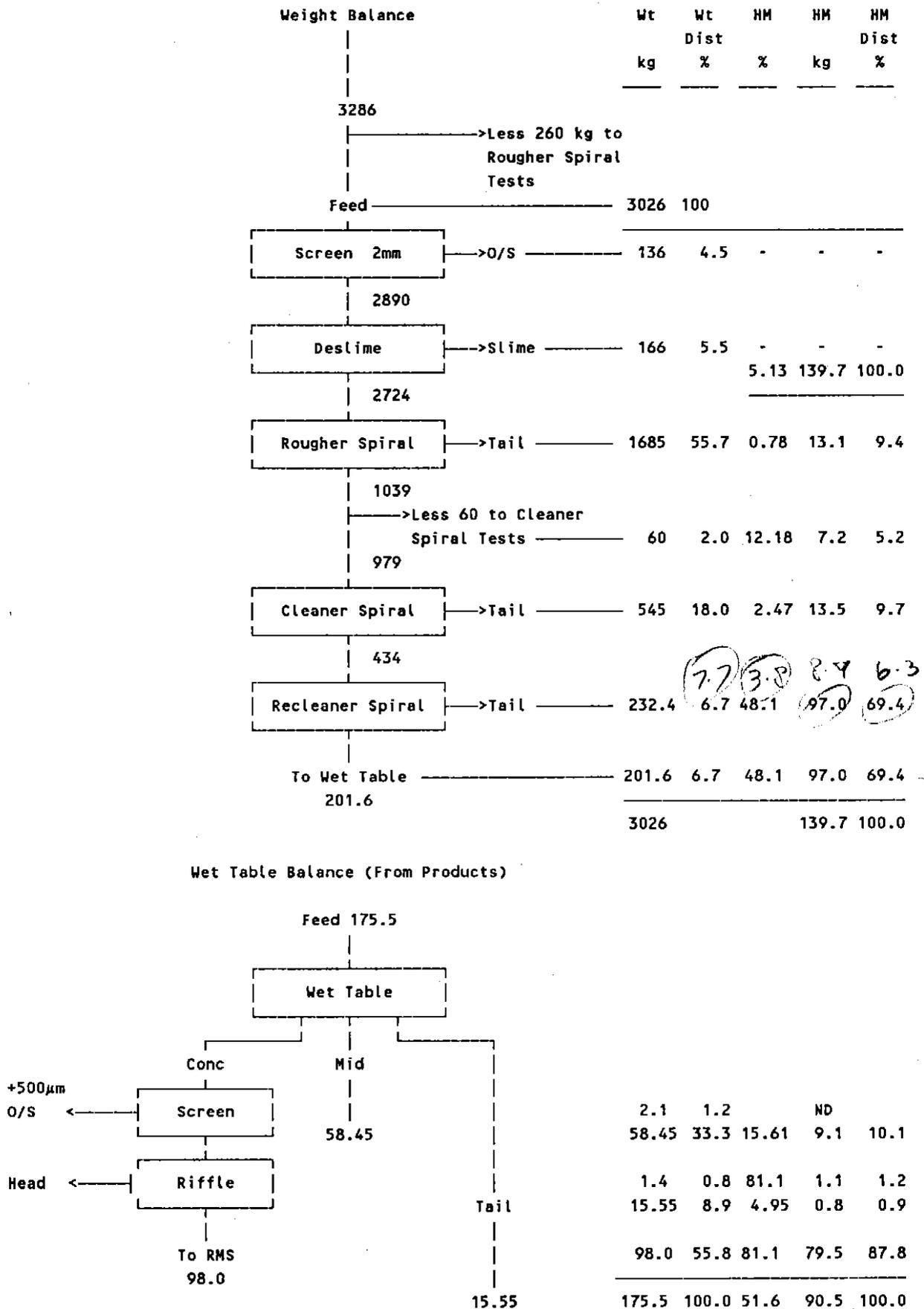


FIGURE 7
TEST PROCEDURE AND RESULTS FOR SECOND STAGE WHIMS TESTWORK

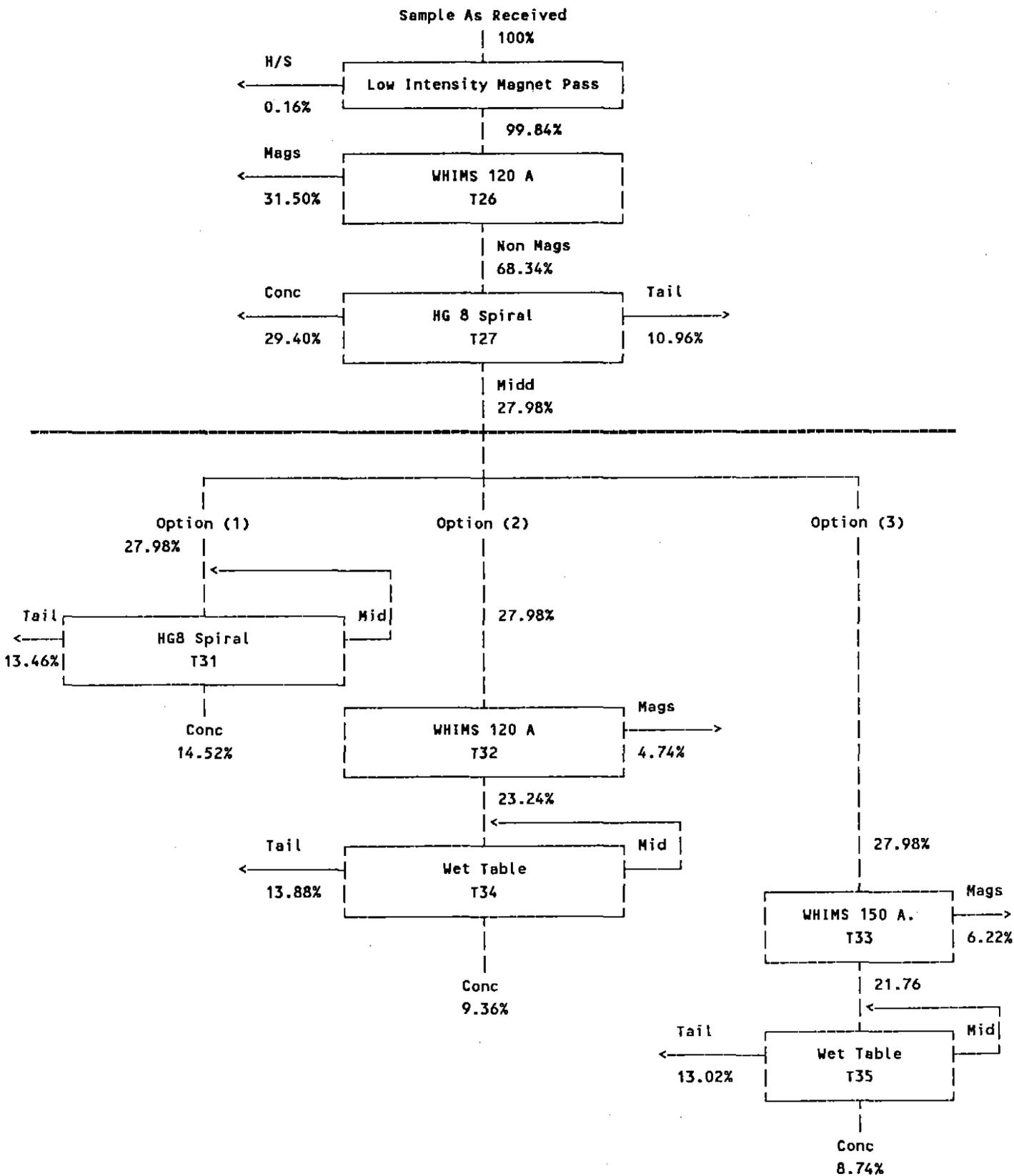


FIGURE 8

TEST PROCEDURE AND RESULTS - DRY PLANT HIGH TENSION AND MAGNETIC SEPARATION FOR ILMENITE RECOVERY

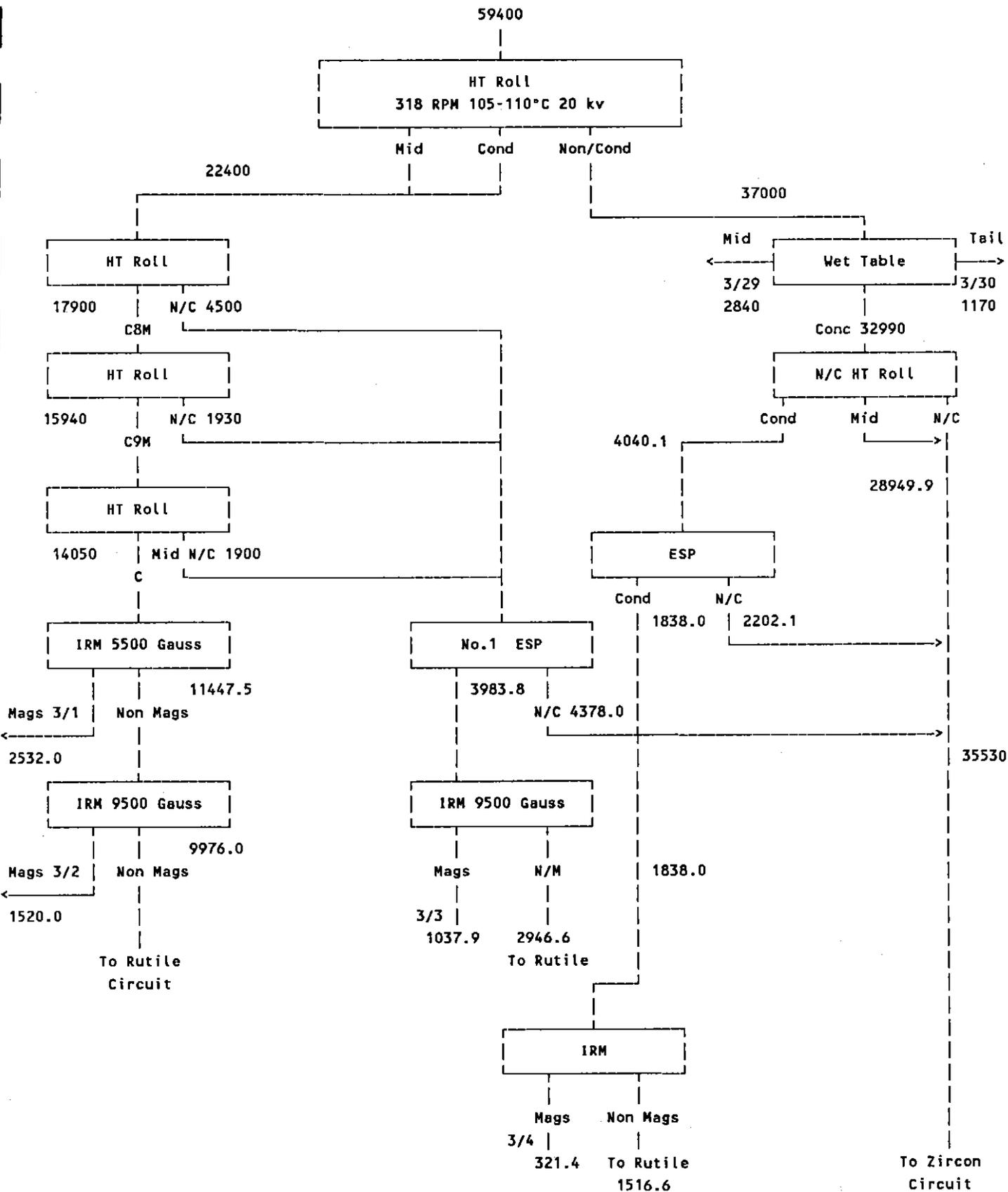


FIGURE 9
RUTILE CIRCUIT - ELECTROSTATIC PLATE CLEANING

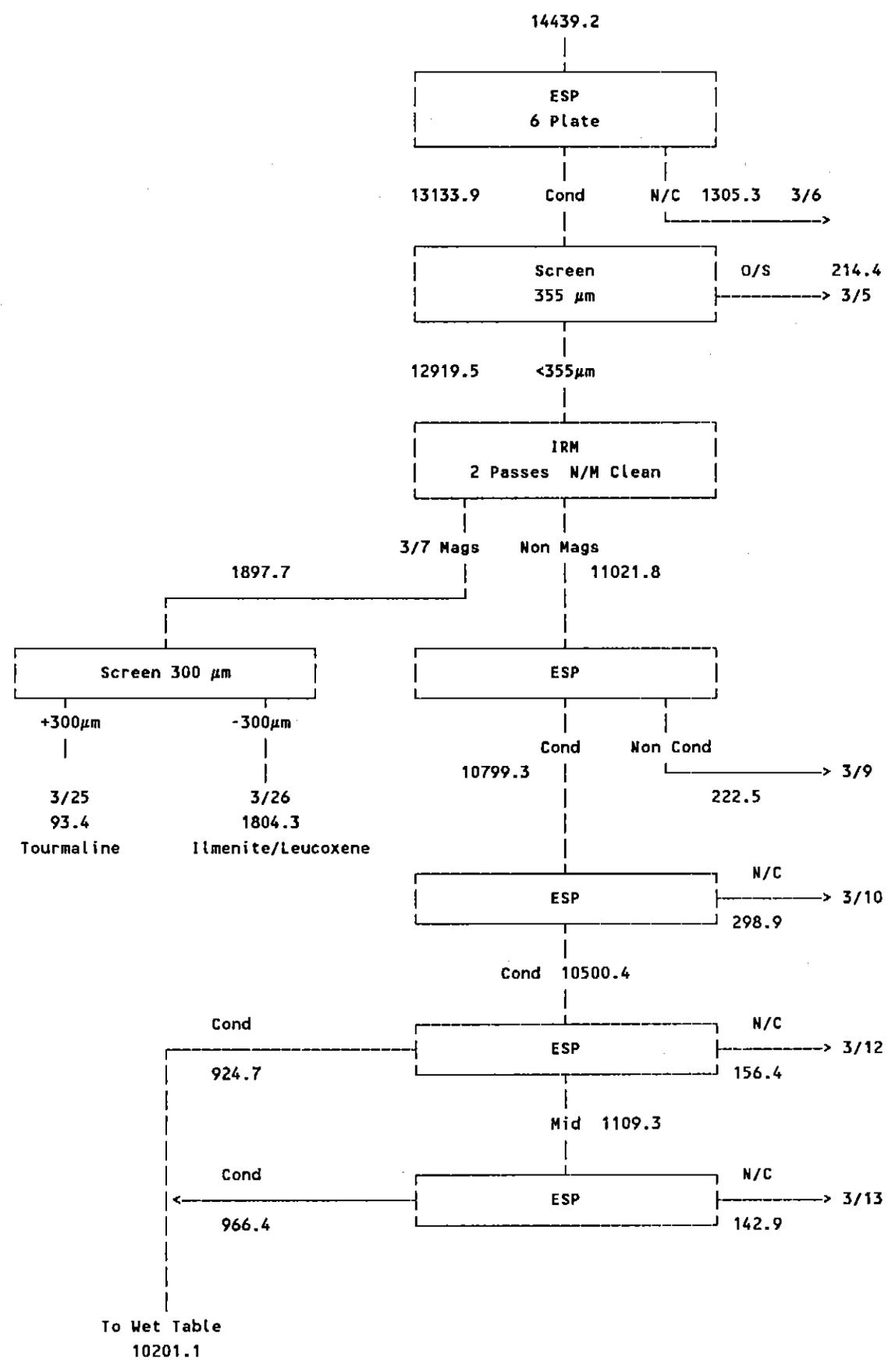


FIGURE 10
RUTILE CIRCUIT - WET TABLE AND FLOTATION TEST RESULTS

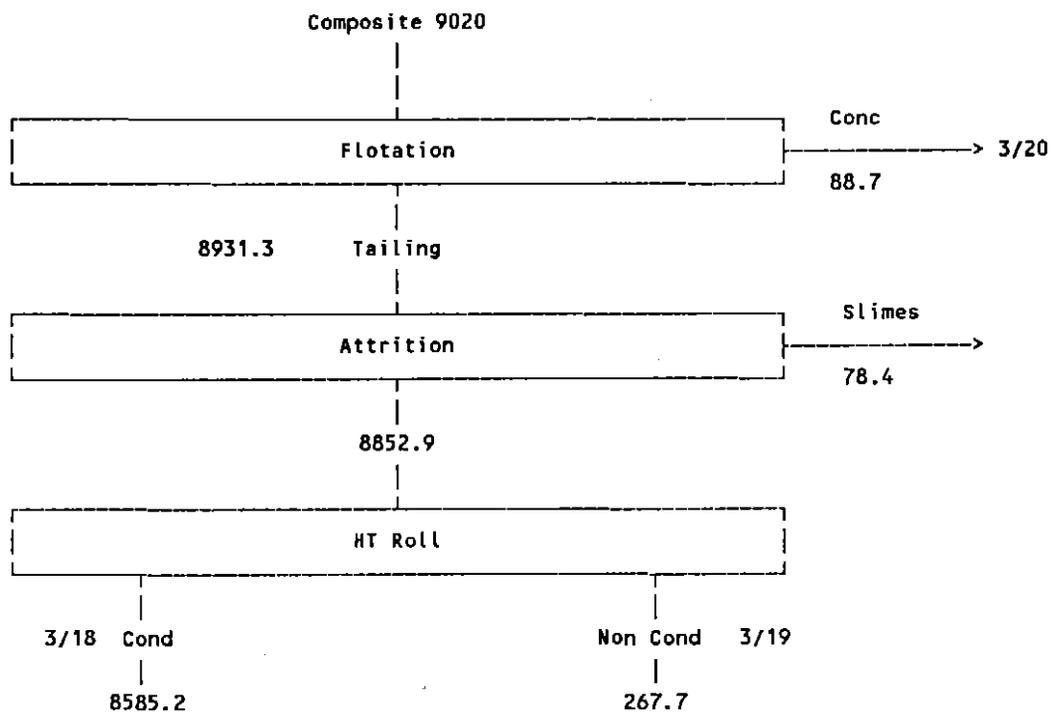
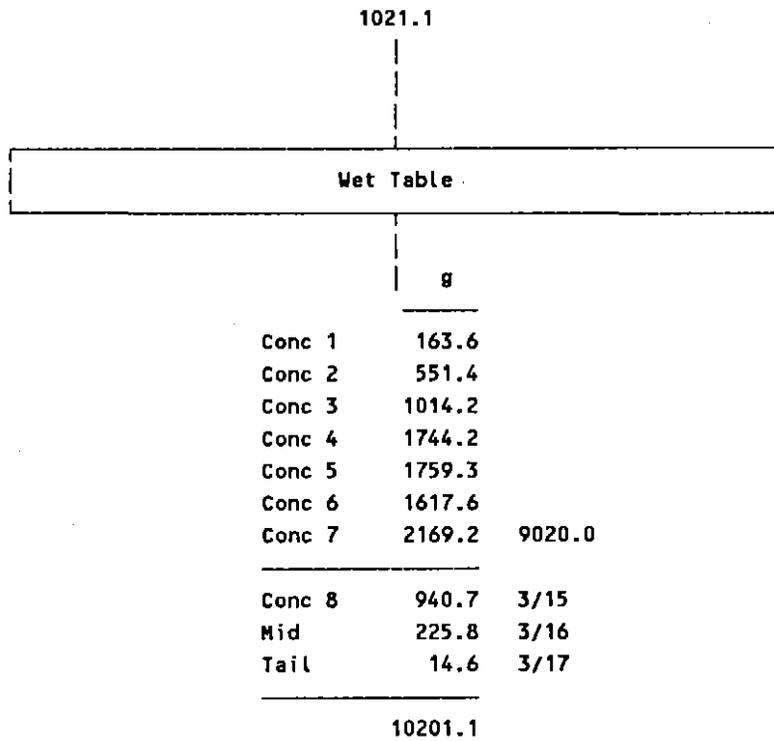


FIGURE 11
ZIRCON CIRCUIT - TEST DATA

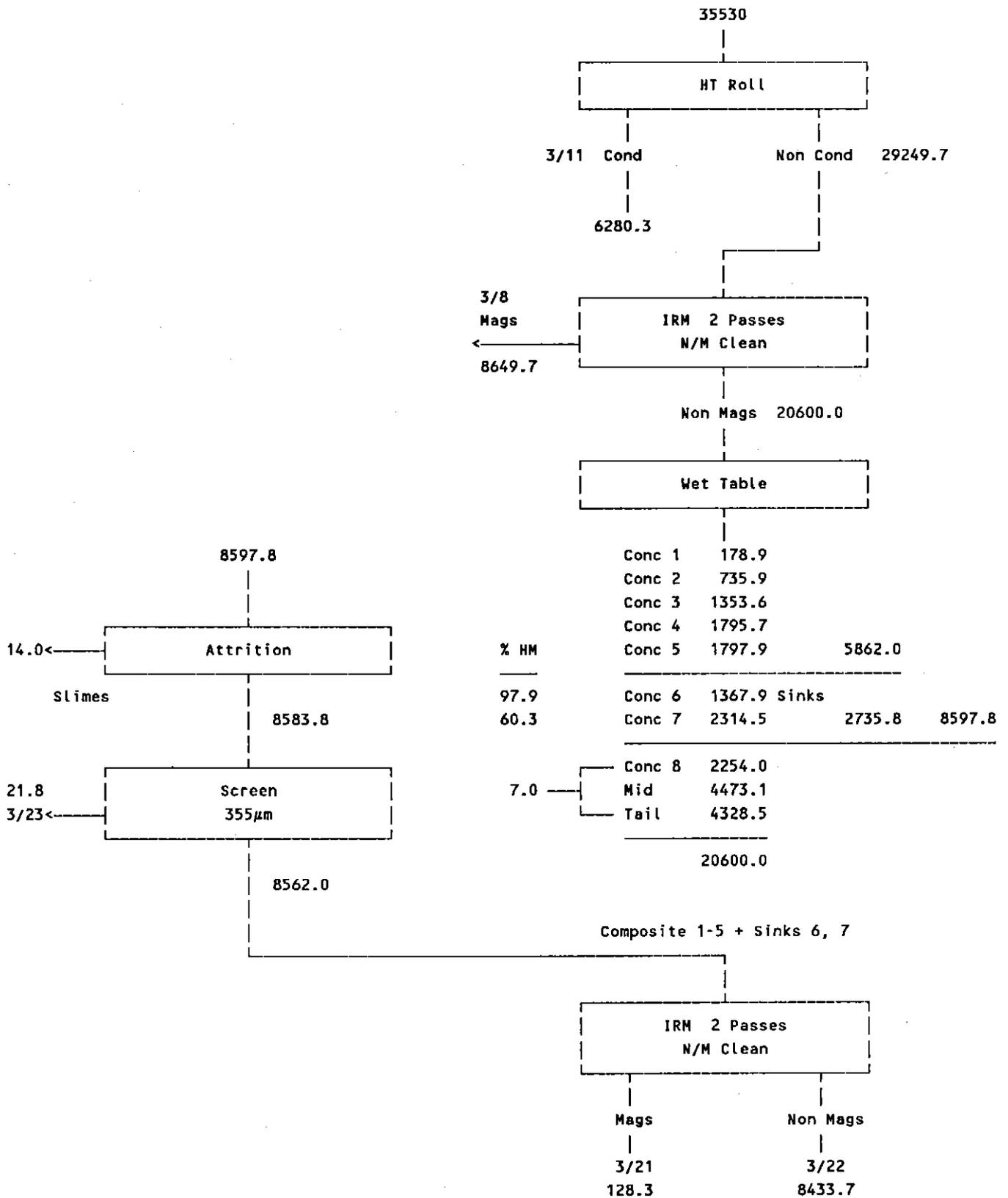
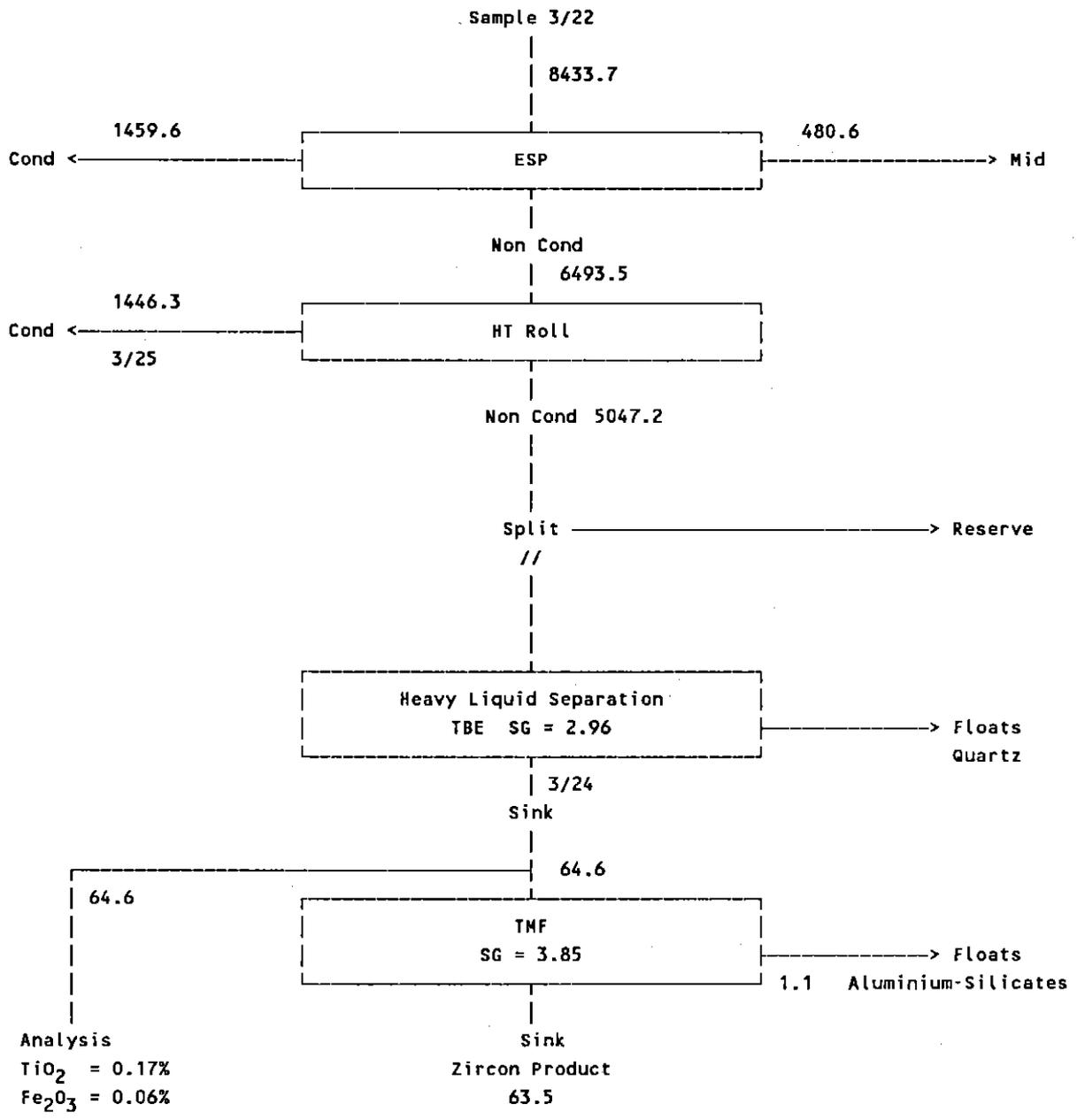


FIGURE 12
ADDITIONAL CLEANING TESTWORK CONDUCTED UPON A ZIRCON PRODUCT



APPENDIX I
SCOPE OF WORK

NARACOOPA PROJECTNEW SECTION 2.5 METALLURGICAL TESTWORK SCOPE OF WORKWet Magnetic Separation Testwork
Based on 3t Bulk Lanherne Beach Sample1.0 TESTWORK SUMMARY

- 1.1 To produce a heavy mineral concentrate suitable for further separation into its saleable constituents. This work incorporates a wet mill gravity study.
- 1.2 To arrange and be responsible for wet high intensity magnetic separation testwork on the heavy mineral concentrate.
- 1.3 To arrange and be responsible for dry mill circuit testwork including the dry mill feed preparation circuit.
- 1.4 To report grades, impurity levels and recoveries of rutile, zircon, leucoxene and ilmenite to all final product and tailings streams.
- 1.5 To produce product samples.

2.0 TESTWORK PROGRAMME

- 2.1 A heavy mineral concentrate is to be produced from a three tonne sample requiring compositing and screening. Concentrate production will be by a conventional spiral circuit comprised of roughing, middling, cleaning and recleaning spirals recognising the presence of leucoxene. It is intended that spirals be tested at a higher and lower solids throughput. Sizing analyses of all products are to be reported.
- 2.2 It is expected that WHIMS testing will be performed on a commercial scale unit so that the only scale up parameter to actual production conditions is solids throughput.

WHIMS testing should examine the effects of rotor speed, wash water quantities, feed pulp densities and magnetic field strength. It should also establish the need for low intensity separation prior to WHIMS.

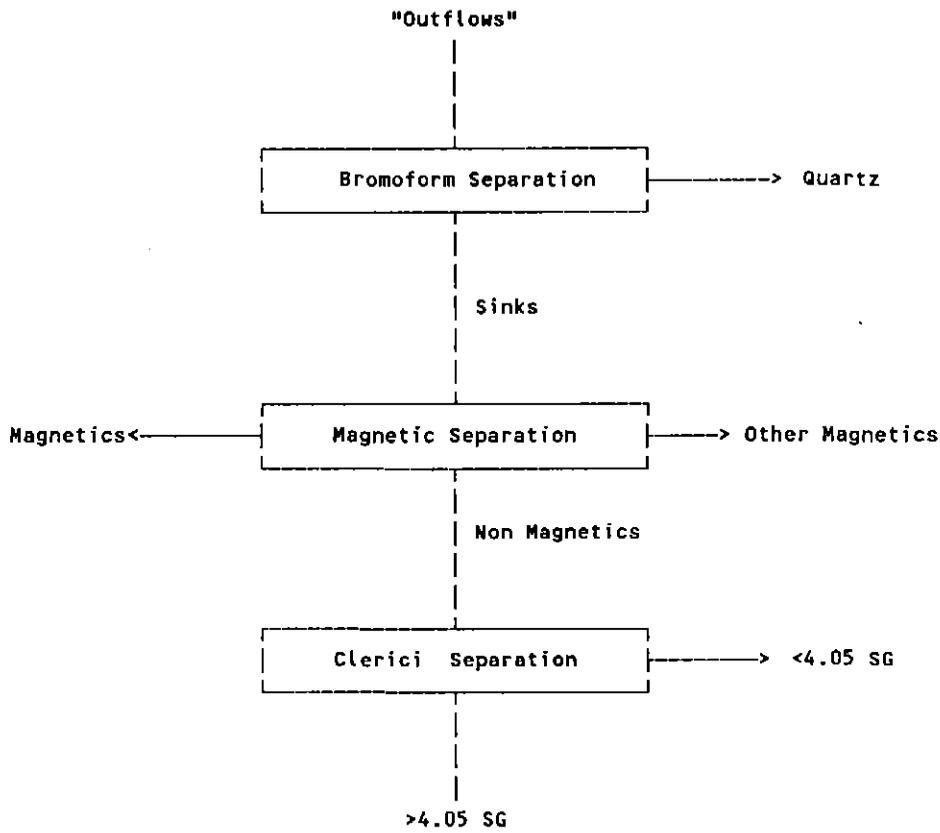
Recovery of magnetics and non-magnetics will be determined for at least a lower and an upper solids throughput.

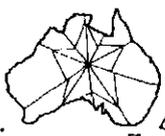
- 2.3 A conceptual dry mill circuit study will be carried out. This testwork may be varied to suit flowsheet conditions as they develop but would basically consist of screening followed by high tension roll separation with cleaning by HT plates and mag. separators. Prior to screening, attritioning tests should be conducted to verify reagent requirements and power inputs.
- 2.4 test reporting will include concentrate recovery and grade, rutile, zircon and leucoxene recoveries and grades, and a radiation activity survey of appropriate products. It is also required to report grades, recoveries and impurity levels of rutile, zircon, leucoxene and ilmenite to all final product and tailings streams. Mineralogical and chemical assays are required to assist in the economic assessment and identification of all recoverable minerals and gangue constituents.
- 2.5 The testwork should also result in the production of product samples suitable for marketing purposes.

APPENDIX II
READINGS METALLURGICAL SERVICES - ANALYSIS TECHNIQUE

READINGS METALLURGICAL SERVICES

ANALYSIS TECHNIQUE





ANNTEC

AUSTRALIAN METALLURGICAL AND MINERAL TESTING CONSULTANTS PTY LTD.

6 MacAdam Place, Balcatta,
Western Australia 6021
Telephone: (09) 344 2416, (09) 344 2418
Telex: AA96177. Fax: (09) 349 7688

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your reference
 our reference
 date

G65/3-AB LWD:KMR
 11th April, 1989

The Manager,
 National Mineral Sands Pty. Ltd.,
 Suite 403, 4th Floor,
 King York Building,
 32 York Street,
 SYDNEY. N.S.W. 2000.

ATTENTION: MR. D. GILLET

Dear Sir,

RE: Hydrogeological Study for Proposed Heavy Mineral Sand Mines - Naracoopa Project (Milford/Lanherne Beach (Naracoopa) and High Dune/Back Beach (Copper Point), King Island

We are pleased to submit our report on of the above project.

We trust the information provided will be sufficient for your present requirements. If you require further information or wish to discuss any matters arising from this report, please do not hesitate to contact the undersigned. We thank you for the opportunity of being of service and wish your project success.

Yours faithfully,
COFFEY & PARTNERS PTY. LTD.


DR. LEN DRURY
 Principal Hydrogeologist



Offices and NATA Registered Laboratories
 Adelaide
 Albury-Wodonga
 Altonville
 Brisbane
 Canberra
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 Wollongong
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 Mandalay, Burma

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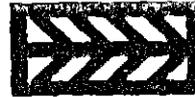
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4.

EXECUTIVE SUMMARY

The heavy mineral deposits of Milford Beach and Lanherne Beach (Naracoopa) and High Dune and Back Beach (Cowper Point) form the Naracoopa Project and are located in beach and aeolian sand sediments along the east coast of King Island.

The hydrogeological study involved the drilling of 23 holes of which 18 were converted to regional observation bores which were incorporated with the 10 water level monitoring points established in the 1988 pre-feasibility study. In addition, two production bores and three production spearpoints were constructed and test pumped. Water levels were measured in additional observation piezometers around the groundwater discharge facility to assess aquifer hydrologic characteristics. On-site chemical analyses were carried out at most observation piezometers, and surface water and groundwater samples sent to a private laboratory for inorganic chemical analysis. Computer modelling assessed the likely quantity of groundwater available from the sand aquifers and regional effects of such withdrawals on the environment.

Naracoopa

The Naracoopa sand deposit consists of a frontal beach, a Recent interdunal system and extensive beach and aeolian sediments of Pleistocene age. The saturated thickness of aquifer in the Pleistocene sand is variable with an average of 7m. This deposit contains diagenetic, carbonaceous cement horizons and peat layers which significantly reduce the permeability of the sand aquifer. Perched systems above the peat are present. Clay bedrock occurs beneath the sand and dips eastwards, being RL 20m near Sea Elephant Road, RL 2m beneath the interdunal system and RL 0m on the beach. The limit of the Naracoopa sand deposit from Sea Elephant Bay is taken as Eldorado Creek to the north, west to Sea Elephant Road and south to the Frazer River. Transmissivity values for the Pleistocene sand range from 0.4 to $6\text{m}^2/\text{day}$, and a value of $36\text{m}^2/\text{day}$ was derived for the interdunal system. This indicates the low permeability of the carbonaceous sand and the more transmissive characteristics in the Recent deposit. The quantity of water in aquifer storage is estimated as 1120 Ml with annual groundwater discharge being 730 Ml of which drainage to Sea Elephant Bay is 630 Ml/year. The required groundwater yield for mining purposes is 1 Ml/day, which is about 60% of discharge to the ocean and 33% of aquifer storage. The preferred area for groundwater withdrawal is the more permeable interdunal system at the base of the Pleistocene deposit. The potentiometric surface at this location is shallow. The most appropriate method of groundwater withdrawal is a spearpoint battery or a collector trench along a 2.5 km length of the interdunal sand deposit to intercept the natural base flow drainage to the ocean.

The salinity of the groundwater is less than $1000\mu\text{S}/\text{cm}$ except in the southern area where higher salinity is assessed as being due to the use of sea water and caustic soda during previous mining operations. The low salinity water is acidic, highly coloured, occasionally contains excessive iron, and hydrogen sulphide gas is present. The water quality indicates that the groundwater in the Naracoopa sands is unsuitable for domestic purposes. Potable water should be obtained from surface water sources.

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Mining close to the Frazer River will have little environmental effect on the watercourse. Salt water encroachment from Sea Elephant Bay due to pumping close to the beach is unlikely to occur due to the geometry of the aquifer system. The use of sea water for mining purposes is not recommended due to the subsequent increase in salinity in the sand aquifer around the mining pond and the long term deleterious effects on the aquifer system including those caused by surface rehabilitation.

Due to the presence of the indurated carbonaceous cement throughout the Pleistocene sand, the aquifer does not form an ideal groundwater supply system. The apparent marginally better hydrologic characteristics of the Recent interdunal sand, and shallow potentiometric surface, indicate that a collector trench system or spearpoint battery should extract the required 1 ML/day. A length of 2.5 km would be needed. Due to the shallow saturated sand thickness along the north-south orientated interdunal system it is assumed that the groundwater quantity required will largely be withdrawn by induced drainage from the Pleistocene sand system. It is further assumed that the saturated sand is hydrologically continuous over the length of extraction. Before an extensive trench system or spearpoint battery is installed it is recommended that a trial 250m length of spearpoints be installed between 1600N to 1850N and pumped over a period of several months to assess the suitability of the withdrawal/interception system. A careful water management scheme is required to effectively utilise and re-use mine waste water to reduce the demand on the groundwater withdrawal facility.

Additional water should be available from the Frazer River during wet periods of the year. Another water supply alternative is the treatment of sea water by reverse osmosis methods, (similar to that on the oil rigs of Bass Strait) however, the capital cost of this method is high.

Cowper Point

The High Dune system extends from the calcareous sandstone at the confluence of Blowhole Creek and Sea Elephant Bay to Cowper Point. The multidune system rises sharply to RL 44m with interdunal areas of RL 5 to 8m. Carbonaceous cement is present in about 50% of the High Dune deposit; the remainder consists of clean, shelly, fine to coarse sand. Bedrock consists of a calcareous sandstone platform located at RL 1 to -2m. The saturated thickness of the unconfined aquifer varies from 0.9 to 7.9m, the average being around 4m. The transmissivity of the High Dune sand aquifer varies from 78 to 739 m²/day (average of 300 m²/day) indicating a clean, transmissive, coarse grained sand unit. Based on the examination of drilled samples the transmissivity of the carbonaceous cemented sand is assumed to be slightly higher than that at Naracoopa.

The quantity of water in storage in the High Dune sand aquifer is estimated as 400 ML with annual rainfall recharge to the aquifer system of 593 ML. The mine requirement of 1 ML/day is 60% of rainfall recharge and 90% of groundwater in storage. A 50 spearpoint battery system established over a 1.25 km length of the interdunal clean sand area between the dunes should extract the required mine water supply. The spearpoints should be spaced 25m apart and are expected to yield 20 m³/day. The water salinity is less than 1000 µS/cm over the central part of the High Dune deposit with increase in salinity to 1760 µS/cm along the flow path. The Na:Cl type water is enriched in calcium and

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bicarbonate ions due to the dissolution of shells within the aquifer, the pH is neutral, the water is colourless to light brown and has a low iron content. The inorganic chemical analysis indicates that the water may be suitable as a potable water supply. No bacteriological analysis was carried out.

It is assessed that if the northern extent of the spearpoint battery was restricted to drill line 4650N there would be no effect on the Sea Elephant River due to groundwater withdrawal activity. Salt water intrusion into the High Dune aquifer is not anticipated from Sea Elephant Bay. The use of sea water in this low salinity, permeable aquifer is not recommended.

The clean sand beneath the High Dunes appears to have good hydrologic characteristics but the lack of saturated sand thickness due to shallow bedrock and carbonaceous cement to the west restricts the groundwater yielding potential of this aquifer. It is unlikely that groundwater yields in excess of 1 Ml/day could be extracted over a length of 1.25 km within the interdunal system. It is recommended that initially a 500m length of spearpoint battery, each spear 25m apart, be initially established and pumped for 1 month with water level monitoring in surrounding piezometers. Additional spearpoints could be added after this trial to increase groundwater extraction rate.

The Back Beach deposit occurs as a slightly elevated beach sand deposit west of the High Dunes. It is of limited aquifer thickness and contains carbonaceous cement throughout. No test pumping was carried out in this deposit.

Surface Water

The quality of groundwater from the surface swamp is similar to the groundwater system to which it is hydrologically connected. The Na:Cl dominant swamp water at Naracoopa is acidic, highly coloured, of low salinity and bicarbonate ion absent. The chemistry of swamp water at Cowper Point is significantly different to that at Naracoopa being of neutral pH, colourless to light brown and with a high bicarbonate content. Water samples from the mouth of Blowhole Creek and the Frazer River indicate hydrologic connection to Sea Elephant Bay.

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7.



1.0 INTRODUCTION

1.1 The Study

King Island is located to the north of the north-western corner of Tasmania between Bass Strait and the Southern Ocean, Figure 1. Naracoopa and Cowper Point are separated by 10km of beach on the southern and northern extremity of Sea Elephant Bay. Four separate heavy mineral deposits have so far been delineated between Naracoopa and Cowper Point which in total comprise the Naracoopa Project. These deposits are Milford Beach, Lanherne Beach, High Dunes and Back Beach, their locations are shown on Figure 2. The Milford/Lanherne Beach deposits were partly mined between 1968 and 1977 and much of the original vegetation was cleared. A large excavation has been left providing a good example of the stratigraphic profile through the dunes in this area. It is proposed to extract heavy minerals from the unconsolidated sand at Milford and Lanherne Beaches near Naracoopa and the high aeolian dunes and back beach deposits near Cowper Point.

Coffey & Partners Pty. Ltd. was engaged by National Mineral Sands Pty. Ltd. to study the regional and site-specific hydrogeology and hydrochemistry with particular emphasis on estimating the long term groundwater yield from sand aquifers in both areas for use in the dredging operation and mineral separation process. In addition a potable water supply was required at Naracoopa. The water requirement for the proposed dredge pond mining operations is not known. Processing plant capacity will be 300 to 600 tonne per hour. Based on experience of mineral sand mining operations along the east coast of Australia in similar aeolian and dune beach sands environments the estimated water requirement will be in the order of 1 Ml/day.

Subject to the limitations of the scope of work as set out below, which was substantially modified from our original work proposal (Report No. GP154/1), comments on the mine hydrogeology, likely long term groundwater yield, hydrochemistry and preferred method of water extraction for both areas are given. A pre-feasibility level groundwater study has previously been carried out by Coffey & Partners Pty. Ltd. at Milford and Lanherne Beaches, (Report No. G65/1 - June 1988). The information from that report was incorporated, where applicable in the present study.

1.2 Scope of Work

The aim of the study was to assess the aquifer systems at both Cowper Point and Naracoopa to such a level that the effects of groundwater utilisation by the mining company on the hydrogeological regime could be estimated and a groundwater withdrawal system at both locations recommended, (if sufficient water in the aquifers was available for such extraction). The hydrogeological assessment entailed both a desk study and field activities (31st January to 10th February 1989). The locations of all observation piezometers, spearpoints and production bores are shown on Figures 3 & 4. This study involved:

- * a review of the previous hydrogeological report and the Tasmanian Government's policy on groundwater extraction and protection.



- * a hydrogeological reconnaissance of the areas to locate existing groundwater supplies, to review the borelogs from the mineral exploration holes and finalise the drilling program.
- * the drilling and installation of 3 additional regional observation piezometers (P19-P21) at Naracoopa. Thirteen holes were drilled in the 1988 hydrogeological study of which 10 were converted to observation points. The drilling of 20 regional groundwater test holes at Cowper Point (P10-P14 and P22-P36) as part of the mineral exploration programme of which 15 were converted to observation piezometers. Each observation piezometer was completed with 25mm ID, Class 12 PVC pipe, slotted at appropriate depths and then backfilled to the surface.
- * the drilling of 250mm diameter, filter packed production bores with the installation of 150mm diameter casing and screen (1m length, aperture 0.5mm diameter), one at Naracoopa and one at Cowper Point and the installation of additional observation piezometers at various distances and direction around the production bores.
- * the drilling of holes for the installation of pumping spearpoints (2 at Naracoopa and 1 at Cowper Point) and the construction of additional observation piezometers.
- * test pumping (single rate and recovery) carried out on the 2 production bores and 3 spearpoints.
- * on-site water analysis (pH, Eh, temperature, specific conductance and dissolved oxygen) on the observation piezometers and all groundwater pumping facilities.
- * the collection of water samples from surface water and groundwater sources for comprehensive inorganic chemical analyses to establish baseline data, and
- * the computer modelling of the Naracoopa and Cowper Point sand aquifers to assess the effect of groundwater withdrawal from the semi-unconfined aquifers, likely long term yields and appropriate method of groundwater extraction.

1.3 Report Format

A review of the physiographic and geological features of the study area is given in Section 2.0. Also included are comments on the baseline chemistry study on surface water and groundwater sources. The hydrogeology of the Naracoopa and Cowper Point areas are given in Sections 3.0 and 4.0 respectively with details of the test pumping results, hydrochemistry, computer modelling and discussions of the findings and recommendation for wellfield construction. Section 5 describes the Tasmanian Government policy on groundwater. Borehole logs are given in Appendix A and chemical analysis in Appendix B.

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9.



2.0 PHYSIOGRAPHIC AND GEOLOGICAL FEATURES; BASE LINE WATER CHEMICAL DATA

2.1 Geomorphology

The aeolian and beach sand dune sequence at Naracoopa rises steeply from the beach along the southern end of Sea Elephant Bay. There is a small frontal dune and a narrow interdunal area of Recent age and then a steep rise to the top of the main sand dune system, of Pleistocene age (Figure 5). The Pleistocene sand rises to 29m above sea level at the Sea Elephant Road along drill line 1600N. The dunal system is undulating in nature. Vegetation consists of ti-tree and heath which are very thick in places and peaty swamps in the interdunal areas. Frazer River borders the southern boundary of the sand deposit adjacent to hard rock outcrop. The intermittent Rocky Creek, Eldorado Creek and associated watercourses truncate the Pleistocene sand in the central and northern part of the lease boundary. A large swamp is located in the western sections of drill lines 1200 to 1400N.

The Cowper Point High Dune system extends from the calcareous sandstone outcrop at the mouth of Blowhole Creek north to the Sea Elephant River. Dune systems rise sharply to RL 44m (AHD) with interdunal areas around RL 5 to 8m, (Figure 6). Topographically there appears to be two high dune systems, one adjacent to the coastline and a second some 300 to 500m inland. Swampy areas occur to the west of the inner high dune system. The vegetation consists of low coastal shrubs.

The Back Beach deposit occurs in a slightly elevated area of distinct beach strand lines. In contrast to the coastal dunes the area is relatively flat, being only 1 to 2m above the surrounding area and is surrounded by interdunal lowlands. It is likely that some of this area would be waterlogged during wetter months of the year. Blowhole Creek and associated watercourses drain the Back Beach area in a southern and easterly direction to Sea Elephant Bay.

2.2 Rainfall

The average annual rainfall at Currie Post Office over a 77 year period is 912mm. The average monthly rainfall is shown on Table 2.1. Heavy rainfall usually occurs in the winter months of June to August; however precipitation occurs throughout the year.

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TABLE 2.1
AVERAGE MONTHLY RAINFALL
1909 TO 1986 - CURRIE POST OFFICE
(Supplied by Bureau of Meteorology, Melbourne)

<u>Month</u>	<u>(mm)</u>
January	35
February	40
March	50
April	69
May	98
June	104
July	126
August	116
September	84
October	76
November	61
December	53
	<u>912</u>

2.3 Geology

The regional and site specific geology, in plan and cross sections, are shown on Figures 2,5 and 6.

2.3.1 Hard Rock Geology

The hard rock which underlies the township of Naracoopa consists of a comparatively unmetamorphosed orthoquartzite-mudstone sequence of Precambrian age. Rock outcrops are unfractured and quite massive. The depth to the hard rock beneath the unconsolidated sand sequence is unknown.

A calcareous sandstone of Tertiary age crops out at the confluence of Blowhole Creek and Sea Elephant Bay and forms a shallow bedrock platform beneath the high aeolian dunes at Cowper Point.

2.3.2 Pleistocene to Recent Deposits

A series of beach and aeolian dune deposits with associated interdunal lagoonal sediments and diagenetic carbonaceous cement of Pleistocene to Recent age occupies the area between Naracoopa and Cowper Point. The heavy minerals have been deposited in this sand complex.

2.3.2.1 Naracoopa Area

The sand deposits at Naracoopa consist of subangular to subrounded quartz grains with heavy minerals concentrated along old beach strand lines and disseminated within the dunes. The sands are rarely clean, being generally quite silty. They usually contain diagenetic, carbonaceous and iron rich cemented indurated layers, derived from the precipitation of organic acids from decaying vegetable matter in a low pH environment. The diagenetic material partly occupies the void space between the sand grains. The indurated layers vary from relatively soft to quite hard horizons, and from a few centimeters to 1 to 2m in thickness. Extensive peat layers are located at various semi-

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continuous horizons within the sand body, particularly to the west of the Lanherne Beach deposit (see Figure 3 & 5). Peat thickness usually ranges from 1 to 3.5 metres. A subangular to subrounded, 0.5 to 1m thick, coarse sand and gravel layer occurs towards the base of the sands, its grain size increases towards the hard rock headland. This basal unit appears to be relatively clean with little silt, the grain sizes varying from medium sand to pea size gravel up to 5mm diameter. The basal section is usually heavily pyritic.

A dark grey to brown, stiff, high plasticity, micaceous clay underlies the sand deposit. Figure 7 shows that the basement profile is quite irregular with a topographic high (RL 0.4m) along 1000N and troughs to the north (1400N) and south (600N). Overall the basement clay dips from RL 20m near Sea Elephant Road, to RL 0.4m beneath the frontal interdunal area to just below sea level on the beach. Minor sand zones are present within the clay however they do not appear to be continuous throughout the area. The depth to the Precambrian age sandstone and quartzite in this area is unknown.

The thickness of the dune and beach sand intersected by drilling varies from 1 to 17m, but is generally in the range of 6 to 11m. Due to the basal clay configuration and surface topographic features the sand thins towards the Frazer River, dips overall to the east, is only 4m thick beneath the frontal interdunal area (about RL 2m) and occurs as a thin veneer on the beach.

2.3.2.2 Cowper Point Area

The High Dune area consists of fine to coarse grained sands with shelly and fine gravelly basal units overlying a calcareous sandstone platform. Diagenetic carbonaceous cemented layers, underlying clean sand, are located in distinct areas within the High Dune sand sequence (Figure 4). The main area of induration is along the older western side of the dune deposit and south of 1900N. The remainder of the High Dune deposit consists of clean, light grey, coarse grained sediment, with no carbonaceous cement.

The thickness of sand varies significantly due to the marked surface topographic contrasts over short distances but should fall within the range 4 to 6m. Based on orthophotomaps and borehole logs the elevation of the sandstone platform is around RL 1 to RL -2m; the exact configuration cannot be given until the area has been more accurately levelled.

The Back Beach deposit consists of silty, fine to coarse grained sand. Indurated horizons occupying the void space between sand grains commonly occur. The thickness of the sand varies from 3 to 5m with bedrock being either a dark brown to green grey, high plasticity clay or the shallow sandstone bedrock platform.

The area between the Back Beach and the High Dune area contains a thin sequence of indurated sand. Depth to bedrock varies from 3 to 7.5m beneath the surface.

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2.4 Baseline Water Chemistry

Water samples from 5 surface sources, the 2 groundwater production bores (P50 and P52) and from production spearpoint P37 were collected to obtain baseline inorganic chemical data in a low rainfall month. The sampling locations are given in Table 2.2 and are shown on Figures 3 and 4. The inorganic chemical analyses are given in Appendix B.

TABLE 2.2

LOCATION OF WATER SAMPLES FOR INORGANIC CHEMICAL

ANALYSIS - KING ISLAND

<u>SOURCE</u>	<u>CO-ORDINATE</u>	<u>WATER SAMPLE NO.</u>
<u>Surface Water</u>		
Mouth of Blowhole Creek	1800E, 1000N	147
Swamp-Cowper Point	2080E, 3450N	148
Frazer River - Mouth	200E, -190N	151
Frazer River - Bridge on Sea		
Elephant Road	750W, 900N	152
Swamp-Naracoopa	380W, 1400N	153
<u>Groundwater</u>		
Production Bore P52 - Naracoopa	028W, 1604N	154
Production Bore P50 -		
Cowper Point	2310E, 4340N	150
Production Spearpoint P37 -		
Naracoopa	037E, 1600N	149

The quality of water from the surface swamps is similar to the hydrologically connected groundwater systems. The Na:Cl dominant swamp water at Naracoopa is acidic (pH = 4.2), has high colour, low salinity and there is no bicarbonate or carbonate anion. This water type is similar to the groundwater from P37 and P52 except the surface water has a higher suspended solids content. In contrast the low salinity, neutral (pH 6.2 to 7.3) groundwater and swamp water at Cowper Point are Na:Cl dominant but with significant calcium and bicarbonate concentrations, presumably due to the dissolution of shells (CaCO₃) within the sand. Where indurated sand is absent colour is low, however in the surface swamp higher colour content is present. The trace metals analysed are in low concentrations and below standards set by government regulatory bodies. The exception is iron which is present in high concentrations in the Frazer River and production spearpoint P37. High salinity, alkaline (pH=7.3 to 8.8) water is present at the mouth of Blowhole Creek and the Frazer River where the watercourses are tidal and thus in direct hydrologic connection with Sea Elephant Bay. The radioactivity of all baseline water samples indicate low gross alpha and beta concentrations.

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3.0 HYDROGEOLOGY OF THE NARACOOPA AREA

Construction details and borehole lithology for observation piezometer, production bores and spearpoints are given in Appendix A. Inorganic chemical analyses for both surface water and groundwater are given in Appendix B. Drilling activity in the 1989 groundwater study was largely concentrated in the area between drill lines 1400N and 1800N, this being the area on the northern extremity of the proposed mining path and the area of thickest sand intersection. A production bore and a spearpoint in the Pleistocene dune system were pump tested to estimate hydrologic characteristics of that deposit and to test the appropriate method of groundwater extraction. A spearpoint was also tested in the Recent interdunal sand regime to study groundwater conditions near the discharge area into the sea.

3.1 Aquifer Identification

It appears likely that Eldorado and Blowhole Creeks truncate the Pleistocene sand to bedrock near Sea Elephant Bay thus partially subdividing the sand system between Naracoopa and Cowper Point into three groundwater entities.

The unconsolidated, silty, heavily indurated and occasionally peaty, aeolian and beach sand deposits south of Eldorado Creek form the most prospective aquifer in the Naracoopa area. The Lanherne Beach and Milford Beach heavy mineral deposits are both located within this regionally extensive sand aquifer and consequently will be considered totally as part of one hydrogeological regime. Perched aquifer systems are present above some peat layers in the western part of the sand deposit.

The basement clay has little potential as an aquifer to supply the mine requirements. The orthoquartzites and mudstones are hard with no apparent primary porosity and fractures appear not to be regionally extensive. No private bore has been located in the hard rock.

3.2 Areal Extent and Thickness of Sand

The southern sand deposit is located along a 4km length of beach between Eldorado Creek and Naracoopa. It is assumed that the mine at Milford/Lanherne Beaches can access the groundwater resource along the total length of this sand deposit. The width of the dune sequence to the Sea Elephant Road varies from 0.25km to 1.7km with an average of about 0.8km. A total sand area of 3.2km² (320 hectares) was thus studied as part of the hydrogeological assessment for the Naracoopa area. The width of the sand sequence west of the Sea Elephant Road has not been determined but appears to be small.

Table 3.1 and Figures 5 & 7 indicate the thickness of saturated sand which varies from 0m (P4) near the Frazer River; 11.3m (P40) on the eastern edge of the Pleistocene dune system; rapidly declining to less than 2m (P37) beneath the adjacent interdunal area. The general trend is for saturated sand thickness in the Pleistocene dune system to increase to the north and east away from the basal clay high located along drill line 1000N. The average thickness of saturated sand is taken as 7m.

SUMMARY OF BORE LOCATION, WATER LEVEL (FEBRUARY 1989), SATURATED THICKNESS AND DEPTH TO CLAY BEDROCK - NARACOOPA - KING ISLAND

BORE NO	CO-ORDINATES		SURFACE RL (m)*	TOTAL DEPTH (m)	CASING STICK UP (m)	S.W.L. (m)			SATURATED THICKNESS (m)	DEPTH TO CLAY	
						BELOW CASING	BELOW GL	RL		GL (m)	RL (m)
P1	360W	1500N	23.5	13.5	0.3	5.72	5.57	17.93	6.03	11.6	11.9
P2	000E	1200N	12.3	7.1	0.4	2.57	2.13	10.17	4.12	6.25	6.06
P3	340W	1200N	17	6.5	0.4	2.22	1.82	15.18	4.48	6.3	10.7
P4	540W	1000N	15	2.7	0.4	2.36	1.90	13.1	-	1.2	13.8
P5	000E	700N	16.0	8.0	0.45	1.41	1.91	14.09	5.69	7.6	8.4
P6	240W	700N	20.0	11.8	0.37	5.34	4.81	15.19	6.79	11.6	8.4
P7	000E	400N	17.1	10.8	0.35	3.86	1.44	15.66	8.96	10.4	6.7
P8	220W	300N	16.0	4.0	0.35	2.57	2.44	13.56	1.06	3.5	12.5
P9	000E	100N	15.2	11.5	0.4	4.81	4.36	10.84	6.64	11.0	4.2
P15**			18	9.0	-		1.8	16.2	5.2	7.0	11.0
P16**			21	18.0	-		5.7	15.3	11.7	17.4	3.6
P17**	040W	1900N	16	11.5	-		3.55	12.45	7.45	11.0	5
P18	420E	2000N	23.0	10.0	0.25	4.62	4.38	18.62	5.12	9.5	13.5
P19	300W	1780N	23	11.5	0.3	1.34	1.04	21.96	8.46	9.5	13.5
P20	200W	1600N	18.5	11.5	0.2	1.57	1.37	17.13	7.63	9.0	9.5
P21	380W	1400N	19	5.7	0.2	1.61	1.41	17.59	4.29	5.7	13.3
P37	037E	1600N	4	3.7	0.1	2.58	2.48	1.52	1.22	3.7	0.3
P38	039E	1600N	4	3.5	0.1	2.40	2.3	1.7	1.2	3.5	0.5
P39	037E	1611N	4	3.6	0.1	2.50	2.40	1.6	1.2	3.6	0.6
P40	045W	1600N	14.2	13.5	0.1	2.17	2.07	12.13	11.33	13.4	0.8
P41	025W	1600N	14.2	12.7	0.1	3.31	3.21	10.99	9.39	12.6	1.6
P42	008W	1600N	14.2	13.4	0.1	1.87	1.77	12.43	10.63	12.4	1.8
P43	200W	1600N	19	10.3	0.1	1.60	1.50	17.5	8.75	10.25	8.75
P44	190W	1600N	19	11.3	0.1	1.43	1.33	17.67	9.87	11.20	7.8
P51	199W	1599N	19	11.0	0.1	2.24	2.14	16.86	>8.86	>11.0	>8
P52	026W	1602N	14.2	12.5	0.1	5.30	5.20	9.0	7.3	12.5	1.7
P53	240W	1600N	19		0.2	2.98	2.78	16.22			

* RL Approximate from orthophotomap

** P15, P16 & P17 part of 1988 drilling programme - not converted to observation piezometers - water level April, 1988.

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The thickness of the saturated sand is hydrologically important in that, in combination with areal extent and storage co-efficient it gives the volume of water in storage.

3.3 Aquifer Hydrologic Characteristics

Representative plots of water level drawdown and recovery in production holes P37, P51 & P52 and their associated observation piezometers during test pumping are given in Figures 8 to 13. The estimated hydraulic characteristics of the sand aquifer, based on these results are given in Table 3.2.

TABLE 3.2

PUMPING TEST RESULTS - NARACOOPA AREA - KING ISLAND

Pumped Bore	Observation Piezometer	Distance to Pump Bore (m)	Transmissivity (m^2/day)	Storage Co-efficient	Method of Analysis																											
P37	P38	2)	36		Distance/Drawdown																											
	P39	11.5)				P51	P20	1)	0.4		Recovery	P43	1.5)	12,49	Cooper-Jacob	P44	10)		Distance/Drawdown	P52	P41		4.3	4×10^{-3}	Recovery	P41	3.4)	4.9	Recovery	P40	19)	5.9
P51	P20	1)	0.4		Recovery																											
	P43	1.5)	12,49		Cooper-Jacob																											
	P44	10)			Distance/Drawdown																											
P52	P41		4.3	4×10^{-3}	Recovery																											
	P41	3.4)	4.9		Recovery																											
	P40	19)	5.9		Distance/Drawdown																											
	P42	18)																														

Production bore P52 was pumped at a constant rate of 0.12 l/sec ($10.4 m^3/day$) for 12 hours with a water level drawdown of 2.04m (28% of saturated thickness). During this period the radius of influence only extended to 20m. The results indicate a low permeability aquifer system. The spearpoint P51 was pumped at 0.015 l/sec ($1.4 m^3/day$) for 5 hours. The low transmissivity, poor groundwater yield and limited radius of influence also indicates a low yielding capacity of the Pleistocene sand aquifer system at this site. Spearpoint P37, located on the interdunal area yielded the highest groundwater supply of 0.15 l/sec ($13.8 m^3/day$) over an 8 hour pumping period. The transmissivity was estimated as $36m^2/day$. Groundwater yields up to $20m^3/day$ may be available at this site by fully slotting the spear over the aquifer interval and with additional water level drawdown.



Due to the presence of the carbonaceous cement infilling the void spaces between the sand grains the permeability of the Pleistocene sand is low. Groundwater movement is further impeded by the presence of peat within the aquifer system. The interdunal sand appears to be the most permeable of the sites tested. The estimated storage co-efficient for the semi-unconfined aquifer is 4×10^{-3} . After prolonged periods of pumping the storage co-efficient should approximate the specific aquifer yield which would be in the order of 0.05.

3.4 Aquifer Storage

Based on the area of 320 hectares and an average saturated sand thickness of 7m in the Pleistocene dune system the volume of water stored in the aquifer system would be 1120 Ml ($320 \times 10000 \times 7 \times 0.05$).

3.5 Aquifer Recharge/Discharge

Recharge to the dune sands is solely by rainfall infiltration. No information is available on the water infiltration capacity of the sandy topsoil at Naracoopa. The presence of peat and perched aquifer systems with the associated swamps along Sea Elephant Road indicate poor infiltration conditions in the western area. In uniform sand dune areas of NSW water infiltration is usually estimated as 30% of rainfall. On North Stradbroke Island, Laycock (1975) estimates rainfall infiltration into the carbonaceous cemented sand between 24% and 47%. At Naracoopa rainfall recharge to the water table would be towards the lower end of the percentage range. A conservative value of 25% is taken as rainfall infiltration, the remainder being lost through evapotranspiration. Surface water runoff in this sandy environment would be negligible.

The average annual rainfall is 912mm (Table 2.1). The average annual recharge to the 320 hectare study area at Naracoopa is 738 Ml. Recharge is about 65% that of groundwater storage.

Figures 5 and 14 indicate that groundwater movement is downgradient away from the Pleistocene dune system, predominantly eastwards to discharge into Sea Elephant Bay. Minor groundwater flow is towards the Frazer River, Eldorado Creek, Rocky Creek and associated tributaries.

Under natural steady state water balance studies, groundwater recharge from rainfall and discharge to the sea and watercourses should be equivalent. Figure 5 indicates the natural hydraulic gradient to the east is 0.025 within the Pleistocene dune complex and 0.18 beneath the interdunal sand to the sea. The overall regional hydraulic gradient is 0.03. Using Darcy's Law with an estimated transmissivity of $15 \text{ m}^2/\text{day}$ and hydraulic gradient of 0.03 the groundwater discharge along the 4 kilometers of beach north of Naracoopa is 1.5 Ml/day or 550 Ml/year.



The difference between rainfall recharge infiltration into the sand dune and groundwater discharge to the sea may be due to aquifer drainage into the Frazer River and associated watercourses or variations in the conservative value of infiltration or transmissivity estimates.

3.6 Interrelationship between Groundwater and Surface Water

Groundwater discharge occurs to the sea, the Frazer River and adjoining swamps. The discharge front along the Frazer River is about 1.5km in length. Groundwater discharge would also occur to Eldorado Creek along the northern periphery of the sand deposit. Groundwater discharge has the effect of maintaining baseflow in the watercourses during dry periods when there is no surface runoff flow.

A borefield located north of drill line 1000N and south of 3000N on either the Pleistocene sand or interdunal system should have little effect on groundwater discharge to the Frazer River or Eldorado Creek as it will be beyond that part of the aquifer which contributes groundwater flow to these watercourses.

The dredge pond during early mine operations may be adjacent to the Frazer River. Because of the peaty and iron rich nature of the sands being mined it is expected that water in the dredge pond will be quite discoloured by humic acid and oxidation or remobilisation of iron may occur. Any seepage from the pond, although expected to be small, may have the effect of discolouring the river pools. Similarly surface runoff from the tailings will probably have the effect of further discolouring the groundwater. The river pools are discoloured under present conditions, (see chemical analyses for Frazer River at bridge, Appendix B) especially during any periods where groundwater baseflow predominates. The overall effect on water quality due to heavy mineral mining near the watercourses is assessed as being small. It is considered that mining will not affect the quantity of groundwater being discharge into the river.

3.7 Groundwater Chemistry

On-site chemical analyses (specific conductance, pH, Eh, temperature and dissolved oxygen) are given in Table 3.3 and the variation in specific conductance shown on Figure 14. Inorganic chemical analysis for P6, P9, P37 and P52 as well as surface water samples are given in Appendix B.

Groundwater with specific conductance values less than 1000 $\mu\text{S}/\text{cm}$ occurs in the sand throughout the Lanherne and Milford Beach area except in the previously mined area where salinity ranges from 1118 to 2469 $\mu\text{S}/\text{cm}$. These higher values appear to be associated with the use of sea water, (see chemical analyses for P9 Appendix B) and caustic soda (P6) for mineral separation and processing during the previous mining operation. The specific conductance values measured in February 1989 are lower than those recorded in May 1988 (Report G65/1). Except for this localised higher salinity zone the areas within the sand complex should contain groundwater less than of 1000 $\mu\text{S}/\text{cm}$. The salinity of water north of drill line 1000N increases to the east as the residence time of groundwater in contact with the sand aquifer increases from recharge to discharge areas.

TABLE 3.3

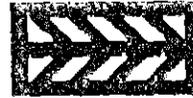
ON-SITE CHEMICAL ANALYSES RESULTS-FEBRUARY 1989 - NARACOOPA - KING ISLAND

BORE NO	SLOTTED/SCREENED INTERVAL (m)	SPECIFIC CONDUCTANCE ($\mu\text{S}/\text{cm}$)	pH	Eh	TEMPERATURE ($^{\circ}\text{C}$)	DISSOLVED OXYGEN ($\text{O}_2\text{mg}/\text{l}$)	(% O_2)	COMMENT
P1	8-10	279	6.27	291	18	4.2	43	
P2	4.5-7.1	626	6.10	268		4.2	45	Brown
P3	3.2-6.5	916	5.33	241		4.8	50	
P4	1.5-2.7	691	5.48	61		4.4	47	
P5	4.5-7.5	832	6.44	188		3.0	29	
P6	6.5-1.0	2461	6.19	120		4.7	45	
P7	4.8-8.0	1261	6.1	273		4.3	40	Light brown
P8	1.6-4.0	2469	5.8	186		2.3	25	Dark brown
P9	8.4-11.4	1118	6.4	179		2.9	30	
P18	6.0-10.0	318	6.6	208		3.2	36	
P19	10.5-11.5	420	6.5	214	18	3.3	34	
P20	8.0-9.0	391	4.4	295		4.4	40	
P21	4.5-5.5	420	4.8	245	17.5	4.4	43	
P37	2.7-3.7	768	3.91	616		10.4	1.1	Brown tinge, no smell, 8 hours pumping.
P38	0 - 3.5							
P39	0.5-3.5							
P40	5.0-8.0	737	4.75	238		3.2	35	
P41	5.0-8.0							
P42	5.0-8.0	912	5.11	175	18.5	3.3	35	
P43	0 - 6.0	340	5.57	186		3.2	33	
P44	2.2-6.2	423	5.58	160		3.2	35	
P49								
P51	8.2-9.2	925	3.87		19			Orange brown to black, 9 hours pumping
P52	11.3-12.3	627	6.06	203		4.7	45	Dark brown to black, 12 hours pumping
P53		414	5.06	249		4.2	47	

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The light brown to black discoloration in the groundwater is due to the presence of humic acids and the associated diagenetic indurated deposits which are derived from decaying organic material under a reduced environment within the sand dune. Under such conditions the water is somewhat acidic (pH=3.9 to 6.6, average 5.5) and hydrogen sulphide gas is commonly present. Groundwater in the sand aquifer is oxygen deficient having a dissolved oxygen range of 1.1 to 9.3 mg/l with an average of 4.6 mg/l as compared to the solubility of oxygen in surface water at 18°C which is 9.5mg/l (Linsley & Franzini, 1972, Table 19-3, P. 19-4).

The inorganic chemical analyses of groundwater from production bore (P52) and spearpoint (P37) indicate a low salinity, acidic, Na:Cl dominant water with a slight to high discoloration and low concentration of trace metals. No bicarbonate anion is present. Bore P52 has a very high biological concentration which makes it unsuitable for human consumption; the reason for such content is not known. Spearpoint P37 has a slightly excessive concentration of iron which if used directly may cause minor brown staining. Iron from groundwater can be effectively removed by adding alum to increase the water pH; aeration for the conversion of iron from the ferrous to ferric state ($Fe^{2+} \rightarrow Fe^{3+}$); and a settling pond for the precipitation and thus separation of iron species from solution.

3.8 Analysis and Method of Groundwater Withdrawal

It will be necessary for large areas of the sand deposit north of Naracoopa to be accessed to intersect small quantities of groundwater throughflow without overstressing the aquifer system. Because the depth to the water table on the low permeability Pleistocene sand is 2.3 to 5.3m beneath the surface (at P52 and P51 respectively) and it contains high concentrations of carbonaceous cement a suitable method of groundwater withdrawal would be a series of low yielding production bores. To extract 1 Ml/day it may be necessary to construct at least 24 production bores over a length of 3km. Alternatively a 2.5km long spearpoint battery system with collector pipe and suction pump buried some 2m beneath the surface may also be constructed to withdraw small quantities of groundwater.

The Recent interdunal system transmits groundwater from the Pleistocene sand to the sea. The water level is around 2.5m beneath the surface, the aquifer appears to contain less carbonaceous cement and consequently is more amenable to groundwater withdrawal. The appropriate methods of groundwater extraction in the interdunal system would be by spearpoint battery or collector trench.

Analysis using a theoretical relationship for lines of extraction points indicate that the extraction of 1 Ml/day should be possible along the base of the Pleistocene sand on the western edge of the interdunal system using a spearpoint or collector trench system. The required annual utilization of 365 Ml is 50% of estimated average annual recharge or 33% of groundwater in storage within the Pleistocene sand. It would be required to intercept about 60% of the groundwater that naturally drains to the ocean. An efficient means of groundwater interception would be the construction of laterally continuous collector trench systems over a 2km length of interdunal sand and sunk to the base of the saturated sand. Construction of deep trenches in saturated sand may prove difficult. If spearpoint batteries were to be used each spearpoint should penetrate the full thickness of the saturated sand deposit and be spaced

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50m apart. Each point should yield $20\text{m}^3/\text{day}$, thus at least 50 spearpoints would be required over a 2.5 km length of groundwater extraction. It should be possible, with careful design and planning to use one vacuum pump to withdraw groundwater from a spearpoint battery over 2.5km. Based on the present assessment of aquifer transmissivity of $10\text{ m}^2/\text{day}$, a hydraulic gradient of 0.04 would be required to support this extraction rate. It should be stressed that only 1 pump test has been carried out in the interdunal area and so the hydrologic continuity along the 2.5 km area has not been determined. Hand augering for heavy mineral exploration indicates that several metres of saturated sand is present within the interdunal system from the Milford Beach deposit to Rocky Creek. Water level monitoring will be required to monitor the response of the aquifer to groundwater withdrawals.

3.9 Salt Water Encroachment

In a coastal environment where the hydrostatic gradient is towards the sea a fresh water/salt water interface boundary develops. If excessive groundwater withdrawal occurs within the low salinity sediments and the radius of influence extends to the interface boundary, salt water will migrate landwards and contaminate the coastal aquifer with deleterious results.

At Naracoopa the basement clay dips to the east being about RLO.4m beneath the frontal dune and just below sea level on the beach. The standing water level in the interdunal aquifer 50m from the shoreline is RL1.5m. If the water level was drawdown to near the base of the sand aquifer, (say RLO.6m) the radius of influence would not extend to the shoreline due to the topography of the sand:clay boundary; the drawdown at the spearpoint being above mean sea level; as well as due to the hydrostatic head of water in the adjacent Pleistocene sand system. Thus it is unlikely that salt water intrusion would occur by withdrawing groundwater from the interdunal system.

3.10 Use of Sea Water

Comments on the viability of utilising sea water as a source of dredge pond make up water instead of low salinity groundwater are given. Sea water was used for the previous mining operations between 1968 to 1977.

If sea water was used as dredge pond make up water, most of the water would initially be retained within the tailings. Seepage of this saline water would eventually occur from the dredge pond mound direct to the aquifer and in the long term rainfall would flush the salt from the tailings. Assuming that the tailings are replaced and shaped similar to the pre-mining topography it can be expected that the shape of the post mining water table would approximate present conditions. Groundwater discharge from the mined area will therefore be maintained towards the sea and Frazer River. Therefore from commencement of mining the groundwater around the mining activity would gradually increase in salinity, reach a peak and then gradually recede as all of the salt water is removed by drainage from the sand aquifer. This will occur over a long period of time and conditions will not return to present natural conditions until well after mining ceases. The current groundwater chemistry study has shown that 10 years after completion of the previous mining event saline water is still being flushed from the aquifer.

The introduction of saline groundwater would have the effect of killing all non-salt tolerant vegetation in the surrounding area of contamination,

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freshwater marine life in the river pools and destroying the natural habitat many other forms of animal life. The introduction of salt water for mining purposes on the sand would have deleterious effects on the aquifer system for long period of time.

Initially only very salt tolerant vegetation could be planted for revegetation of the tailings, but with time and as flushing of salt occurs, these could eventually be replaced by non-salt tolerant plants. Again it must be stressed that this would occur over a long period of time.

3.11 Assurance of Water Supply

Due to the presence of low permeability indurated sands at Naracoopa the aquifer does not form an ideal groundwater supply system. The study on the Pleistocene system indicates that a large number of low yielding production bores, (>24) or an extensive buried spearpoint battery system would be necessary to extract the water requirement. The hydrologic characteristics of the Recent, less indurated interdunal system and its shallow potentiometric surface indicate that an extensive spearpoint battery ^{or} of a trench system should yield 1 Ml/day from the groundwater regime.

The required mine water supply of 1 Ml/day is 68% of the estimated groundwater discharge towards Sea Elephant Bay and 33% of water in aquifer storage. If a spearpoint battery or trench was developed at the base of the Pleistocene deposit along a 2.5km length of interdunal sand (out of the 4km length south of Rocky Creek) it appears likely that even if all groundwater passing this section was intersected, some water from storage would also be required. The estimate of groundwater availability to the trench or spearpoint system assumes that such quantity can be drained from the higher indurated Pleistocene sand. It further assumes that the saturated sand along the interdunal system is hydrologically continuous over the length to be utilised. Before an extensive trench or spearpoint battery system is developed it is recommended that a trial 250m length be constructed and pumped over an extended period to determine the applicability of the water interception/withdrawal method before a full scale production field is developed.

Additional mine water may be available from the Frazer River upstream of the tidal limit and pumped into a storage facility. No hydrological information on the Frazer River has been obtained.

The risk of salt water intrusion from Sea Elephant Bay into the unconfined sand aquifer appears to be small. It appears that potable water is not available from the sand aquifer (based on bacteriological, colour and iron concentration). It may be necessary to obtain such a supply from a surface catchment source.

Alternative sources of water that may require study include surface water catchments and the use of reverse osmosis sea water treatment. Reverse osmosis occurs when a pressure is applied to a saline solution in a pressure chamber forcing water of low salt content through a semi-permeable membrane leaving behind most of the dissolved salts. Such treatment is available to reduce sea water to less than 1000 $\mu\text{S}/\text{cm}$ but the capital cost of a treatment plant to supply 1 Ml/day is high.



The required quantity of groundwater appears to be available from the aquifer system south of Rocky Creek to Naracoopa but extensive lengths of trenches or spearpoint batteries would be required and the capital cost of such an interception scheme will be expensive. A careful water management scheme is required to effectively utilise and re-use the mine waste water to reduce the quantity of groundwater required from the aquifer system.

4.0 HYDROGEOLOGY OF THE COWPER POINT AREA

Twenty regional groundwater test holes were drilled in the Cowper Point area (Figure 4) of which 15 were converted to observation piezometers. A production bore (P50) and a spearpoint (P49), were constructed in the High Dune region and pump tested to determine aquifer hydrologic characteristics. The production bore and spearpoint were sited in the topographically low interdunal region between the outer and inner aeolian dunes where the depth to the water table was shallow. Additional observation piezometers were installed nearby to measure water level fluctuation during periods of groundwater withdrawal. Construction details are given in Appendix A, inorganic chemistry of groundwater from P50 in Appendix B and representative plots of water level drawdown during pumping on Figures 16 to 22.

Only the High Dune area has been studied in sufficient detail to estimate available groundwater withdrawal. No pump tests were carried out in the Back Beach area.

4.1 Aquifer Identification

Both the High Dune and Back Beach deposits are underlain by an unconfined to semi-unconfined aquifer of aeolian and beach origin. The total area behaves as part of one aquifer system of variable permeability. Where the sand is silty and the carbonaceous indurated horizons are present the aquifer is assumed to have relatively low permeability compared to that in the central High Dune region where the diagenetic deposit is absent. No perched aquifers are known to occur in the High Dune region. Blowhole Creek truncates the sand near Sea Elephant Bay and partially hydrologically separates the northern aquifer system from the southern sand deposits.

The basement calcareous sandstone underlying the High Dune is assumed to have little potential as an aquifer to supply the mine requirement. All test bores were terminated when basement was intersected thus hydrogeological testing of the hard rock was not carried out. The high plasticity clay basement, intersected beneath the Back Beach deposit is assumed to have no potential to supply any usable groundwater.

4.2 Thickness of Saturated Sand

Table 4.1 and Figures 6 and 15 indicate the thickness of saturated sand (measured February 1989). Due to large variations in surface topographic relief over short distances the saturated zones appear irregularly distributed within the High Dune area (eg. P23, P24). The thickness of saturated sand

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SUMMARY OF BORE LOCATION, WATER LEVEL (FEBRUARY 1989), SATURATED THICKNESS AND DEPTH TO BEDROCK - COWPER POINT - KING ISLAND

BORE NO	CO-ORDINATES	SURFACE RL (m)*	TOTAL DEPTH (m)	CASING STICK UP (m)	S.W.L. (m)			SATURATED THICKNESS (m)	DEPTH TO BEDROCK		TYPES*
					BELOW CASING	BELOW GL	RL		GL	RL	
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P14***			6.0						5.8		C
P15***			5.5						5.2		C
P16***			5.5						3.5		C
P17***			6.3						6.3		C
P22	2320E 4350N	4.1	8.0	0.45	2.95	2.5	1.6	5.5	8.0	-3.9	C.S
P23	2560E 3750N	16	9.1	0.68	8.86	8.18	7.82	0.92	9.1	6.9	C.S
P24	2520E 3750N	12	12.5	0.50	5.11	4.61	7.35	7.85	12.5	-0.5	C.S
P25	2480E 3450N	7	6.25	1.18	3.78	2.6	4.4	3.65	6.25	0.75	C.S
P26	2440E 3450N	9	7.2	0.63	4.68	4.05	4.95	3.15	7.2	1.8	C.S
P27	2400E 3450N	9	6.25	0.52	4.09	3.57	5.43	2.68	6.25	2.75	C.S
P28	2320E 3450N	9	9.0	0.56	4.76	4.2	4.8	3.7	7.9	1.1	C.S
P29	2240E 3450N	7	5.5	0.92	2.22	1.32	5.68	4.18	5.5	1.5	C.S
P30	1320N 3150N	12.5	7.5	0.15	1.04	0.89	11.61	6.61	7.5	5	C.S
P31	840E 3150N	13	5.25	0.33	0.69	0.36	12.64	4.89	5.25	7.75	C
P32	1000E 2200N	12	6.0	0.10	0.94	0.84	11.16	5.16	6.0	6	C.S
P33	1880E 2200N	4.5	3.0	0.27	1.49	1.22	3.26	1.76	3.0	1.5	C.S
P34	1000E 1600N	13	3.5	0.11	1.81	1.7	11.3	1.8	3.5	9.5	C.S
P35	2100E 2500N	4.5	15.0	0.65	1.0	0.35	4.15		15.0		C.S
P36	2308E 4378N	6	6	0.5							
P45	2308E 4378N	6	8.5	0.5	2.09	1.59	4.41	5.81	7.4	-1.4	C.S
P46	2320E 4320N	6	9.5	0.5	3.57	3.07	2.93	6.33	9.4	-3.4	C.S
P47	2481E 3462N	7	6.6	0.5	2.51	2.01	4.99	4.49	6.5	0.5	C.S
P48	2291E 4341N	6	5.6	0.5	3.63	3.13	2.87	2.47	5.6	0.4	C.S
P49	2481E 3448N	7	6.5	0.5	2.61	2.11	4.89	4.39	6.5	0.5	C.S
P50	2310E 4340N	6	7.5	0.5	2.51	2.01	3.99	5.29	7.3	-1.3	C.S

* R.L Approximate from orthophotomaps

** C.S Calcareous Sandstone

C = Clay

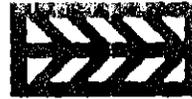
*** P14, P15, P16 & P17

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under the High Dune varies from 0.92 to 7.85m with a general trend for thickness to increase to the north. The average saturated sand thickness beneath the High Dune system is taken as 4m. The saturated sand is less than 2m thick to the south (P33 or P34) but in the slightly elevated strand line of the Back Beach deposit saturated sand thickness varies from 4.9 to 6.6m. Blowhole Creek truncates the sand to bedrock near Sea Elephant Bay and forms the southern extremity of the partially isolated northern sand body.

The total sand areas beneath the High Dune and the Back Beach deposits, which form part of the total northern aquifer system are 130 & 54 hectares respectively. The areal extent of non-carbonaceous sand beneath the High Dune area is approximately 60 hectares.

4.3 Aquifer Hydrologic Characteristics

The aquifer hydrologic characteristics of the clean sand unit beneath the High Dune, as assessed from the pumping tests are given in Table 4.2.

TABLE 4.2

PUMPING TEST RESULTS - COWPER POINT - KING ISLAND

Pumped Bore	Observation Piezometer	Distance Pump Bore (m)	Transmissivity (m^2/day)	Storage Coefficient	Method of Analysis
P49			138		Recovery
	P25	2.0	135	6.6×10^{-3}	Recovery
	P47	30	90	4.25×10^{-2}	Type Curve
	P26	40			
P50	P25, P47, P26		78		Distance/Drawdown
			234		Cooper-Jacob Drawdown
			259		Recovery
	P22	10.9	348	2.4×10^{-2}	Type Curve
			739	1×10^{-3}	Recovery
	P45	40	No measurable water level drawdown		
	P46	21.2	439	0.34	Type Curve
			400	3.5×10^{-3}	Recovery
	P48	18.2	174	1.2×10^{-2}	Type Curve
			662		Recovery
	P22, P45, P46, P48		176		Distance/Drawdown

Production bore P50 was pumped at a constant rate of $105m^3/day$ for 12 hours with a water level drawdown of 1.56m (29% of saturated thickness). This pumping rate is ten times the groundwater yield from the production bore at Naracoopa (P52) with a smaller water level drawdown. The estimated transmissivity ranges from 176 to $739 m^2/day$. Transmissivity values for a clean, 4m thick, coarse grained sand aquifer usually range between 200 to $400 m^2/day$ (Todd, 1980, p.38).

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Storage coefficient values for an unconfined aquifer after prolonged periods of pumping should approach the specific yield value of 0.1.

Results of pumping spearpoint P49 at a constant rate of 45 m³/day for 10 hours indicate the presence of a less permeable sand aquifer. The aquifer has an absence of carbonaceous cement, silt and peat. The aquifer transmissivity was estimated between 90 and 138 m²/day.

The carbonaceous cemented sand, where present beneath the High Dune area appears less concentrated and consolidated than in the Back Beach and Naracoopa areas. For this less permeable part of the High Dune aquifer system a transmissivity value of 20 m²/day would be appropriate.

4.4 Aquifer Storage

Based on a clean aquifer area of 60 hectares, an average sand thickness of 4m and a specific yield of 0.1 the volume of water stored in the non-carbonaceous section of the High Dunes would be 250 ML. The estimated volume of groundwater in storage in the High Dune deposit including the carbonaceous cemented horizons is 400 ML.

4.5 Aquifer Recharge/Discharge

Recharge to the aquifer system would be from precipitation. No surface watercourses are present in the High Dunes. There is a general absence of peat and perched aquifer systems. A recharge value of 50% is taken as rainfall infiltration, the remainder being lost through evapotranspiration. The average annual rainfall is 912mm. Assuming an area of 130 hectares the annual recharge to the High Dune area is 593 ML (1.6 ML/day).

The potentiometric surface indicates that groundwater discharge is eastwards directly into Sea Elephant Bay or westwards from the High Dunes to surface watercourses and swamps which drain into the Sea Elephant River or Blowhole Creek and associated tributaries or is lost by evapotranspiration.

4.6 Interrelationship between Groundwater and Surface Water

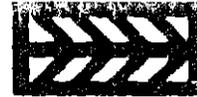
The elevated potentiometric surface in the High Dunes maintains groundwater drainage by gravity towards the central swamps, the sea and surface watercourses. Blowhole Creek is usually dry along the Back Beach deposit during February to April each year. There is no visible evidence of baseflow into the extensive tidal estuary of Sea Elephant River although the potentiometric surface indicated that groundwater movement from the northern section of the High Dunes is towards this watercourse.

The development of borefields in the interdunal system within the High Dune sand system between 3000N and 4650N would have negligible effect on baseflow to the Sea Elephant River or Blowhole Creek as they are beyond that part of the aquifer which contributes groundwater flow to these watercourses. The reduction in the potentiometric surface around the borefield would create additional void space which would assist in the accommodation of additional recharge water to the aquifer system.

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Heavy mineral mining close to the Sea Elephant River would not induce salt water intrusion as long as the water level in the dredge pond is maintained above river level.

When the dredge pond is located in the carbonaceous cement and iron rich sections of the High Dunes it is expected that the groundwater would become more discoloured due to the disturbance of the cement and the oxidation and remobilisation of the iron. Seepage from the pond in this environment would not increase salinity but may marginally increase the colour of groundwater discharging to the surface or towards the borefield.

4.7 Groundwater Chemistry

On-site chemical analyses of groundwater from the observation piezometers and production facilities are given in Table 4.3 and the variation in specific conductance shown on Figure 15. Inorganic chemical analyses for production bore P50 is given in Appendix B.

Groundwater with specific conductance less than 1000 $\mu\text{S}/\text{cm}$ is located along the High Dune and Back Beach recharge areas with salinity increasing along the groundwater flow path. Higher salinity groundwater (up to 1370 $\mu\text{S}/\text{cm}$) is located in the northern part of the High Dunes around P50 and 1760 $\mu\text{S}/\text{cm}$ in the swamp along drill line 3450N. Inorganic chemical analyses of groundwater from P50 indicate a neutral, colourless to light brown, Na:Cl type water enriched in calcium and bicarbonate. Dissolution of shells within the northern sand deposit has taken calcium and bicarbonate into solution. It is likely that higher concentration of discolouration occurs in the High Dunes where carbonaceous cement is present.

Dark brown, acidic water, (pH = 3.6-6.4) with a hydrogen sulphide smell dominates in the carbonaceous cement rich Back Beach area.

No bacteriological analyses of groundwater in the High Dune area was undertaken.

4.8 Computer Modelling Results and Method of Groundwater Withdrawal

A two dimensional, finite element model of the Cowper Point region was developed to assess relationships between groundwater recharge and observed groundwater levels. Figure 23 shows the finite element model which comprises approximately 330 triangular and rectangular isoparametric elements. The eastern boundary, corresponding to the coastline was assigned as a constant head boundary. The western boundary, corresponding to the western limit of the dunal system was assigned as a no flow boundary. The northern boundaries are no flow boundaries chosen to correspond with assumed groundwater flow lines. A transmissivity of 20 m^2/day was adopted for the indurated horizons and a permeability of 30 m/day was adopted for the clean sands. An impermeable basement at RL 0m was assumed. The hydrologic uniformity throughout the clean dune system has not been established, although permeable aquifer parameters at the two sites tested indicate that the hydrologic aquifer characteristics may be consistent.

TABLE 4.3

ON-SITE CHEMICAL ANALYSES RESULTS-FEBRUARY 1989 - COWPER POINT - KING ISLAND

BORE NO	SLOTTED/SCREENED INTERNAL (m)	SPECIFIC CONDUCTANCE ($\mu\text{S}/\text{cm}$)	pH	Eh	TEMPERATURE ($^{\circ}\text{C}$)	DISSOLVED OXYGEN ($\text{O}_2\text{mg}/\text{l}$)	(% O_2)	COMMENT
P22	7.0-8.0	672	6.64	212		2.2	24	Light brown, no smell
P23	8.1-9.1	656	6.23	239		7.3	66	Colourless
P24	11.5-12.5	693	6.41	242		6.3	66	Colourless
P25	5.75-6.25	936	7.05	224	25	9.3	90.7	Colourless
P26	6.2-7.2	839	6.21	235		3.8	34	Weakly brown
P27	5.25-6.25	915	6.41	239		3.9	36	Colourless
P28	6.9-7.9	938	6.4	145		4.0	39	Light brown
P29	4.5-5.5	493	6.3	192		8.2	77	Light brown
P30	6.5-7.5	1361	5.69	63	25	5.3	51	Brown
P31	4.25-5.25	497	3.6	497	25	3.5	32	Brown H_2S
P32	5.0-6.0	1480	5.4	255		7.1	75	Brown H_2S
P33	2.0-3.0	1292	6.34	97		1.1	12.9	Brown
P34	2.5-3.5	752	6.6	102		3.4	36	Brown
P35	14.0-15.0	1375	6.91	203	18	3.7	42	Brown
P36								
P45	2 - 8.5	1238	6.31	211	17.5	4.8	61	
P46	2 - 6.0	1208	6.81	203	18.1	5.4	57	
P47	0 - 4.0	971	6.25	2.01		5.6	42	Dark grey, milky H_2S
P48	4 - 5.6				18			
P49	5.2-6.0	891	6.14	189		4.6	47	Colourless, weak H_2S - 9hr Pumping
P50	5.9-6.9	1580	7.3	79		1.4	17	After 12 hours pumping.

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Figure 23 shows calculated groundwater contours under a steady rainfall infiltration rate of 1 mm/day (365 mm/year). The computer model indicates that the hydraulic gradient towards the sea would be of the order of 0.5m in 100m. This computed value is much lower than the observed gradient of about 3m per 100m. This anomaly could be explained by the existence of a hydrologic barrier to outflow along the sea shore. No direct evidence of such a barrier has been found.

Analysis indicates that the extraction of 1 Ml/day may be possible by the establishment of spearpoint battery withdrawal facilities that fully penetrated the saturated aquifer thickness along the interdunal section of the High Dune. Each point should yield 20 m³/day and be spaced 25m apart, thus at least 50 points would be required over a 1.25 km length of groundwater extraction. The required annual utilisation of 365 Ml is about 60% of estimated annual recharge to the High Dune aquifer system and 90% of groundwater in storage. It would be physically impossible to intercept the total natural drainage from the dunes thus additional groundwater must also be taken from aquifer storage for an adequate supply for the mining operation.

The depth to the water table beneath the interdunal section of the High Dunes varies from 2-3m beneath the surface. It would appear that spearpoint batteries in the configuration suggested would be an appropriate, economic method of groundwater extraction. If insufficient water is withdrawn along the 1.25 km length of extraction additional spearpoints can be installed to expand the spearpoint battery.

It would be necessary to monitor the aquifer behaviour due to groundwater withdrawals by the measurement of water levels in observation piezometers near the spearpoint battery.

The availability of low salinity surface water to supply the mine water requirement is assessed as poor.

4.9 Salt Water Intrusion

Under natural conditions the hydrostatic head within the High Dunes maintains the fresh water/salt water interface in the sand aquifer towards the Sea Elephant River and Sea Elephant Bay. Salt water intrusion may occur if excessive groundwater withdrawal takes place and where the radius of influence from the spearpoint battery is in hydrologic connection with the interface boundary.

At Cowper Point the calcareous sandstone bedrock occurs as a shallow bedrock platform at RL1 to RL-2m. The standing water level in the clean sand aquifer along the interdunal section of the High Dune varies from RL2 to RL5m. If a spearpoint battery was developed along the N-S interdunal area between 3400N and 4650N and the water table was drawn down to 0.5m from the base of the aquifer analytical calculations indicate that the radius of influence would not intersect water from Sea Elephant Bay. Thus it is unlikely that salt water intrusion would occur from the ocean with a spearpoint battery sited in the defined interdunal area. Salt water intrusion landwards from the Sea Elephant River towards a spearpoint battery would occur if the withdrawal facility was within a distance of 300m from the tidal watercourse. If the dredge pond was between the Sea Elephant River and the spearpoint battery a positive

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hydrostatic head from the groundwater mound beneath the pond would be established. Under this circumstance the withdrawal facility could be established up to 100m from the tidal watercourse without salt water intrusion occurring.

4.10 Assurance of Water Supply

The clean aquifer system beneath the High Dune at Cowper Point appears to have good hydrologic characteristics. The presence of shallow bedrock, thin aquifer thickness and carbonaceous cement west of the clean sand restricts the groundwater yielding potential of the area. The required mine water supply of 1 Ml/day should be available from the aquifer beneath the High Dunes. This water demand is 60% of estimated recharge to the aquifer system and 90% of groundwater in storage. It is unlikely that groundwater yield in excess of 1 Ml/day could be extracted from the High Dune system. It will be necessary to withdraw groundwater over a large area (1.25km) for long term operations or over shorter distance for intermittent supplies. An appropriate means of groundwater extraction is by spearpoint battery.

The risk of salt water intrusion from Sea Elephant Bay into the aquifer is small. Salt water encroachment from the Sea Elephant River is possible if the spearpoint battery is located close to its shore.

It is recommended that a 500m length of spearpoint battery be initially established and pumped over an extended period of time with monitoring of water levels in nearby observation piezometers. Additional spearpoints can be added as required to increase the groundwater extraction rate.

The upper limit of groundwater extraction in the High Dune appears to be 1 Ml/day and should not be exceeded until the aquifer system has been monitored over an extended period of time. A careful water management scheme is required to effectively utilise and re-use the mine waste water to reduce the quantity of groundwater required from the clean aquifer system.

5.0 THE TASHMANIAN GOVERNMENT GROUNDWATER ACT (1985)

The following notes are extracted from a paper given by Mr. P.C. Stevenson, Supervising Geologist, Groundwater, Department of Mines Tasmania to a Workshop in Sydney (October 1987). The notes are intended to provide an insight into the Government's policy on groundwater extraction and protection.

5.1 Allocation Principles

The first allocation principle is seen in Section 8 of the Groundwater Act (1985) in the duties of the Director. This states, inter alia, that the Director must obtain and collate all possible information on groundwater, that he must ensure that a high quality is maintained, that supplies are not unduly depleted, and that "... groundwater is utilised equitably in the best interests of Tasmania...". This seeks to inculcate a spirit of co-operation which is amplified by other provisions of the Act. The second principle is Section 16 relating to Well Orders. If any of the principles enshrined in his duties are offended against, then the Director may, by order served on the owner or occupier, direct him to do one or more of a whole range of fundamental things

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to his bore, including filling it in, restricting discharge, using the water for specified purposes only, and so on.

5.2 Legislation

The Act states that an owner or occupier may take groundwater for his reasonable requirements. Considerations of ownership are not entered into.

There are no proclaimed areas as yet, but one is under consideration and monitoring, and two others have been suggested.

5.3 Licensing

The licensing of drillers is not required.

Bore construction permits are not required in the first instance, except in future proclaimed regions.

5.4 Allocation

There will be "equitable" sharing of groundwater which is in the best interests of the State.

As far as conjunctive use is concerned, the nature of the aquifers makes the concept rather academic, but the Act allows for it in its requirement for co-operation between the surface water and the groundwater authorities - the duty to consult.

Water mining, (excessive groundwater withdrawals) is possible, but has not yet arisen.

There is a permit fee, which is set at \$50.

Metering can be required as a permit condition in a proclaimed region or as a result of a well order in any region. The meter is provided and owned by the Government, which is also responsible for maintenance. There is no intention at the moment for metering to be widely used, so that the cost is unlikely to be very significant, and is absorbed into the annual costs of the monitoring programme.

Restrictions on permits - "conditions", can be placed on when permits are issued in proclaimed regions, or can be placed anywhere at any time by means of the well order.

5.5 Impact of Allocation Policies on Environmental Issues

The Groundwater Act (1985) post-dates the setting up of the Department of the Environment, and powers in respect of pollution are now shared with that authority. This takes the form of a requirement to consult which acts reciprocally on both authorities. Whenever consultation takes place, the matter must also be taken up by the Advisory Committee.

Quite apart from the joint powers with Environment, one of the items left over

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from the 1966 Act is an offence carrying a penalty of \$5000 for the pollution of groundwater, and now incorporated in the new Act.

The twin approaches on environmental issues is that of persuasion to co-operate in equitable distribution, and the threat of well orders. These could be invoked in the event of an increase in salinity in exploited groundwater. This particular hazard is not likely on a big scale, but is already being experienced in sand dune aquifers supplying water to golf courses in Tasmania.

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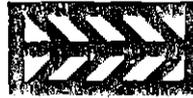
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REFERENCES

1. Groundwater Allocation Workshop, (1987). Aust. Water Res. Council Groundwater Committee. Sydney, October 27-28.
2. Laycock, J.W., (1975). North Stradbroke Island - Hydrogeological Report. Geological Survey of Queensland, Report No. 88.
3. Linsley & Franzini, (1972). Water Resources Engineering. McGraw Hill Inc
4. Todd, D.K., (1980). Groundwater Hydrology. John Wiley & Sons N.Y. Second Edition.

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GLOSSARY OF GROUNDWATER TERMS

This groundwater glossary has been compiled to assist in the use of this report. Some of the definitions given are not scientifically rigorous, but should not cause misunderstanding in common groundwater situations.

Groundwater terminology in Australia generally follows the traditional British nomenclature. Loman et.al. (1972) gives a terminology widely used in the USA which is probably much nearer to common international usage.

ACID

Any chemical compound containing hydrogen capable of being replaced by positive elements or radicals to form salts. In terms of the dissociation theory, it is a compound which, on dissociation in solution, yields excess hydrogen ions. Acids lower the pH. Examples of acids or acidic substances are humic acid, hydrochloric acid and tannic acid.

AERATION

The process of bringing air into intimate contact with water, usually by bubbling air through the water to remove dissolved gases like carbon dioxide and hydrogen sulfide or to oxidize dissolved materials like iron compounds.

ALKALINE

Any of various soluble mineral salts found in natural water and arid soils having a pH greater than 7. In water analysis, it represents the carbonates, bicarbonates, hydroxides, and occasionally the borates, silicates, and phosphates in the water.

ANION

A negatively charged ion that migrates to an anode, as in electrolysis.

ANION EXCHANGE

Ion exchange process in which anions in solution are exchanged for other anions from an ion exchanger.

ANISOTROPIC

Having some physical property that varies with direction.

AQUIFER

An aquifer is a body of saturated rock or soil containing a system of interconnected voids sufficient to yield significant quantities of water to bores, dugwells or springs.

**BEDROCK**

A general term for the rock, usually solid, that underlies soil or other unconsolidated material.

CAPILLARY FRINGE

The zone at the bottom of the vadose zone where groundwater is drawn upward by capillary force.

CAPACITY

The capacity of a bore is the maximum rate at which water has been, or could be, withdrawn from the hole. The capacity of a bore commonly decreases as the period of continuous pumping increases.

CATION

An ion having a positive charge and, in electrolytes, characteristically moving toward a negative electrode.

CONE OF DEPRESSION

The cone of depression measures the extent and amount of lowering of the potentiometric surface by the withdrawal of water from a bore or group of bores. It varies in size and shape with the rate and duration of withdrawal and the nature of the aquifer.

CONFINED GROUNDWATER

Confined groundwater is held in an aquifer at a pressure greater than atmospheric by the presence of an overlying confining bed. This bed has a distinctly lower hydraulic conductivity than the aquifer.

CONFINING BED

A confining bed is a body of less permeable material overlying or underlying an aquifer. This term is now preferred to the terms "AQUICLUDE", "AQUIFUGE" and "AQUITARD".

DARCY'S LAW

A derived equation for the flow of fluids on the assumption that the flow is laminar and that inertia can be neglected.

DIAGENESIS

Process involving physical and chemical changes in sediment after deposition that converts it to consolidated rock; includes compaction, cementation, recrystallization, and perhaps replacement as in the development of dolomite.

**DISSOLVED OXYGEN**

The amount of oxygen dissolved in water or sewage, expressed in parts per million (ppm) by weight, or milligrams per liter (mg/l).

DRAWDOWN

The drawdown at a point in an aquifer is the lowering of potential due to the withdrawal of water from an adjacent bore or dugwell.

ELECTRICAL RESISTIVITY

The property of a material which resists the flow of electrical current measured per unit length through a unit cross-sectional area.

EVAPOTRANSPIRATION

Loss of water from a land area through transpiration of plants and evaporation from the soil.

GROUNDWATER

Groundwater is the water in the saturated zone.

HARDNESS

A property of water causing formation of an insoluble residue when the water is used with soap. It is primarily caused by calcium and magnesium ions.

HEAD

The static head is the height above a standard reference datum of the surface of a column of water that can be supported by static pressure against the pressure of the atmosphere. The static head is the elevation of the water table above the datum. Within the zone of saturation the static head is the sum of the elevation of the measurement point above datum and the pressure of the water at that point relative to atmospheric pressure.

HEAVY MINERALS

The accessory detrital minerals of a sedimentary rock, of high specific gravity, which are separated in the laboratory from minerals of lesser specific gravity by means of liquids of high density, such as bromoform. Examples include zircon, rutile, ilmenite, monazite and tourmaline.

HETEROGENEOUS

Non-uniform in structure or composition throughout.

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**HOLOCENE**

Recent; that period of time (an epoch) since the last ice age (120,000 years B.P) also the series of strata deposited during that epoch.

HOMOGENEOUS

Uniform in structure of composition throughout.

HYDRAULIC CONDUCTIVITY

Hydraulic conductivity is a measure of the ease with which water, in the conditions prevailing in the aquifer, can flow through rock or soil. It is measured as the flow per unit cross sectional area under unit hydraulic gradient.

HYDRAULIC GRADIENT

The hydraulic gradient is the change in static head per unit of distance in a given direction. If not specified, the direction generally is understood to be that of the maximum rate of decrease in head.

HYDROGEOLOGIC

Those factors that deal with subsurface waters and related geologic aspects of surface waters.

INDURATED

Rendered hard; confined in geological use to masses hardened by heat, baked, etc., as distinguished from hard or compact in natural structure. In modern usage the term is applied to rocks hardened not only by heat, but also by pressure and cementation.

INFILTRATION

Infiltration is the movement of water through the ground surface into small voids in either the saturated or unsaturated zone.

INTERFERENCE

The condition occurring when the area of influence of a water well comes into contact with or overlaps that of a neighboring well, as when two wells are pumping from the same aquifer or are located near each other.

ION

An element or compound that has gained or lost an electron, so that it is no longer neutral electrically but carries a charge.

**LAMINAR FLOW**

Water flow in which the stream lines remain distinct and in which the flow direction at every point remains unchanged with time. It is characteristic of the movement of groundwater.

METAMORPHIC ROCKS/METAMORPHOSED

Any rock derived from pre-existing rocks by mineralogical, chemical, and/or structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment, generally at depth in the Earth's crust.

MUDSTONE

Mudstone includes clay, silt, siltstone, claystone, shale, and argillite. It should only be used when there is doubt as to precise identification of when a deposit consists of an indefinite mixture of clay, silt, and sand particles, the proportions varying from place to place, so that a more precise term is not possible.

OBSERVATION PIEZOMETER

A bore drilled in a selected location for the purpose of observing parameters such as water levels and pressure changes.

ORTHOQUARTZITE

A clastic sedimentary rock composed of silicemented quartz sand. The cement is commonly deposited in crystallographic continuity with the quartz of the worn grains.

OXIDATION

The combining of an element with oxygen.

PERCHED GROUNDWATER

Perched groundwater is separated from the main underlying body of groundwater by an unsaturated zone. Where it is unconfined, it has a perched water table. Perched groundwater is held up by a confining bed whose hydraulic conductivity is so low that water percolating downwards through it is not able to bring water in the underlying unsaturated zone above atmospheric pressure. Perched groundwater is a common, though not a necessary, feature of recharge areas.

PERMEABILITY

The permeability of a rock or soil is a measure of the ease with which fluids can flow through it. In physical terms it is independent of the properties of the fluid but it is sometimes used as a synonym of hydraulic conductivity.

**pH**

A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with acidity. Originally stood for the words potential of hydrogen.

PLEISTOCENE

The earlier of the two epochs comprising the Quaternary Period. Also the Post-Pliocene glacial age, (120,000 to 32,000 years BP) which in the above terminology implies the glacial age is over. Also the series of sediments deposited during this epoch.

POROSITY

The porosity of a rock or soil is its property of containing voids (spaces in the material not occupied by solid matter) and may be expressed quantitatively as the ratio of the volume of the voids to its total volume. With respect to the movement of water only the effective porosity, that due to interconnected voids, is significant. Many confining beds are distinguished from aquifers by their low effective porosity and/or extremely fine pore size, thus high specific retention rather than by differences in total porosity.

POTENTIAL

The potential of groundwater is the mechanical energy per unit mass of the groundwater at a given point in space and time with respect to an arbitrary state and datum. The groundwater potential is proportional to the head.

POTENTIOMETRIC SURFACE

A potentiometric surface is an imaginary surface defined by the potentials at all points on a given plane in an aquifer. Where the hydraulic gradient perpendicular to the aquifer is much less than the hydraulic gradient along the aquifer it is reasonable to apply the concept of potentiometric surface to the aquifer as a whole. Potentiometric surface is a synonym of piezometric surface.

PRECAMBRIAN

All rocks formed before the Cambrian Period.

PUMPING TEST

A test that is conducted to determine aquifer or bore characteristics.

RADIUS OF INFLUENCE

The radial distance from the centre of a bore to the point where there is no lowering of the table or potentiometric surface (the edge of its cone of depression).

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**RECENT**

see Holocene

RECHARGE

Recharge of groundwater is the addition of water to an aquifer, either directly from the surface, from the unsaturated zone, or discharge from overlying or underlying aquifer systems.

RUNOFF

That part of precipitation flowing to surface streams.

SAFE YIELD

The aim of many investigations of groundwater resources is to estimate, quantitatively, the water available for the intended use. This estimate is often expressed as the "safe yield" or "sustained yield" of a groundwater basin. It may be defined as the maximum rate at which water can be artificially withdrawn from a groundwater basin without causing depletion or deterioration of the resources to the extent that withdrawal at that rate is no longer economically feasible. But it must be stressed that safe yield, is not a fixed figure but must vary as hydraulic, economic and technical factors change with time.

SALINITY

The total content of dissolved solids in groundwater, commonly expressed as parts of dissolved solids per million parts of solution, or milligrams of dissolved solids per litre of solution (mg/l). The significance of salinity depends on the nature as well as the amount of the dissolved solids. See also SPECIFIC CONDUCTANCE.

SALT WATER ENCROACHMENT/INTRUSION

The phenomenon occurring when a body of salt water, because of its greater density, invades a body of fresh water. It can occur either in surface or groundwater bodies. The balance between the fresh and salt water, and static situations, is expressed by Ghyben-Herzberg formula.

SANDSTONE

A sedimentary rock composed of abundant rounded or angular fragments of sand set in a fine grained matrix (silt or clay) and more or less firmly united by a cementing material.

SATURATED ZONE

The saturated zone is that part of a body of permeable rock or soil in which all voids, large or small, are filled with water under pressure greater than atmospheric. The saturated zone may depart from the ideal in some respects. A rising water table may cause entrapment of some air in



the upper part of the zone of saturation and the lower part of the zone may include accumulations of other fluids, including oil and natural gas. Despite its name, the zone is defined by pressure conditions rather than the filling of all voids with waters. Parts of the unsaturated zone, which typically overlies the saturated zone, may have all pores filled with water, but this water is at less than atmospheric pressure and cannot drain from the rock into a bore or dugwell penetrating it.

SCREEN

A filtering device used to keep sediment from entering a water well.

SEMI-CONFINED AQUIFER

A semi-confined aquifer is one where the confining bed has sufficient permeability to allow some vertical water movement through the less permeable layer to the aquifer, thus contributing water to the aquifer system for withdrawal.

SEMI-UNCONFINED AQUIFER

If the hydraulic conductivity of the sediment above the water table is so great that the vertical flow component from the vadose zone cannot be ignored, the underlying aquifer is called a semi-unconfined aquifer. In general, such aquifers do not release their water instantaneously from storage and exhibit what is called delayed drainage.

SPEARPOINT

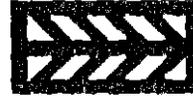
A screening device, equipped with a point on one end, that is meant to be driven or jetted into the ground.

SPECIFIC CONDUCTANCE

A determination of total dissolved solids (TDS) can be made by measuring the electrical conductance of a groundwater sample. Specific conductance is preferred rather than its reciprocal resistance, because it increases with salt content. Specific conductance defines the conductance of a cubic centimeter of water of a standard temperature of 25°C, measure in microsiemens/cm ($\mu\text{S}\cdot\text{cm}^{-1}$). Specific conductance may also be expressed as decimetres/metre ($\text{dS}\cdot\text{m}^{-1}$). An increase of 1°C increases the specific conductance by about 2 percent.

SPECIFIC YIELD

The specific yield of a rock or soil is the volume of water yielded by gravity drainage of unit volume of previously saturated material. The definition assumes that gravity drainage is complete, but in practice the time available for drainage may be limited so that the calculated specific yield is significantly less than the theoretical values.



STATIC WATER LEVEL

The static water level of groundwater is the water level that can be measured in a bore screened in an unconfined aquifer which is not being pumped. It is a measure of the head of the groundwater at the time of measurement at the depth at which the bore is open to the aquifer.

STORAGE COEFFICIENT

The storage coefficient is the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

In a confined water body the water derived from storage with decline in head comes from expansion of the water and compression of the aquifer. In an unconfined water body, the amount of water derived comes from gravity drainage.

TOTAL DISSOLVED SOLIDS, TDS

A term that expresses the quantity of dissolved material in a sample of water, either the residue on evaporation, dried at 356°F. (180°C), or, for many waters that contain more than about 1000 mg/L, the sum of the chemical constituents.

TRACE METALS

Metals present in minor amount in the earth's crust. All elements except the eight abundant rock-forming elements, (oxygen (O), silicon (Si), aluminium (Al), iron (Fe), calcium (Ca), sodium (Na), potassium (K), and magnesium (Mg)).

TRANSMISSIVITY

Transmissivity is the rate at which the water in an aquifer is transmitted through a unit width of aquifer under a unit hydraulic gradient. It embodies the permeability and saturated thickness of the aquifer, and the properties of the water in it. It is equal to the summation of the hydraulic conductivities across a unit width of the saturated part of the aquifer perpendicular to the flow paths.

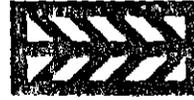
TRANSPIRATION

The process by which water absorbed by plants, usually through the roots, is evaporated into the atmosphere from the plant surface.

UNCONFINED GROUNDWATER

The upper surface of unconfined groundwater is formed either by a body of surface water or by a water table.

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**UNDERGROUND WATER**

The subsurface zone, usually starting at the land surface, that contains both air and water.

WATER TABLE

The water table is that surface in an unconfined water body at which the pressure is atmospheric. In bores which penetrate just far enough to hold standing water. In bores which penetrate to greater depths, the water level will stand above or below the water table if an upward or downward component of groundwater flow exists.

YIELD

Yield of a water bore can refer either to the capacity of the bore or to the amount of water actually withdrawn.

IMPORTANT INFORMATION

ABOUT YOUR GEOTECHNICAL ENGINEERING REPORT

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More construction problems are caused by site subsurface conditions than any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, due in large measure to programs and publications of ASFE/ The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the geotechnical-related delays, cost-overruns and other costly headaches that can occur during a construction project.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A geotechnical engineering report is based on a subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include: the general nature of the structure involved, its size and configuration; the location of the structure on the site and its orientation; physical concomitants such as access roads, parking lots, and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program. To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting geotechnical engineer indicates otherwise, *your geotechnical engineering report should not be used:*

- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified;
- when there is a change of ownership, or
- for application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered in their report's development have changed.

MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are extrapolated by geo-

technical engineers who then render an opinion about overall subsurface conditions, their likely reaction to proposed construction activity, and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those inferred to exist, because no geotechnical engineer, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions. *Nothing can be done to prevent the unanticipated, but steps can be taken to help minimize their impact.* For this reason, *most experienced owners retain their geotechnical consultants through the construction stage, to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.*

SUBSURFACE CONDITIONS CAN CHANGE

Subsurface conditions may be modified by constantly-changing natural forces. Because a geotechnical engineering report is based on conditions which existed at the time of subsurface exploration, *construction decisions should not be based on a geotechnical engineering report whose adequacy may have been affected by time.* Speak with the geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineers' reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. Unless indicated otherwise, this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose, or by the client for a different purpose, may result in problems. *No individual other than the client should apply this report for its intended purpose without first conferring with the geotechnical engineer. No person should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.*

A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical engineering report. To help avoid these problems, the geotechnical engineer should be retained to work with other appropriate design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to geotechnical issues.

BORING LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT *

Final boring logs are developed by geotechnical engineers based upon their interpretation of field logs (assembled by site personnel) and laboratory evaluation of field samples. Only final boring logs customarily are included in geotechnical engineering reports. *These logs should not under any circumstances be redrawn* for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, *give contractors ready access to the complete geotechnical engineering report* prepared or authorized for their use. Those who do not provide such access may proceed un-

- * For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical Information in Construction Contracts" published by The Institution of Engineers Australia, National Headquarters, Canberra, 1987.

der the *mistaken* impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes which aggravate them to disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical consultants. To help prevent this problem, geotechnical engineers have developed model clauses for use in written transmittals. These are *not* exculpatory clauses designed to foist geotechnical engineers' liabilities onto someone else. Rather, they are definitive clauses which identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your geotechnical engineering report, and you are encouraged to read them closely. Your geotechnical engineer will be pleased to give full and frank answers to your questions.

OTHER STEPS YOU CAN TAKE TO REDUCE RISK

Your consulting geotechnical engineer will be pleased to discuss other techniques which can be employed to mitigate risk. In addition, ASFE has developed a variety of materials which may be beneficial. Contact ASFE for a complimentary copy of its publications directory

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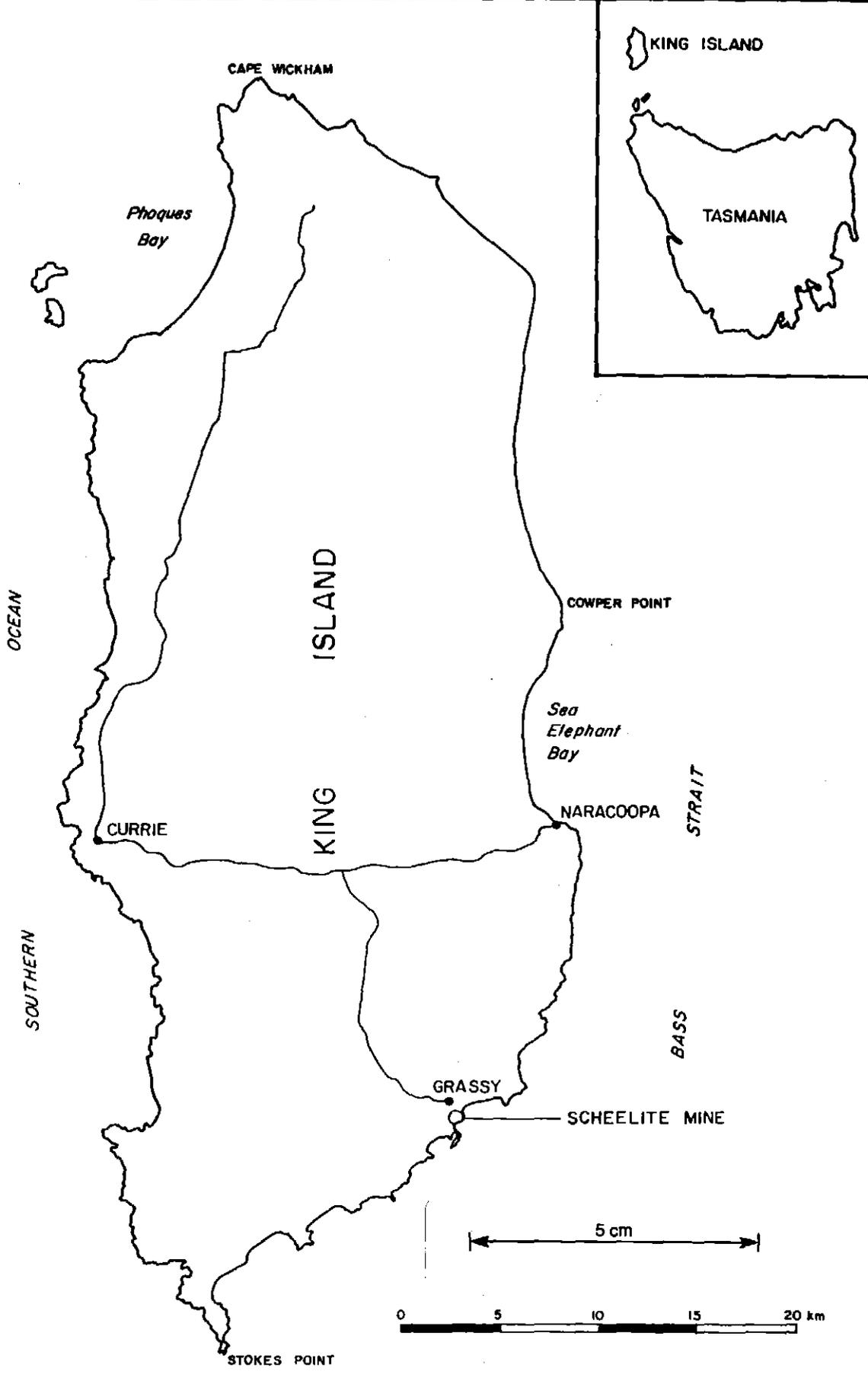
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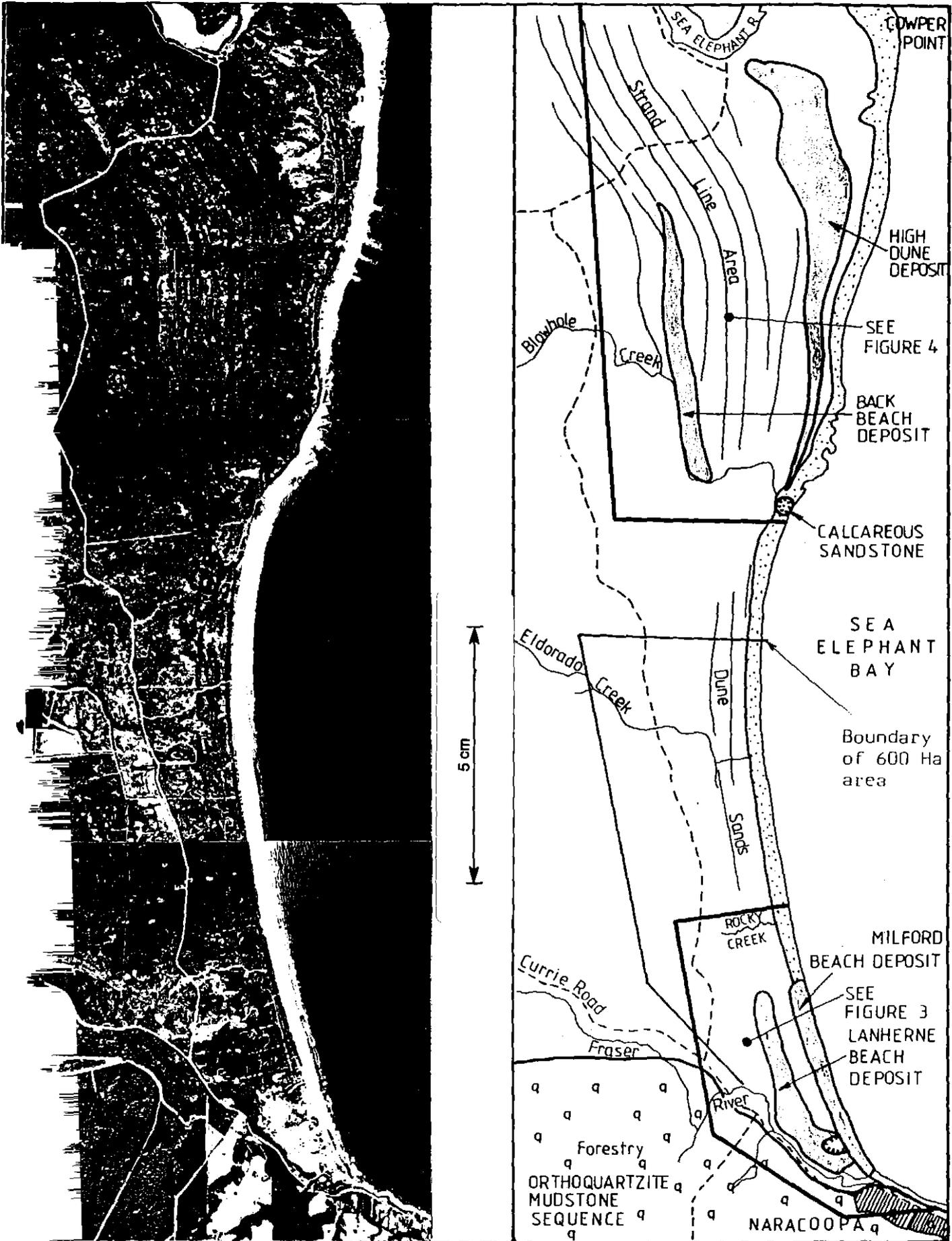
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NATIONAL MINERAL SANDS
KING ISLAND HEAVY MINERAL DEPOSITS
LOCALITY PLAN



FIGURE 1

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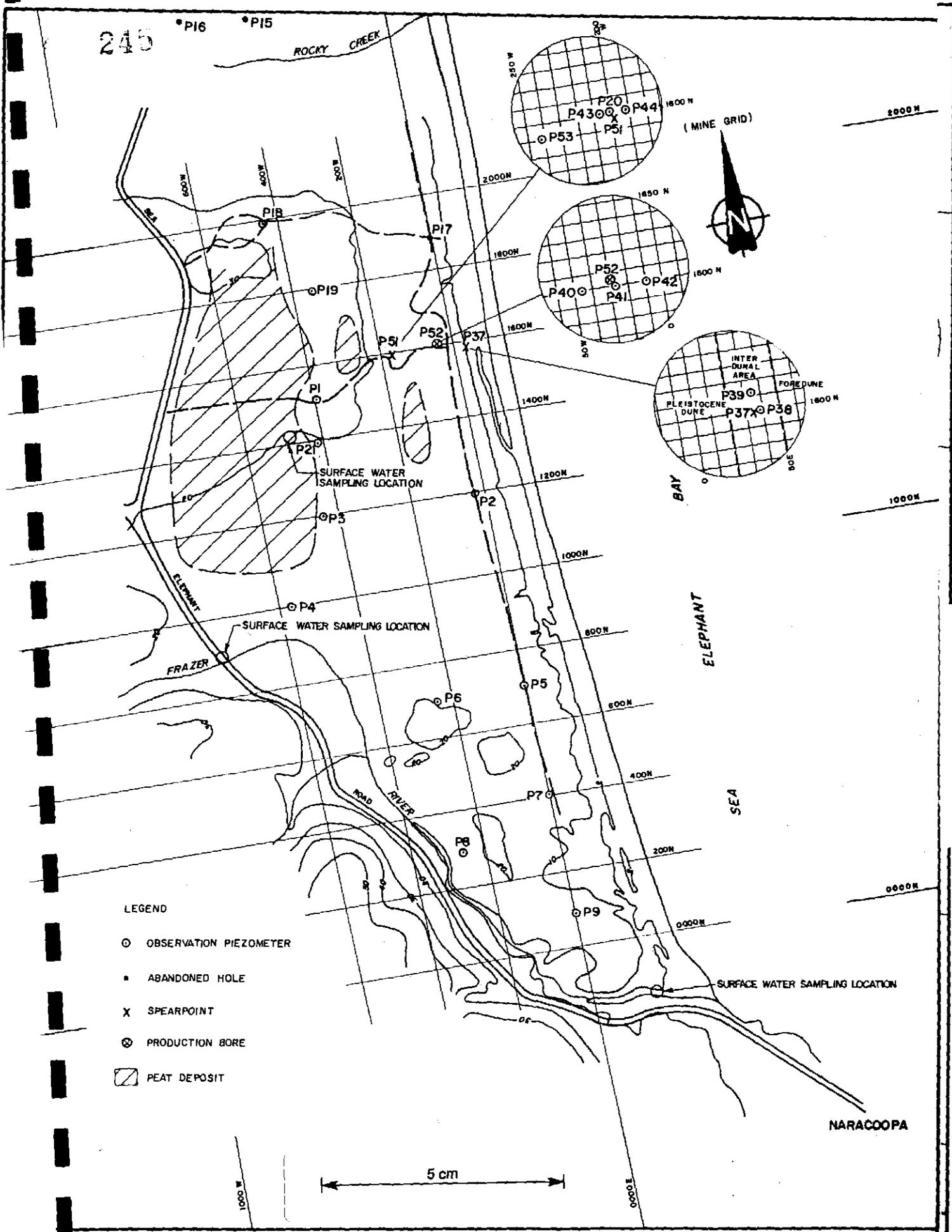
NATIONAL MINERAL SANDS
KING ISLAND HEAVY MINERAL DEPOSITS
LOCALITY PLAN & DEPOSITS



FIGURE 2

job no. G65/3

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- LEGEND
- OBSERVATION PIEZOMETER
 - ABANDONED HOLE
 - X SPEARPOINT
 - ⊗ PRODUCTION BORE
 - ▨ PEAT DEPOSIT

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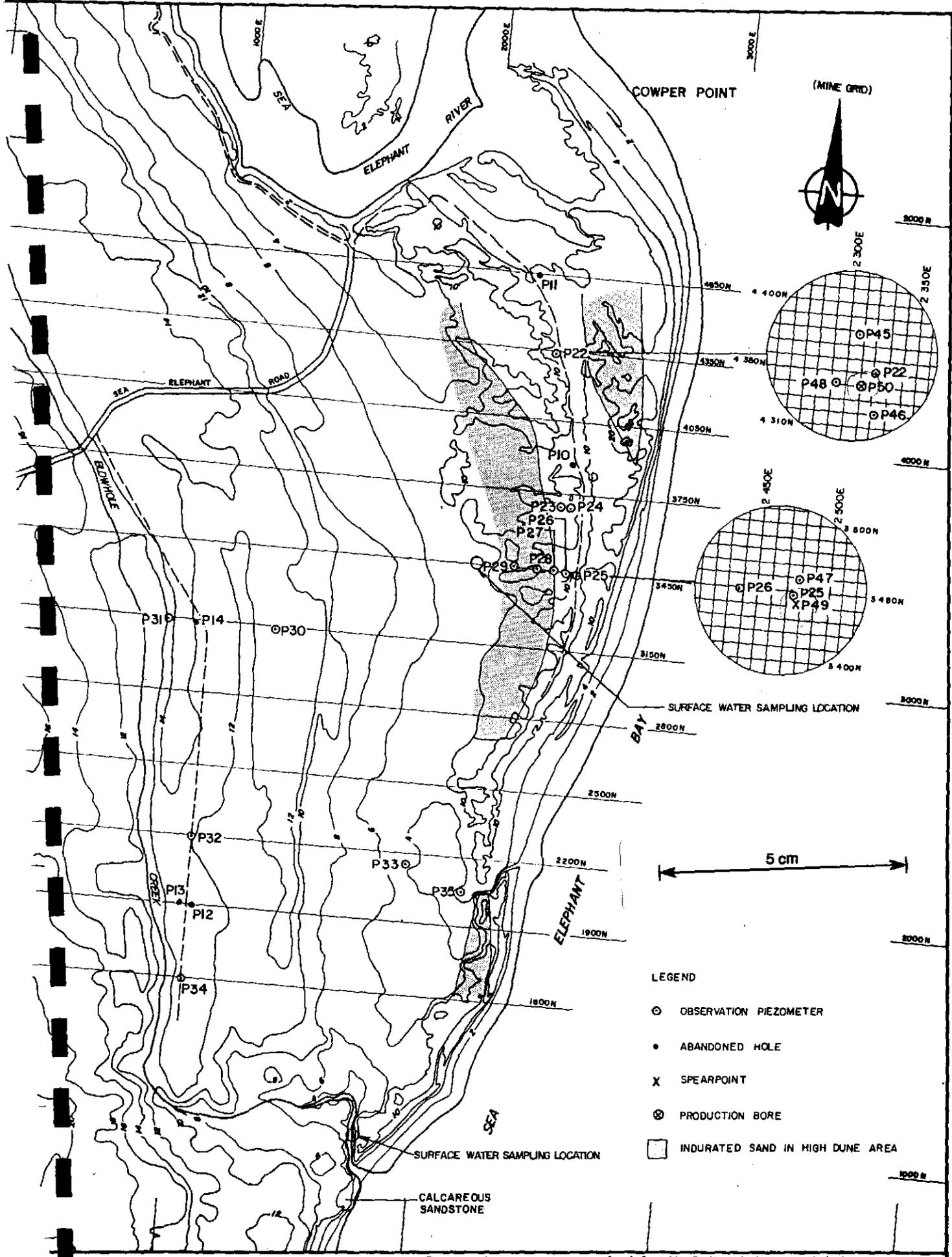
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NATIONAL MINERAL SANDS
KING ISLAND HEAVY MINERAL DEPOSITS
LOCATION OF OBSERVATION PIEZOMETERS,
SPEARPOINTS & BORES

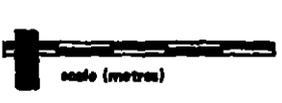


FIGURE 3



- LEGEND
- ⊙ OBSERVATION PIEZOMETER
 - ABANDONED HOLE
 - X SPEARPOINT
 - ⊗ PRODUCTION BORE
 - ▣ INDURATED SAND IN HIGH DUNE AREA

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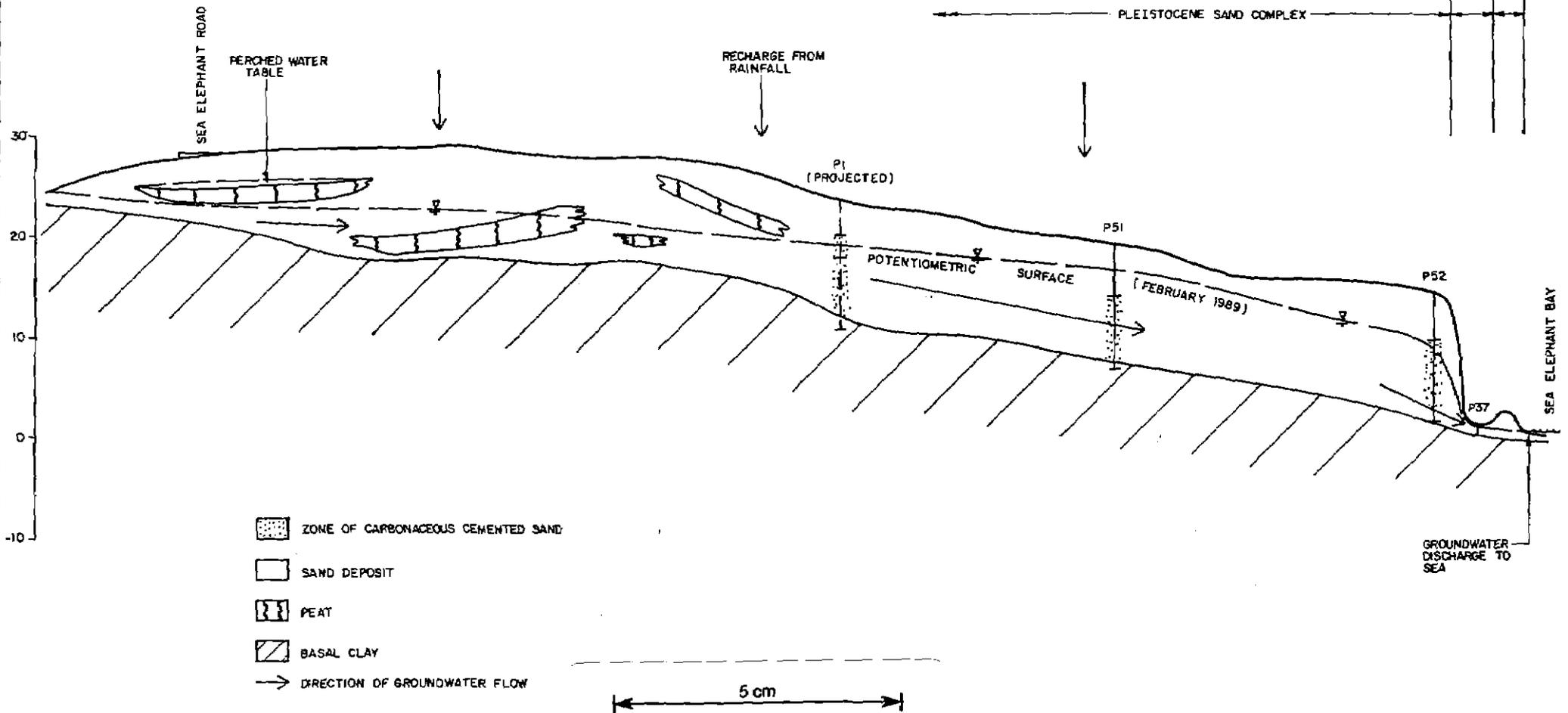
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NATIONAL MINERAL SANDS
 KING ISLAND HEAVY MINERAL DEPOSITS
 LOCATION OF OBSERVATION PIEZOMETERS,
 SPEARPOINT & PRODUCTION BORE

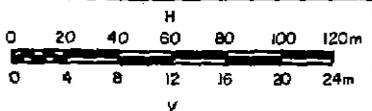


FIGURE 4

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revision	description	drawn	approved	date

drawn	LWO/AB
checked	<i>[Signature]</i>
date	12/1/89

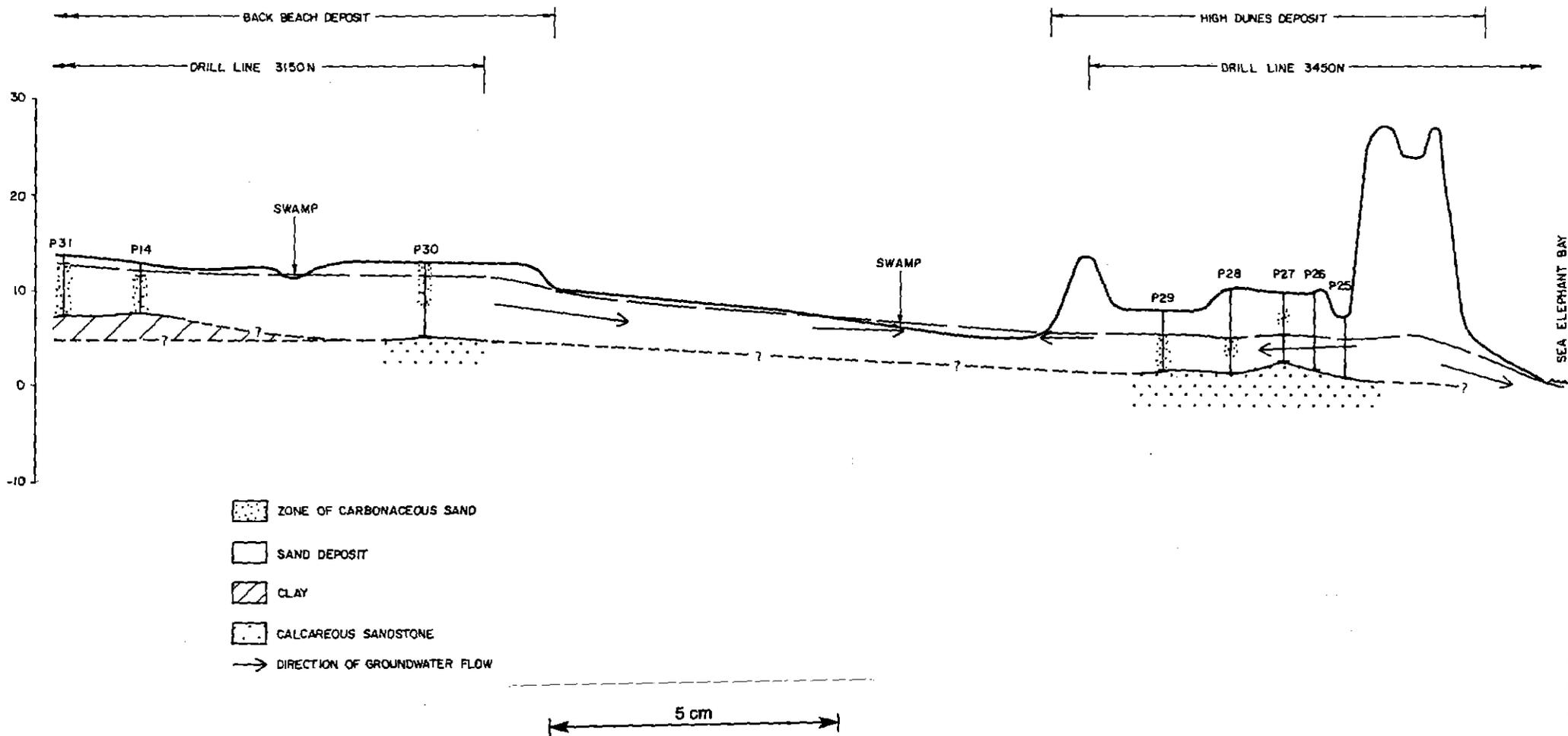
NATIONAL MINERAL SANDS
 KING ISLAND HEAVY MINERAL DEPOSITS
 HYDROGEOLOGICAL CROSS SECTION
 DRILL LINE 1600N - NARACOOPA



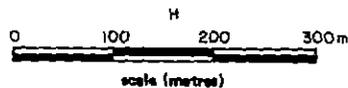
FIGURE 5
 Job no G65/3

542257

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drawn LWD/AB
 checked [Signature]
 date 12/4/89

NATIONAL MINERAL SANDS
 KING ISLAND HEAVY MINERAL DEPOSITS
 HYDROGEOLOGICAL CROSS SECTION
 ACROSS DRILL LINES 3150N & 3450N



FIGURE 6
 Job no G65 / 3

542258

219

(MINE GRID)

2000N



1000N

BAY

ELEPHANT

SEA

0000N

NARACOOPA

LEGEND

- 10--- DEPTH TO CLAY BEDROCK (m RL)
- #--- THICKNESS OF SATURATED SAND (m)

5 cm

1000 E

0000 E

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drawn	LDW/PAB
checked	<i>[Signature]</i>
date	12/4/89

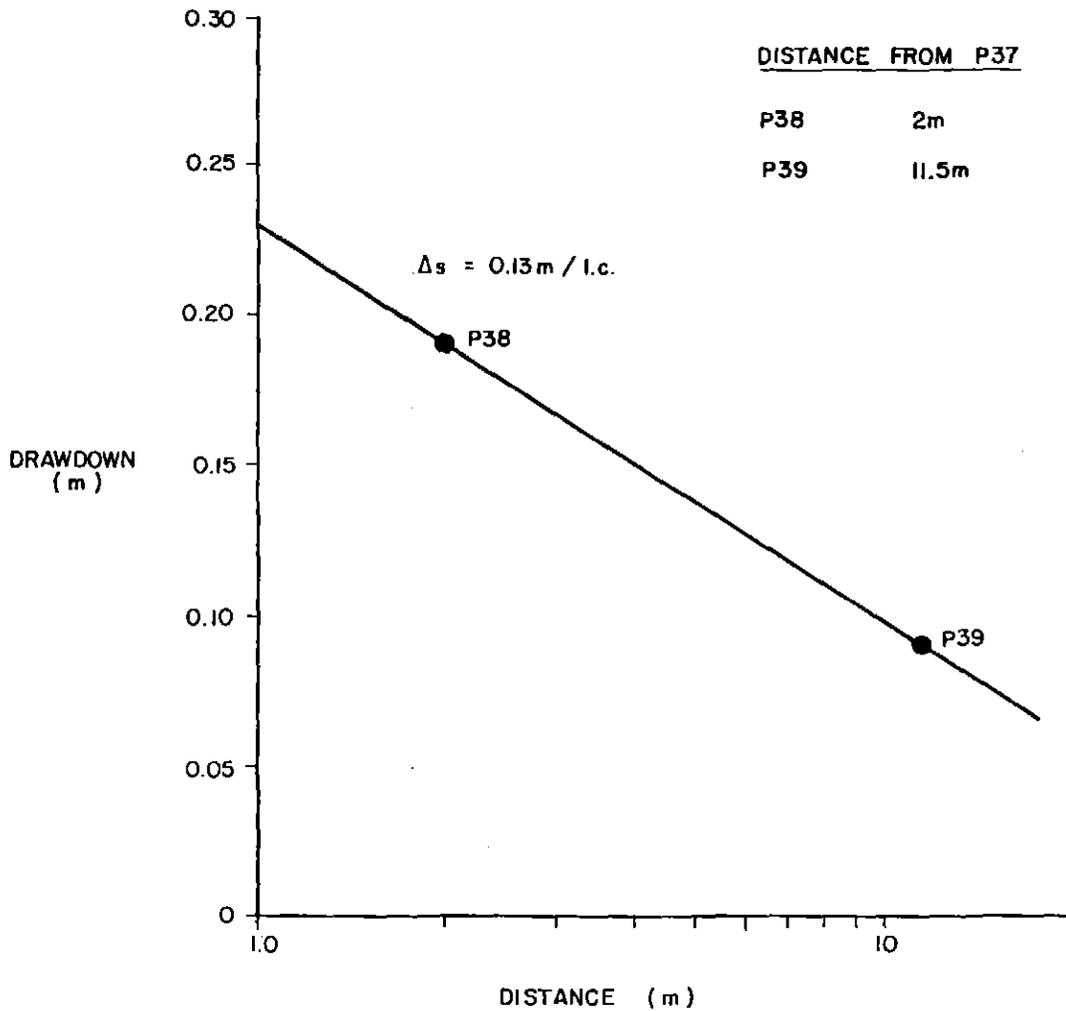
NATIONAL MINERAL SANDS
KING ISLAND HEAVY MINERAL DEPOSITS
DEPTH TO CLAY BEDROCK &
THICKNESS OF SATURATED SAND



FIGURE 7

250

Q = 13.8 m³/day
 T = 36 m²/day



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Drawn by LWD/AB
 Checked by *[Signature]*
 Date 12/4/89

NATIONAL MINERAL SANDS
 KING ISLAND HEAVY MINERAL DEPOSITS
 PUMP TEST ON PRODUCTION
 SPEARPOINT P37

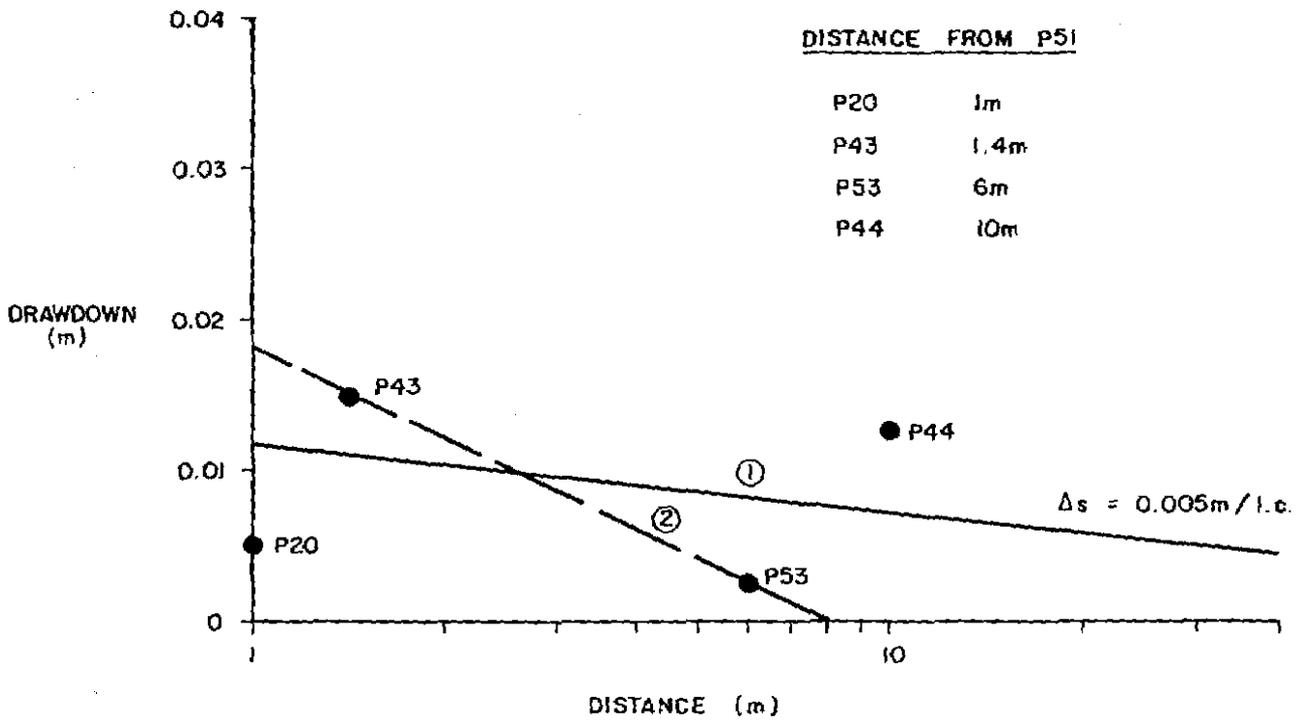


FIGURE 8

job no: G65/3

251

Q = 1.4 m³/day
 T₁ = 49m²/day
 T₂ = 12m²/day



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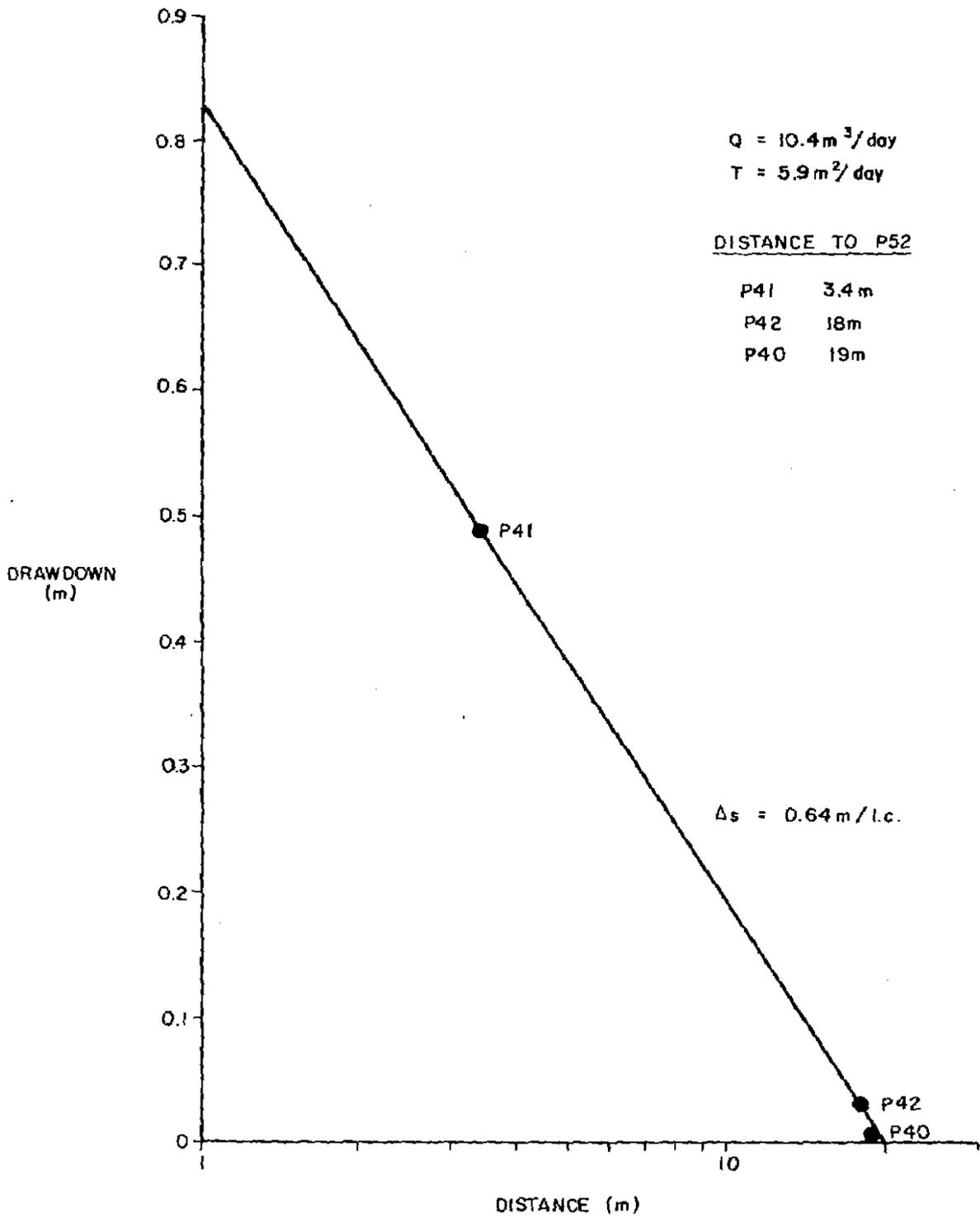
LWD/AB
 12/14/89

NATIONAL MINERAL SANDS
 KING ISLAND HEAVY MINERAL DEPOSITS
 PUMP TEST ON PRODUCTION
 SPEARPOINT P51



FIGURE 9

253



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Drawn	LWD/AB
Approved	<i>[Signature]</i>
Date	12/4/89
Scale	

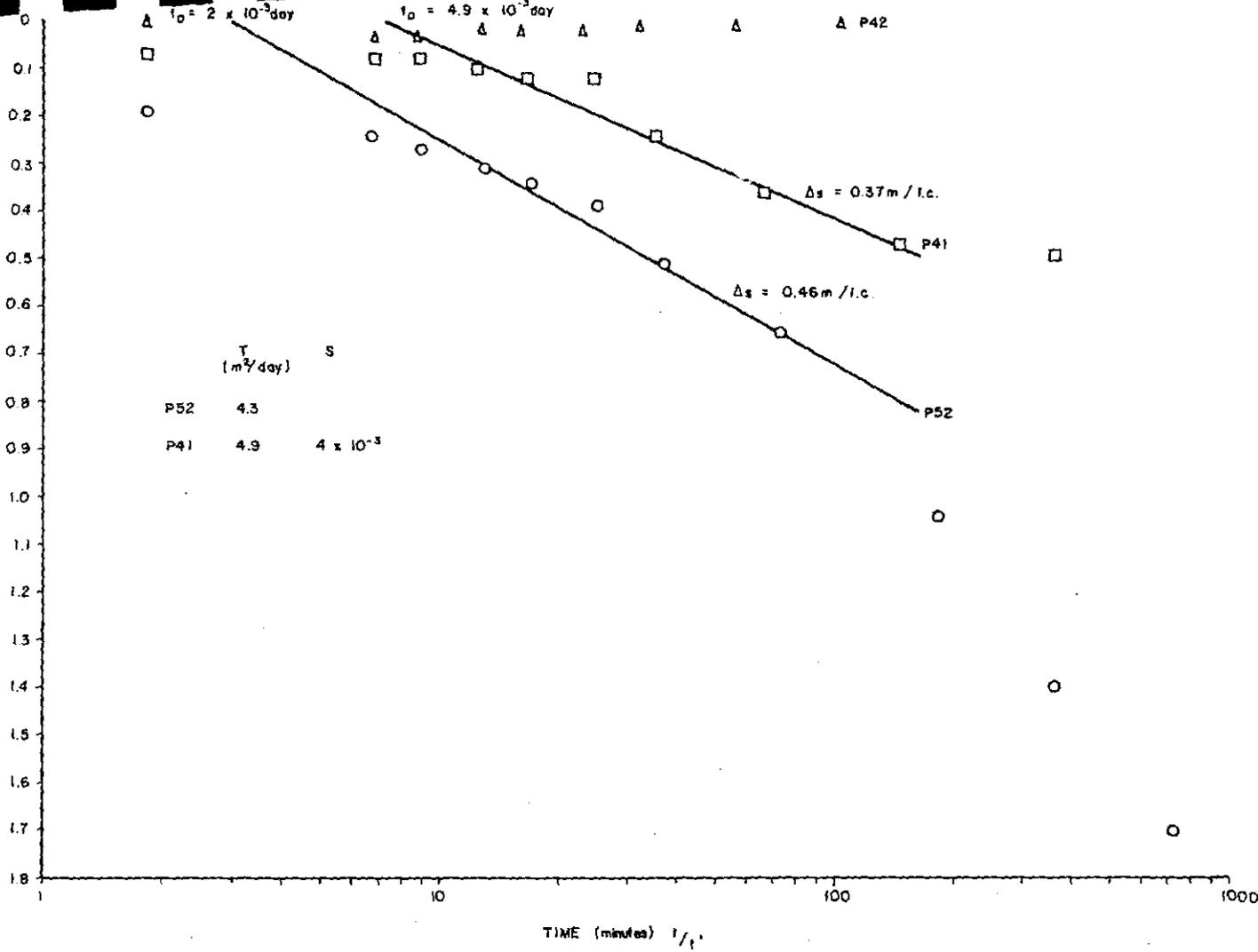
NATIONAL MINERAL SANDS
KING ISLAND HEAVY MINERAL DEPOSITS
PUMP TEST ON PRODUCTION
BORE P52



FIGURE 11

254

WATER LEVEL RECOVERY (m)

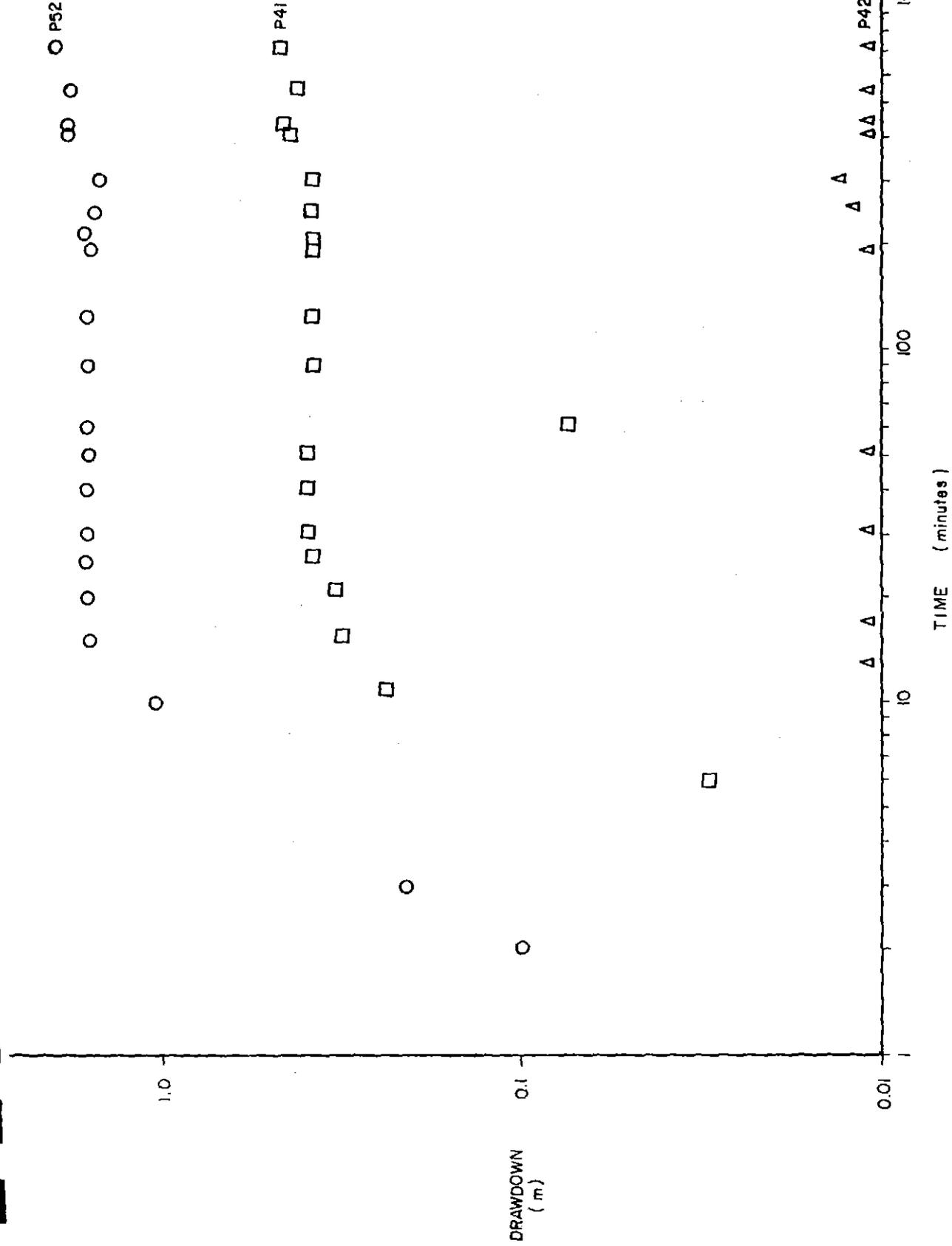


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<p>scale (metres)</p>	<p>UNIVERSITY</p>	description	drawn	approved	date	drawn	LWD/AB	<p>NATIONAL MINERAL SANDS KING ISLAND HEAVY MINERAL DEPOSITS MODIFIED NON STEADY STATE EQUATION RECOVERY vs TIME P52, P41, P42</p>		<p>FIGURE 12</p>
						checked	<i>[Signature]</i>			
						date	12/11/89			
								job no	G65/1	

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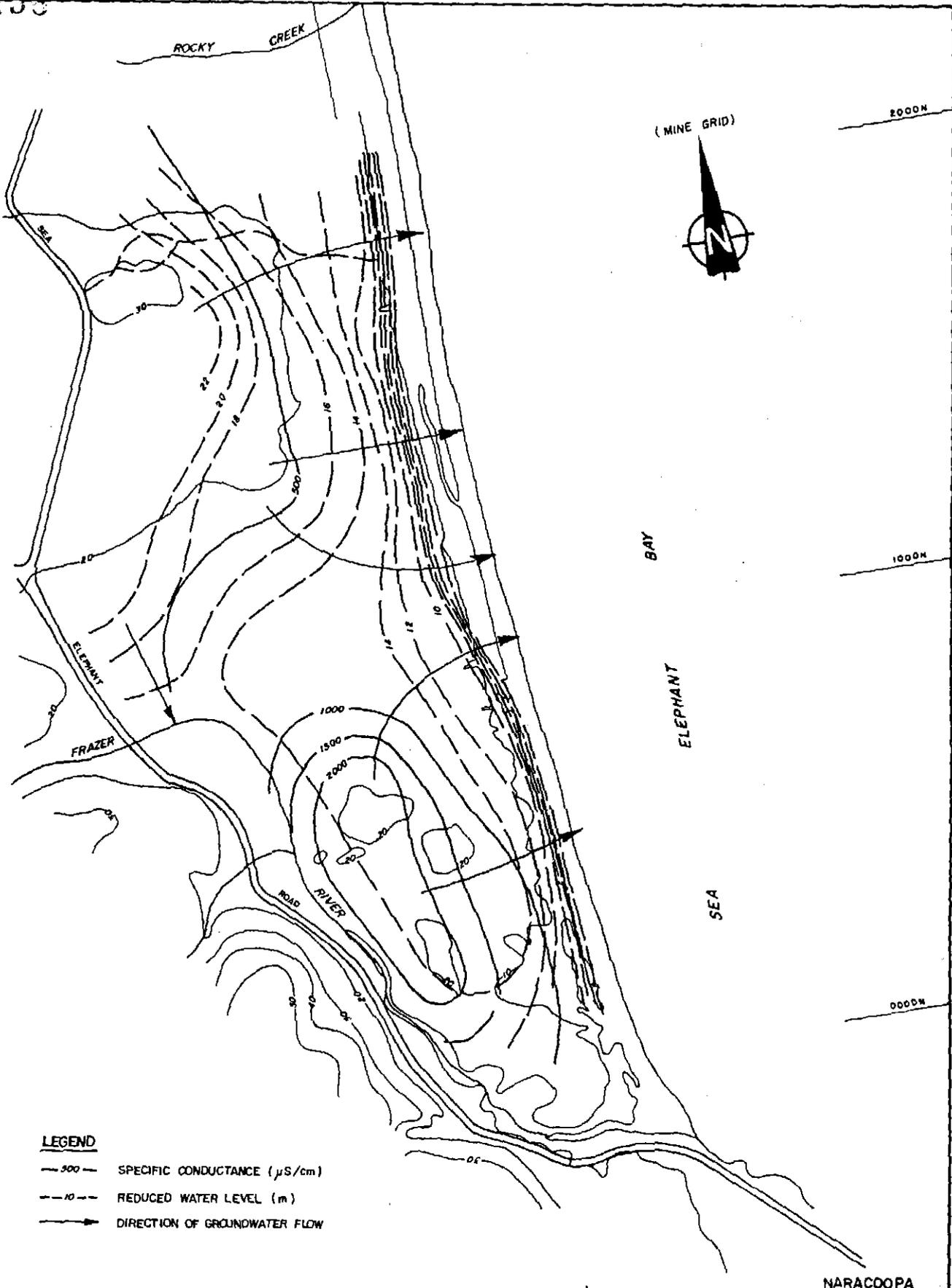
Drawn	LWD/AB
Checked	<i>[Signature]</i>
Date	12/4/89

NATIONAL MINERAL SANDS
 KING ISLAND HEAVY MINERAL DEPOSITS
 PUMP TEST AT P52
 TIME vs DRAWDOWN



FIGURE 13
 job no: G65/1

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LEGEND

— 500 — SPECIFIC CONDUCTANCE ($\mu\text{S}/\text{cm}$)

- - - 10 - - - REDUCED WATER LEVEL (m)

→ DIRECTION OF GROUNDWATER FLOW

NARACOOPA

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scale (metres)

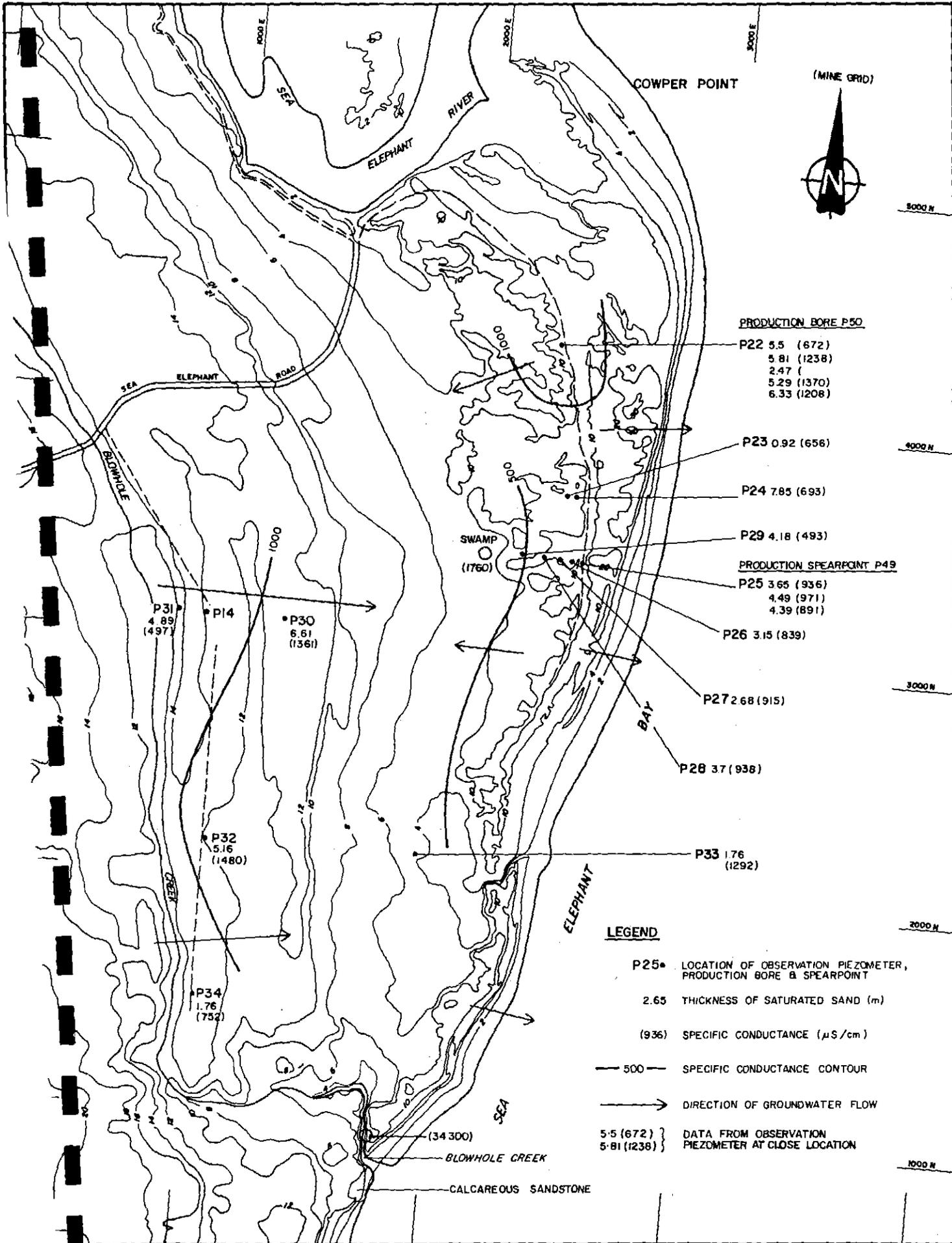
drawn	LDW/AB
checked	<i>[Signature]</i>
date	24/89

NATIONAL MINERAL SANDS
KING ISLAND HEAVY MINERAL DEPOSITS
SALINITY, REDUCED WATER LEVEL & DIRECTION
OF GROUNDWATER FLOW

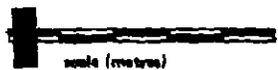


FIGURE 14

[Handwritten mark]



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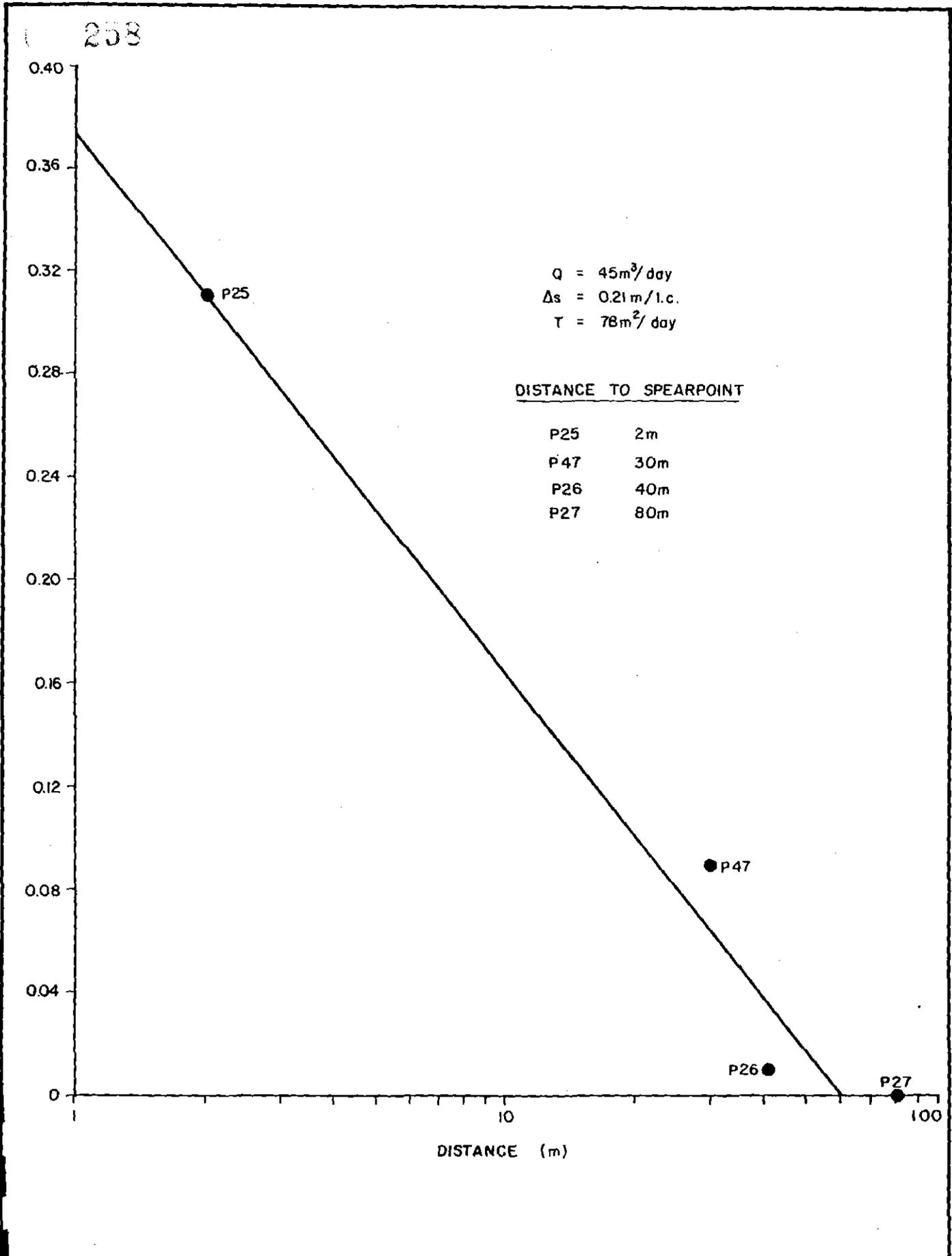


drawn	LWD/SW
checked	<i>[Signature]</i>
date	14/1/89

NATIONAL MINERAL SANDS
KING ISLAND HEAVY MINERAL DEPOSITS
THICKNESS OF SATURATED SAND &
SPECIFIC CONDUCTANCE OF OVERBURDEN



FIGURE 15



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Drawn	LWD/AB
Approved	<i>[Signature]</i>
Date	12/4/89
Scale	

NATIONAL MINERAL SANDS
 KING ISLAND HEAVY MINERAL DEPOSITS
 PUMP TEST ON SPEARPOINT P49
 PLOT OF DISTANCE vs DRAWDOWN



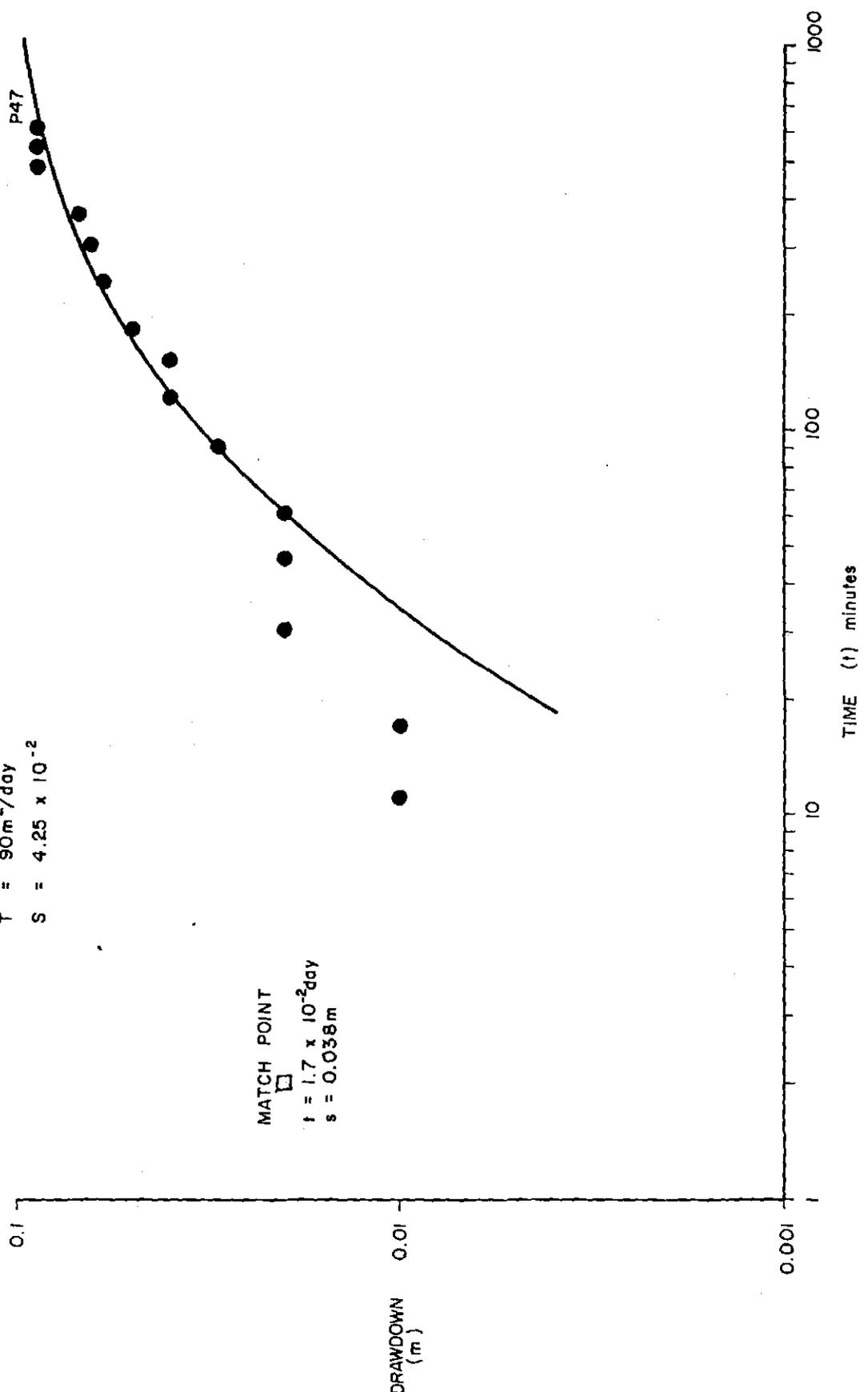
FIGURE 16

job no: G65/1

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Q = 45 m³/day
 T = 90 m²/day
 S = 4.25 x 10⁻²

MATCH POINT
 t = 1.7 x 10⁻² day
 s = 0.038 m



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LWD/AB
 12/4/89

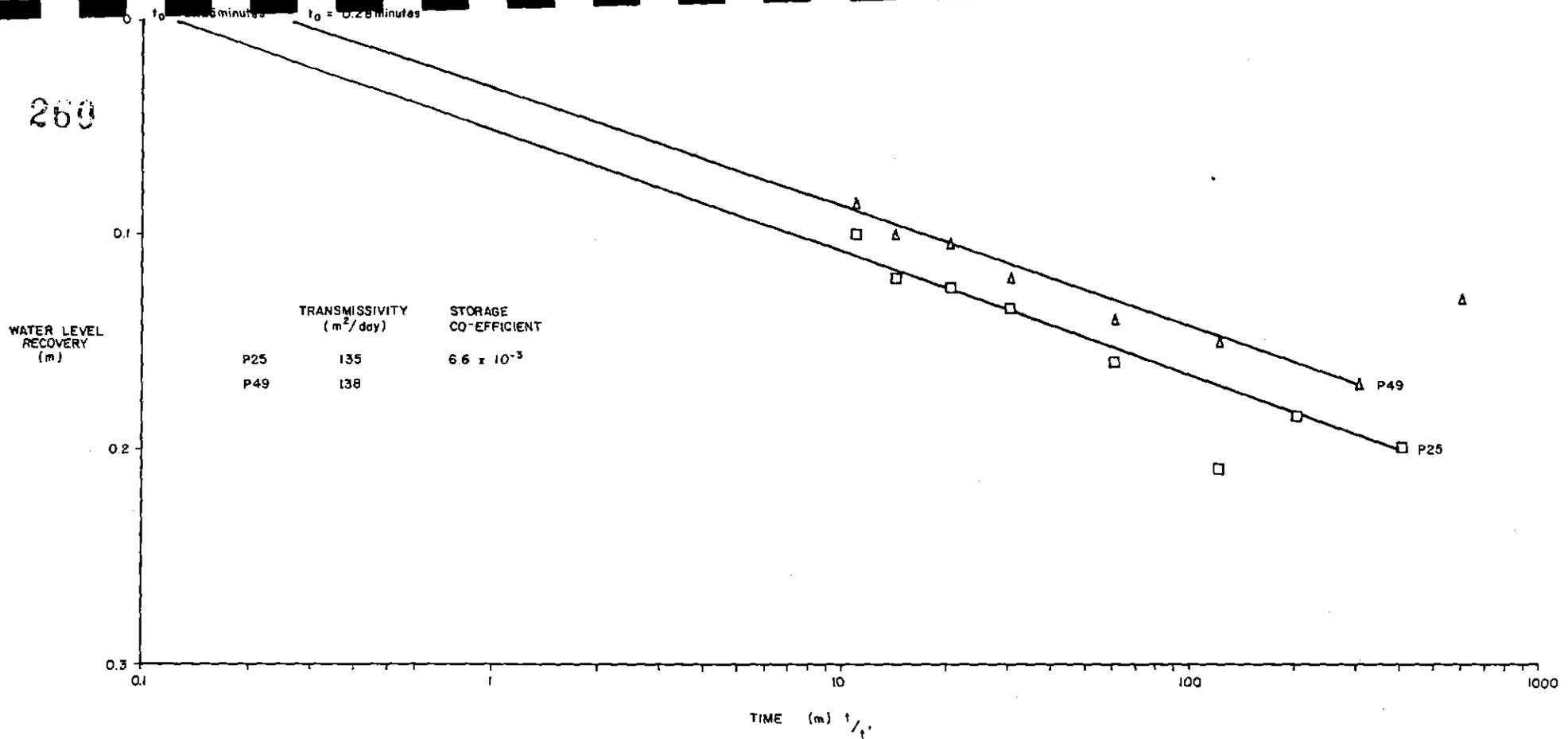
NATIONAL MINERAL SANDS
 KING ISLAND HEAVY MINERAL DEPOSITS
 TYPE CURVE SOLUTION P47
 NON STEADY STATE



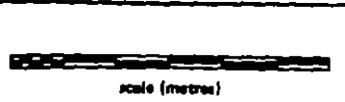
FIGURE 17

job no: G65/1

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NATIONAL MINERAL SANDS
KING ISLAND HEAVY MINERAL DEPOSITS
MODIFIED NON STEADY STATE EQUATION
RECOVERY vs TIME P25 & P49



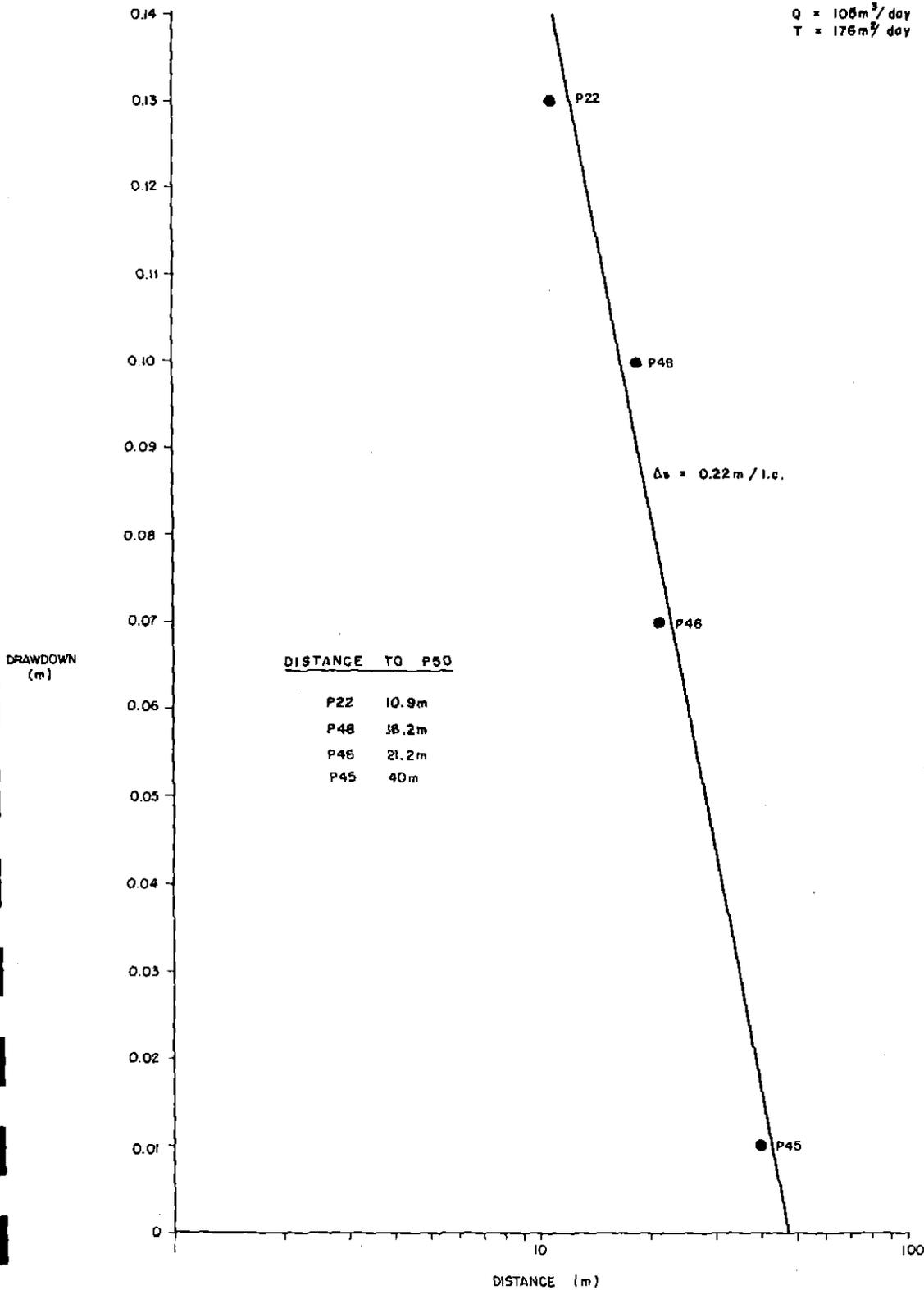
FIGURE 18
job no G65/1

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[Handwritten mark]

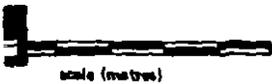
0 281

Q = 108m³/day
T = 176m³/day



AS

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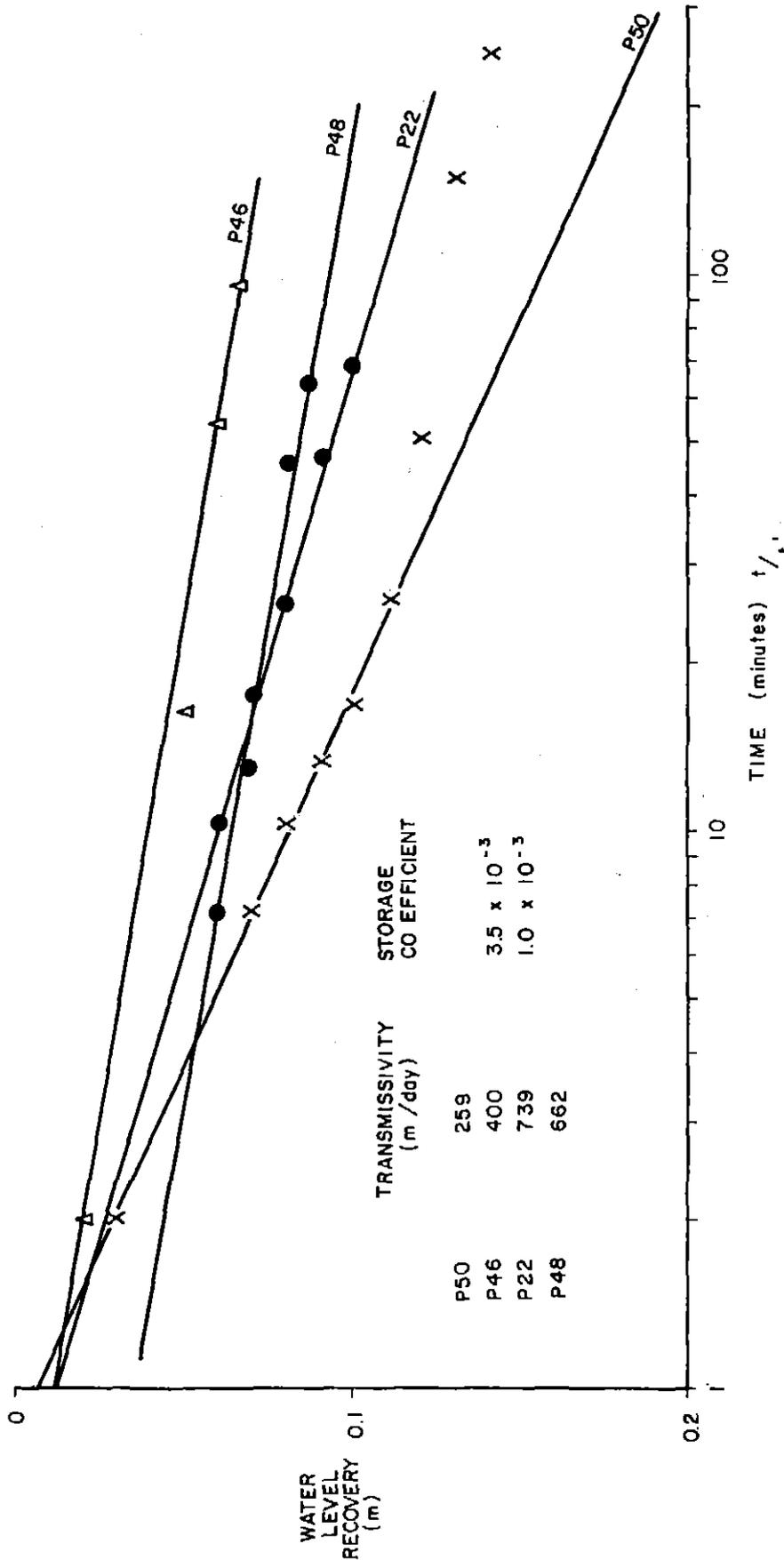
drawn	LWD/AB
checked	<i>[Signature]</i>

NATIONAL MINERAL SANDS
KING ISLAND HEAVY MINERAL DEPOSITS
PUMP TEST ON PRODUCTION



FIGURE 19

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drawn LWD/AB
 approved [Signature]
 date 12/4/87
 scale

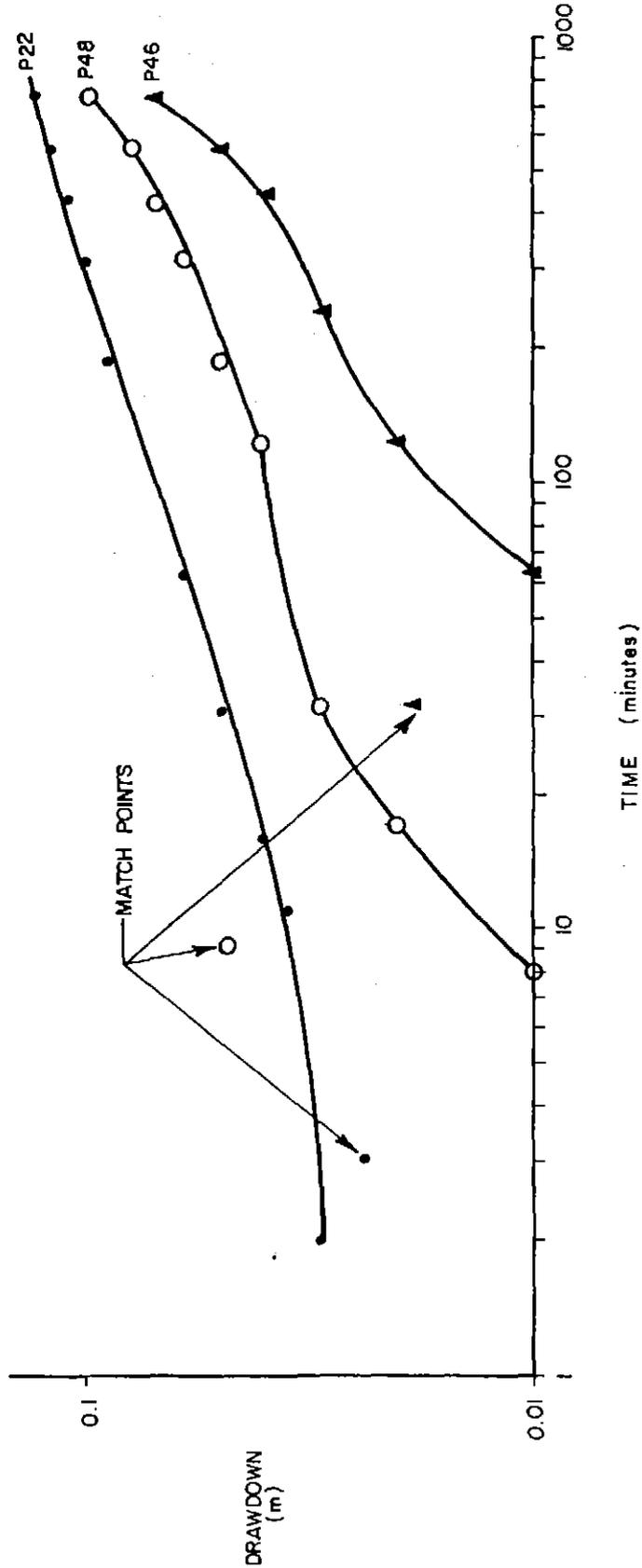
NATIONAL MINERAL SANDS
 KING ISLAND HEAVY MINERAL DEPOSITS
 MODIFIED NON STEADY STATE EQUATION
 RECOVERY vs TIME
 P50, P22, P48 & P46



FIGURE 21

job no: G65/1

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	TRANSMISSIVITY (m ² /day)	STORAGE CO-EFFICIENT
P22	348	2.4×10^{-2}
P48	174	1.2×10^{-2}
P46	439	3.4×10^{-1}

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approved	<i>[Signature]</i>
date	12/4/87
scale	

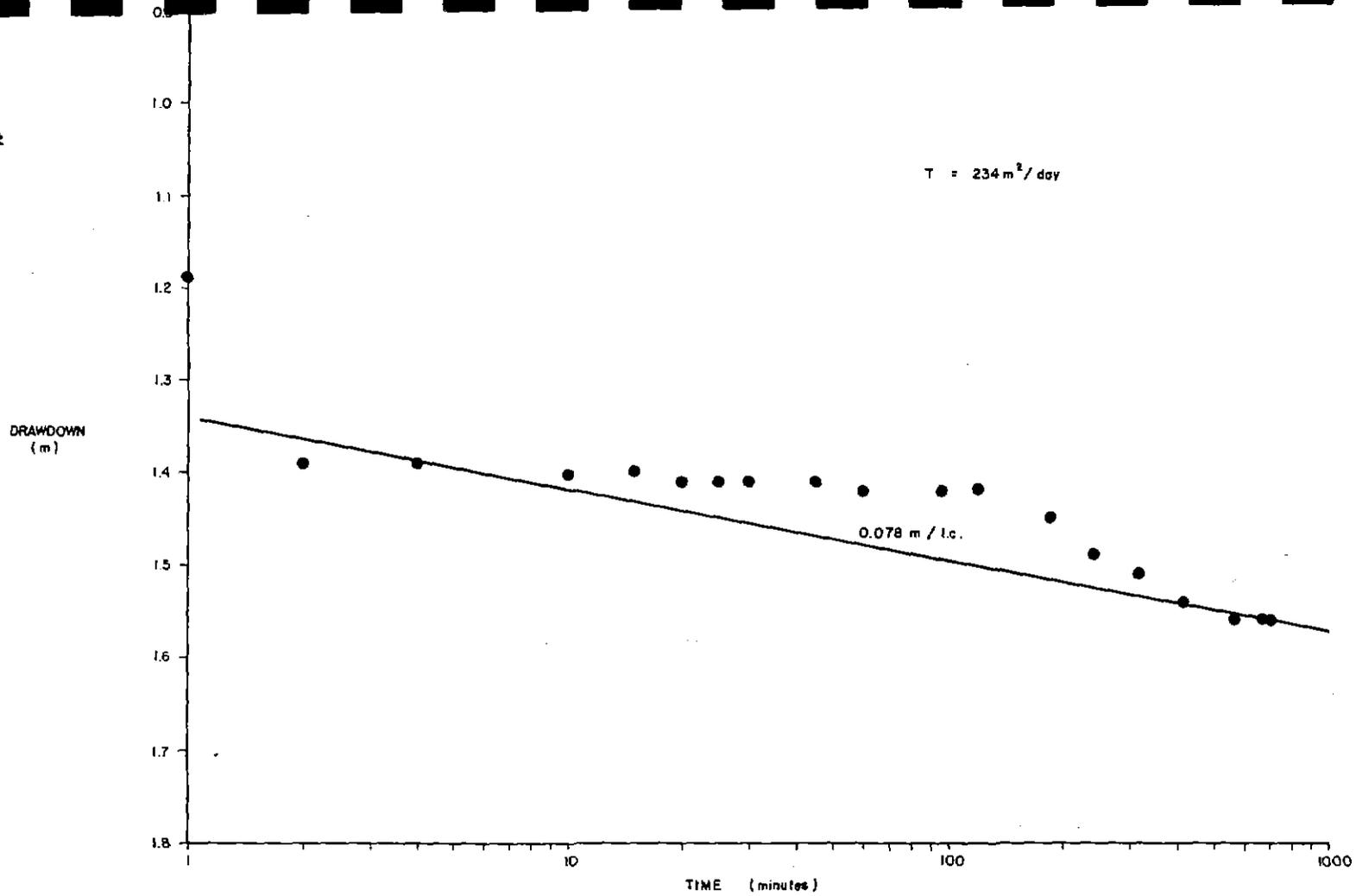
NATIONAL MINERAL SANDS
 KING ISLAND HEAVY MINERAL DEPOSITS
 TYPE CURVE SOLUTION P22, P48, P46
 NON STEADY STATE



FIGURE 20

job no: G65/1

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revision	description	drawn	approved	date	drawn	checked	date

NATIONAL MINERAL SANDS
 KING ISLAND HEAVY MINERAL DEPOSITS
 COOPER JACOB STRAIGHT LINE SOLUTION
 P50 DRAWDOWN DATA

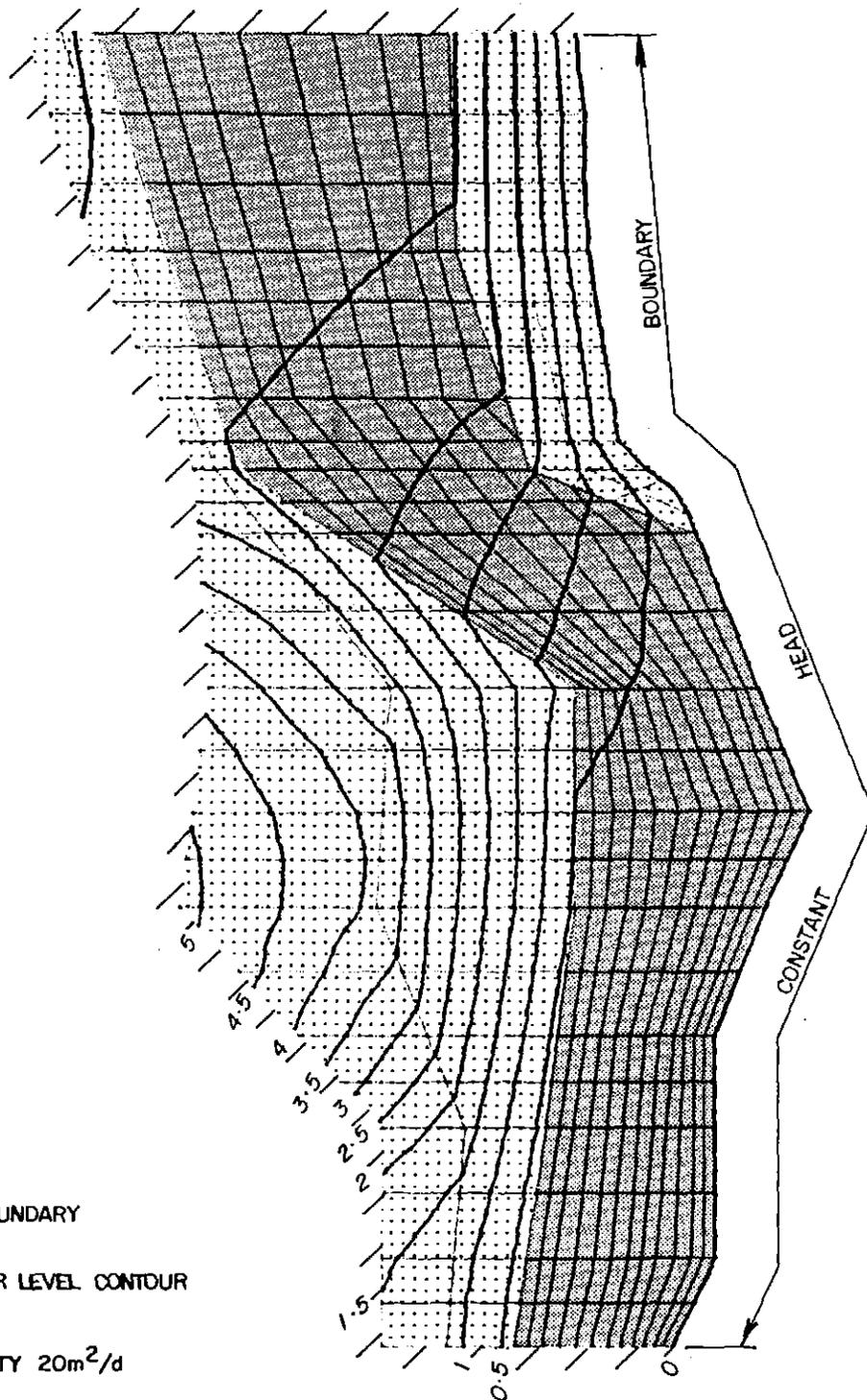


FIGURE 22

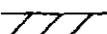
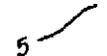
Job no 665/1

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LEGEND

-  NO FLOW BOUNDARY
-  GROUNDWATER LEVEL CONTOUR
-  TRANSMISSIVITY 20m²/d
-  PERMEABILITY 30m /d

INFILTRATION RATE 365mm/YEAR

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Consulting Engineers in the geotechnical sciences

drawn	RJB/SW
approved	<i>[Signature]</i>
date	12/01/89
scale	

NATIONAL MINERAL SANDS
 KING ISLAND HEAVY MINERAL DEPOSITS
 FINITE ELEMENT MODEL



FIGURE 23

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PHOTO 1

Production bore No. P52, Naracoopa
with injector pump before installing
for pump test.

PHOTO 2

Construction of production Spearpoint
P51 at Naracoopa. Spearpoint in foreground

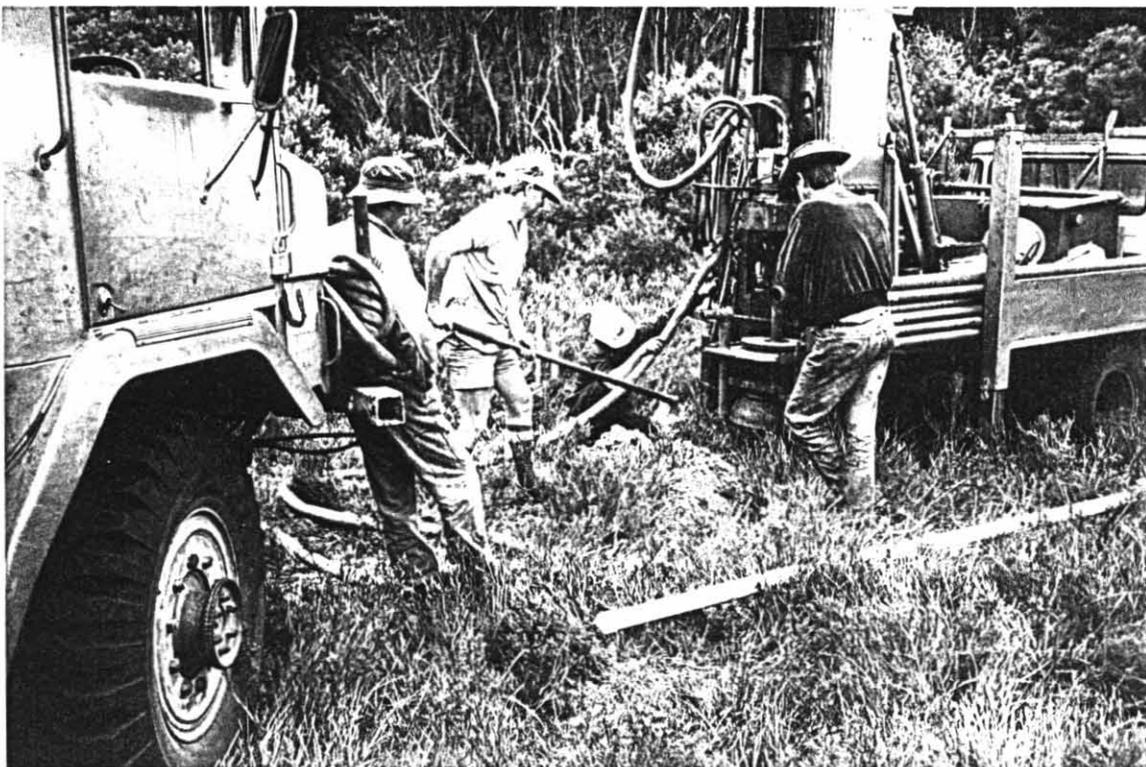


PHOTO 3

Pump testing Spearpoint P37 in interdunal system behind foredune, Naracoopa. Lay flat hose takes groundwater to Sea Elephant Bay.

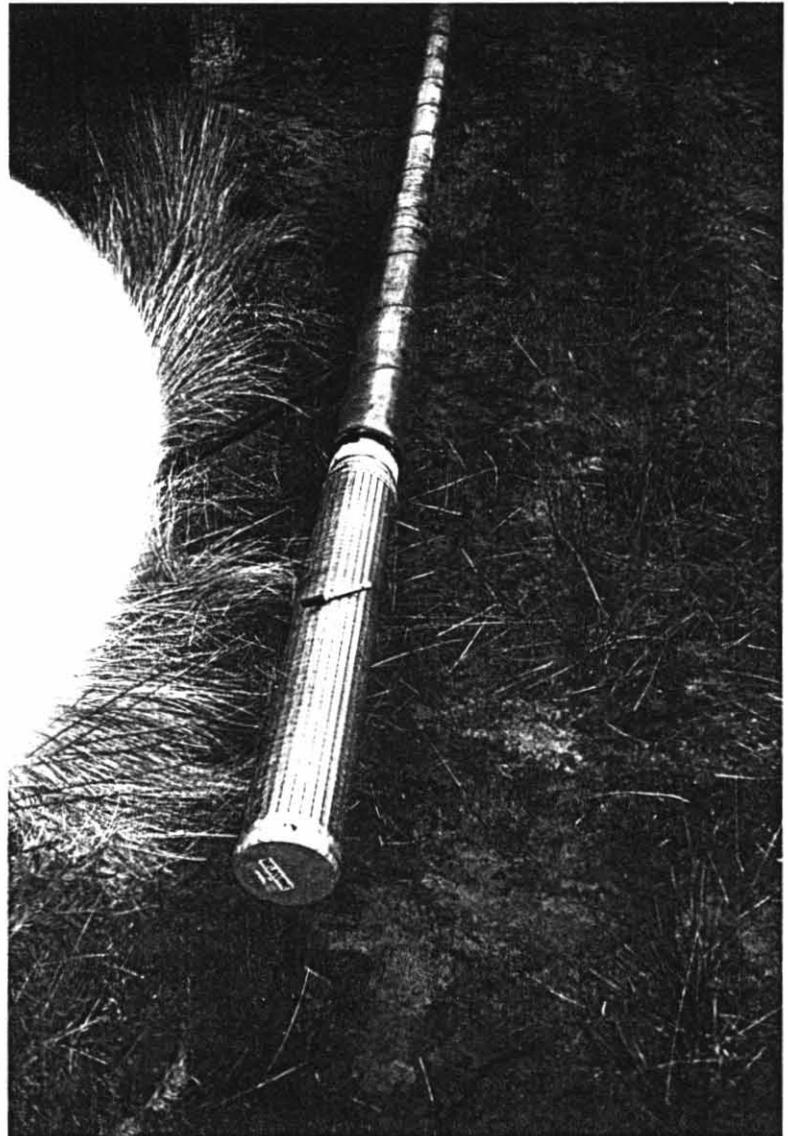
PHOTO 4

Drilling hole for pumping Spearpoint P49, High Dunes. Observation piezometer P25 between the 2 trucks.



PHOTO 5

Production stainless steel screen and steel casing (150mm diameter nominal) before insertion in P50, High Dunes.

PHOTO 6

Pumping production bore P50, High Dunes using centrifugal pump.

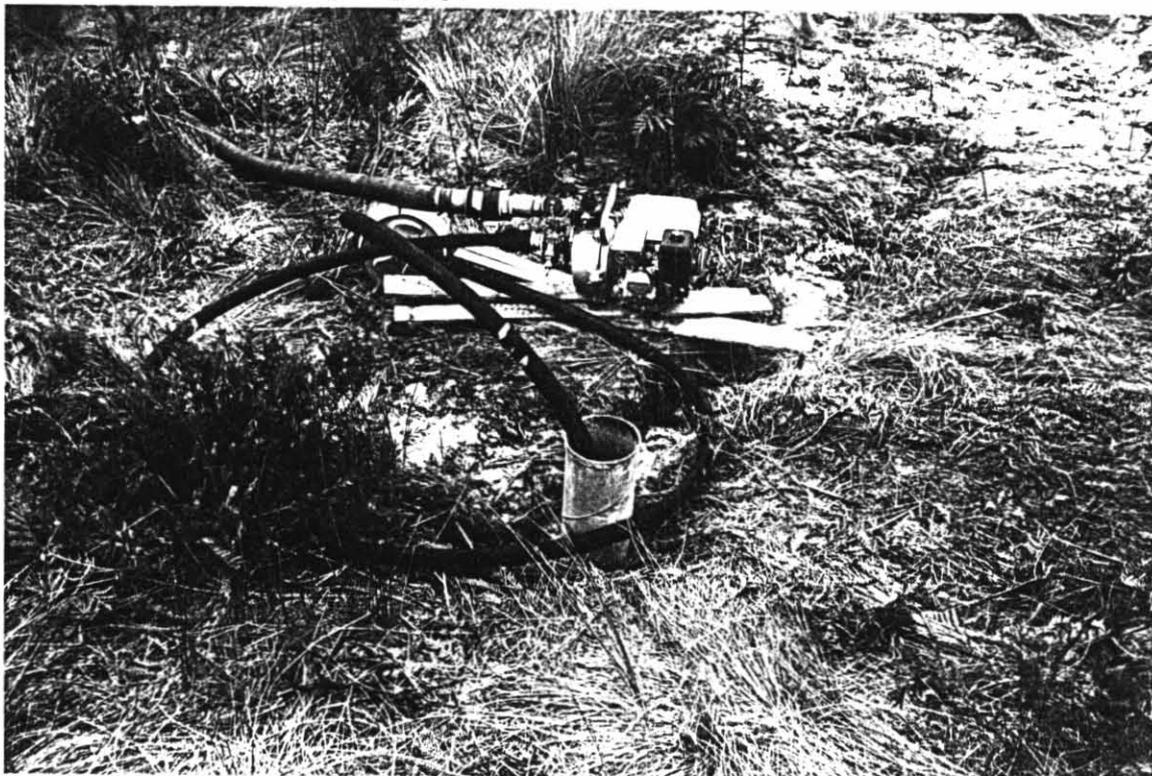




PHOTO 7 - Location of surface water sample at mouth of Blowhole Creek.



PHOTO 8 - Calcareous sandstone outcrop on beach midway between Naracoopa and Cowper Point.

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APPENDIX A

Construction details for Observation Piezometers,
Production Bores and Spearpoints

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composite borehole log



borehole no P1
sheet 1 of 1

BRISBANE G65/1

client: NATIONAL MINERAL SANDS PTY LTD project: KING ISLANDS HEAVY MINERAL DEPOSITS borehole location: See FIGURE 2		hole commenced: 29.4.88 hole completed: 29.4.88 supervised by: EHB checked by: EHB			
drill model and mounting: RC/Truck hole diameter: 56 mm		RL casing: RL surface: datum: M.S.L. total depth: 13.5m			
bore construction diagram mm 100 50 0 50 100	S.W. L. R. L.	depth metres	graphic log classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations
		0	SP	SAND-Grey, humus rich. SAND-Fine-medium grained, light grey, clean.	Water intersected at about 3.3m above peaty & indurated layers (perched layer).
		2		SAND-Light brown, silty, slightly peaty, moist.	
		4			
		6	SM	SILTY SAND-Fine-medium grained, dark brown, silty. Indurated layers varying from soft to hard. Peat layers.	
		12	CH	CLAY-High plasticity, brown to light brown, stiff, mica flakes.	
				terminated at 13.5m.	

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borehole no P2
sheet 1 of 1

composite borehole log

BRISBANE G65/1

client:	NATIONAL MINERAL SANDS PTY LTD	hole commenced:	29.4.88
project:	KING ISLAND HEAVY MINERALS DEPOSITS	hole completed:	29.4.88
borehole location:	1200 N 00 E	supervised by:	EHB
		checked by:	EHB

drill model and mounting:	RC/Truck	RL casing:	12.701m	datum:	M.S.L.
hole diameter:	56 mm	RL surface:	12.301m	total depth:	7.1m

bore construction diagram mm 100 50 0 50 100	S.W.L.	depth metres R.L.	graphic log	classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations
	2.70	0		SP	SAND-fine-medium grained quartz, white/cream, clean.	Water intersected at approx. 2m above peaty & indurated layers.
		2		SM	SILTY SAND-Brown, silty, soft to moderately hard indurated layers and peat layers.	
		6		SP/GP	SAND/GRAVEL-Fine-coarse grained sand to gravel light brown, clean.	
				CH	CLAY-High plasticity, grey to grey brown, stiff, mica flakes. Terminated at 7.1m.	

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borehole no P3
sheet 1 of 1

composite borehole log

BRISBANE G65/1

client:	NATIONAL MINERAL SANDS PTY LTD	hole commenced:	30.4.88
project:	KING ISLAND HEAVY MINERAL DEPOSITS	hole completed:	30.4.88
borehole location:	1200N 340W	supervised by:	EHB
		checked by:	EHB

drill model and mounting:	RC/Truck	RL casing:		datum:	M.S.L.
hole diameter:	56 mm	RL surface:		total depth:	6.5m

bore construction diagram mm 100 50 0 50 100	S.W. L. R. L.	depth metres	graphic log	classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations
		0		SP	SAND-Fine-medium grained, light brown, clean.	0.5m indurated layer, hard, carbonate.
		2		SM	SILTY SAND-Dark brown to red brown, silty, peaty.	
		2.77				2.5m Indurated layer.
		4		SM/SP	SILTY SAND/SAND-Light brown, brown.	
				SP	SAND-Light brown.	
		6		SP/GP	SAND/GRAVEL-Rounded, gravel up to 0.5cm dia. clean.	
				CH	CLAY-High plasticity, grey, stiff.	
					Terminated at 6.5m.	

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borehole no P4
sheet 1 of 1

composite borehole log

BRISBANE G65/1

client:	NATIONAL MINERAL SANDS PTY LTD	hole commenced:	30.4.88
project:	KING ISLAND HEAVY MINERAL DEPOSITS	hole completed:	30.4.88
borehole location:	1000 N 540 W	supervised by:	EHB
		checked by:	EHB

drill model and mounting:	RC/Truck	RL casing:	datum: M.S.L.
hole diameter:	56 mm	RL surface:	total depth: 2.7m

bore construction diagram mm 100 50 0 50 100	S. W. Li S. L. Li	depth metres	graphic log	classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations
	Dry	0		SP	SAND (FILL) -Dune sand pushed out over swamp.	
		2			HUMUS/SOIL-Swamp vegetation grading to clayey silty peat.	
					CLAY-Grey, stiff, micaceous.	
					Terminated at 2.7m.	

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borehole no P5
sheet 1 of 1

composite borehole log

BRISBANE G65/1

client: NATIONAL MINERAL SANDS PTY LTD project: KING ISLAND HEAVY MINERAL DEPOSITS borehole location: 700 N 00 E		hole commenced: 30.4.88 hole completed: 30.4.88 supervised by: EHB checked by: EHB				
drill model and mounting: RC/Truck hole diameter: 56 mm		RL casing: 14.154m RL surface: 13.704m				
		datum: M.S.L. total depth: 8.0m				
bore construction diagram mm 100 50 0 50 100	S. W. L. m	depth metres R. L. m	graphic log classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations	
		0	SM	SILTY SAND-Fine-medium grained, brown, silty.		
		2				
		6			SILTY SAND-Dark brown, very silty, peaty.	
		7.5	SP/GP	SAND/GRAVEL-Light brown, up to 0.5cm dia.		
		8		CLAY-Grey, stiff, micaceous.		
				Terminated at 8.0m.		

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Coffey & Partners Pty. Ltd.

composite borehole log



borehole no P6
sheet 1 of 1

BRISBANE G65/1

client: NATIONAL MINERAL SANDS PTY LTD		hole commenced: 30.4.88				
project: KING ISLAND HEAVY MINERAL DEPOSITS		hole completed: 30.4.88				
borehole location: 700 N 240 W		supervised by: EHB				
		checked by: EHB				
drill model and mounting: RC/Truck		RL casing:	datum: M.S.L.			
hole diameter: 56 mm		RL surface:	total depth: 11.8m			
bore construction diagram mm 100 50 0 50 100	S.W. L. S.L.	depth metres S.L.	graphic log classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations	
		0	SP	SAND-Fine-medium grained, brown, very slightly silty.		
		2				
		4			SAND-fine-coarse grained, light brown/grey, slightly silty.	SAND/GRAVEL from 3.5-3.6m.
		5.57			SAND-Fine-coarse grained, grey, clean.	
		8		SM	SILTY SAND-Dark brown, very silty.	
		10			PEAT/PEATY SAND-Dark brown.	
					SM	SILTY SAND-Fine-medium grained, dark grey.
			CL	CLAY-Medium plasticity, grey.		
				Terminated at 11.8m.		

Colley & Partners Pty. Ltd.



borehole no P7
sheet 1 of 1

composite borehole log

BRISBANE G65/1

client:	NATIONAL LMINERAL SANDS PTY LTD	hole commenced:	30.4.88
project:	KING ISLAND HEAVY MINERAL DEPOSITS	hole completed:	30.4.88
borehole location:	400 N 00 E	supervised by:	EHB
		checked by:	EHB

drill model and mounting:	RC/Truck	RL casing:	16.854m	datum:	M.S.L.
hole diameter:	56 mm	RL surface:	16.504m	total depth:	10.8m

bore construction diagram mm 100 50 0 50 100	S.W.L. R.L.	depth metres R.L.	graphic log	classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations	
		0		SM	SILTY SAND-Fine-medium grained, brown.		
		2		SP	SAND-Fine-coarse grained, light grey, clean.		
		4					
		6		SM	SILTY SAND-Fine-coarse grained, dark brown.		
		8		SM	PEATY SILTY SAND-Fine-very coarse grained, dark brown, some indurated layers.		
		10					
						CLAY-Grey, stiff.	
						Terminated at 10.8m.	

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borehole no P8
sheet 1 of 1

composite borehole log

BRISBANE G65/1

client:	NATIONAL MINERAL SANDS PTY LTD	hole commenced:	30.4.88
project:	KING ISLAND HEAVY MINERAL DEPOSITS	hole completed:	30.4.88
borehole location:	300 N 220 E	supervised by:	EHB
		checked by:	EHB

drill model and mounting:	RC/Truck	RL casing:		datum:	M.S.L.
hole diameter:	56 mm	RL surface:		total depth:	4.0m

bore construction diagram mm 100 50 0 50 100	S.W.L. R.L.	depth metres	graphic log	classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations
	2.66	0		SP	SAND-Fine-medium grained, light brown/brown, clean.	
		4			CLAY-Grey, sticky.	
					Terminated at 4.0m.	

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borehole no P9
sheet 1 of 1

composite borehole log

BRISBANE G65/1

client:	NATIONAL MINERAL SANDS PTY LTD	hole commenced:	30.4.88
project:	KING ISLAND HEAVY MINERAL DEPOSITS	hole completed:	30.4.88
borehole location:	100 N 00 E	supervised by:	EHB
		checked by:	EHB

drill model and mounting:	RC/Truck	RL casing:	15.380m	datum:	M.S.L.
hole diameter:	56 mm	RL surface:	14.980m	total depth:	11.5m

bore construction diagram mm 100 50 0 50 100	S.W.L. q. L.	depth metres	graphic log	classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations
		0		SP	SAND-Fine-medium grained, light brown, clean.	Moist at 3m.
		2				
		4				
		5.31		SM	SILTY SAND-Dark brown, peaty, indurated layers	
					INDURATED LAYER-Moderately hard.	
		8		SM	SILTY SAND-Fine-coarse grained, brown, some indurated layers.	
		10		SP/GP	SAND/GRAVEL-Brown, up to 0.5cm dia.	
				SM	SILTY SAND-Fine grained, dark brown, very silty.	
					CLAY-Grey brown, stiff, micaceous.	
					Terminated at 11.5m.	

542290

280

Coffey & Partners Pty. Ltd.



borehole no P10
sheet 1 of 1

composite borehole log

client: NATIONAL MINERAL SANDS PTY LTD		hole commenced:				
project: KING ISLAND HEAVY MINERAL DEPOSITS		hole completed:				
borehole location: HIGH DUNE DEPOSIT (FIGURE 4)		supervised by:				
		checked by:				
drill model and mounting: RC/Truck		RL casing:	datum: M.S.L.			
hole diameter: 56 mm		RL surface:	total depth: 6.3m			
bore construction diagram mm 100 50 0 50 100	S.W. L. S. L.	depth metres R. L.	graphic log	classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations
No casing installed.		0		SP	SAND-Fine-medium grained quartz, light brown, slightly silty.	1.5-3.5m-High content of heavy minerals.
		2			SAND-Fine-coarse grained, grey.	
		4				
		6		SP/GP	SAND/GRAVEL/SHELL-Gravel to 0.5cm dia.	
					SHELL Beds - Grey, hard, cemented.	
					Terminated at 6.3m.	

281

542291

Coffey & Partners Pty. Ltd.



borehole no P11
sheet 1 of 1

composite borehole log

Sydney G65/3

client: NATIONAL MINERAL SANDS PTY LTD project: KING ISLAND HEAVY MINERAL DEPOSITS borehole location: HIGH DUNE DEPOSIT (Figure 4)		hole commenced: hole completed: supervised by: checked by:			
drill model and mounting: RC/Truck hole diameter: 56 mm		RL casing: RL surface: datum: M.S.L. total depth: 10.5m			
bore construction diagram mm 100 50 0 50 100	S.W. L. P. L.	depth metres	graphic log classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations
No casing installed.	3.30	0	SP	SAND-Fine-medium grained, light brown.	Peaty induration at 0.9m.
		0.9		SAND-Fine-medium grained, grey, clean.	
		2			High content of heavy mineral.
		4		SAND-Fine-coarse grained, grey, clean.	
		6	SP/GP	SAND/GRAVEL/SHELL-Grey, clean, up to 0.5cm dia & shell fragments.	
				6.5	
		8		CLAY/SHELL-Grey, sticky marine clay with shells.	
		10	CH	CLAY-High plasticity, dark grey.	
Terminated at 10.5m.					

542292

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Coffey & Partners Pty. Ltd.



borehole no P12
sheet 1 of 1

composite borehole log

Sydney G65/3

client: NATIONAL MINERAL SANDS PTY LTD
 project: KING ISLAND HEAVY MINERAL DEPOSITS
 BACK DUNE DEPOSITS (FIGURE)
 borehole location: 15m East of Star Picket marked "60"

hole commenced: _____
 hole completed: _____
 supervised by: _____
 checked by: _____

drill model and mounting: RC/Truck
 hole diameter: 56 mm
 RL casing: _____
 RL surface: _____
 datum: M.S.L.
 total depth: 5.5m

bore construction diagram mm 100 50 0 50 100	S.W.L. R.L.	depth metres R.L.	graphic log	classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations
No casing installed.	1.78	0			SANDY PEAT-Swamp humus with fine-medium grained sand.	Hard indurated layers.
		2			SILTY, PEATY SAND-Dary brown, very silty.	
		4		CH	CLAY-High plasticity, dark brown.	
		5.5			CLAYSTONE-Yellow brown, hard. Terminated at 5.5m.	

12.

Coffey & Partners Pty. Ltd.



borehole no P13
sheet 1 of 1

composite borehole log

Sydney G65/3

client: NATIONAL MINERAL SAND PTY LTD project: KING ISLAND HEAVY MINERAL DEPOSITS BACK DUNE DEPOSITS (FIGURE 4) borehole location: 20m West of Star Picket marked "60"		hole commenced: _____ hole completed: _____ supervised by: _____ checked by: _____				
drill model and mounting: RC/Truck hole diameter: 56 mm		RL casing: _____ RL surface: _____ datum: M.S.L. total depth: 5.5m				
bore construction diagram mm 100 50 0 50 100	S.W. L. R. L.	depth metres	graphic log	classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations
No casing installed.	2.8	0		SP	SAND-Fine-medium grained, grey, clean.	Hard indurated layers.
		2		SM	SILTY SAND-Brown to dark brown, very silty, peaty, Dark brown CLAY layer 4.5-4.6m.	
		4		SP/GP	SAND/GRAVEL-Pea size, rounded.	
					CLAY-Dark brown, grey, sticky.	
					Terminated at 5.5m.	

Colley & Partners Pty. Ltd.



borehole no P16
sheet 1 of 1

composite borehole log

Sydney G65/3

client: NATIONAL MINERAL SANDS PTY LTD
 project: KING ISLAND HEAVY MINERAL DEPOSITS
 borehole location: See FIGURE 3
 hole commenced:
 hole completed:
 supervised by:
 checked by:

drill model and mounting: RC/Truck
 hole diameter: 56 mm
 RL casing:
 RL surface:
 datum: M.S.L.
 total depth: 18.0

bore construction diagram mm 100 50 0 50 100	S.W. L. R. L.	depth metres	graphic log	classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations
No casing installed.	5.7	0		SP	SAND-fine-medium grained, grey.	Indurated layers from 3.5m.
		2		SM	SILTY SAND-fine-medium grained, dark brown, peaty, silty. Sand from 3.5m is fine-coarse grained.	
		4				
		6				
		8				
		10		SM/GP	SILTY SAND/GRAVEL-Dark brown, up to 0.5cm dia.(pea size).	
		12		CH	PEATY CLAY-High plasticity, dark brown.	
14		SM	SILTY SAND-fine grained, well rounded quartz, grey, with heavy mineral and mica flakes.			
16		SC-SM	SILTY CLAYEY SAND-As above, but becoming clayey.			
18			CLAY-Brown, grey, plastic.	Terminated at 18.0m.		

SL

Coffey & Partners Pty. Ltd.



borehole no P17
sheet 1 of 1

composite borehole log

Sydney G65/3

client: NATIONAL MINERAL SANDS PTY LTD	hole commenced:
project: KING ISLAND HEAVY MINERAL DEPOSITS	hole completed:
borehole location: See FIGURE 3	supervised by:
	checked by:

drill model and mounting: RC/Truck	RL casing:	datum: M.S.L.
hole diameter: 56 mm	RL surface:	total depth: 11.5m

bore construction diagram mm 100 50 0 50 100	S. W. L.	depth metres R. L.	graphic log	classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations
No casing installed.	3.59	0	[SP symbol]	SP	SAND-Fine-medium grained, white/grey, clean.	Indurations. Hard indurated layers.
		2	[SM symbol]	SM	SILTY SAND-Fine-medium grained, dark brown, pealy.	
		4	[SP symbol]	SP	SAND-fine-medium grained, light brown, clean, grading into dark brown silty.	
		6	[SP/GP symbol]	SP/GP	SAND/GRAVEL-Brown, up to 0.5 cm dia.	
		8	[SM/GP symbol]	SM/GP	SILTY SAND/GRAVEL-As above.	
		10	[CLAY symbol]		CLAY-Brown, plastic.	
		11.5			Terminated at 11.5m.	

Colley & Partners Pty. Ltd.



borehole no P18
sheet 1 of 1

composite borehole log

BRISBANE G65/1

client:	NATIONAL MINERAL SANDS PTY LTD	hole commenced:	2.5.88
project:	KING ISLAND HEAVY MINERAL DEPOSITS	hole completed:	2.5.88
borehole location:	See FIGURE 3	supervised by:	EHB
		checked by:	EHB

drill model and mounting:	RC/Truck	RL casing:	datum:	M.S.L.
hole diameter:	56 mm	RL surface:	total depth:	10.0m

bore construction diagram mm 100 50 0 50 100	S. W. L. S. L.	depth metres	graphic log	classification symbol	material type, plasticity or particle characteristic color, secondary & minor components	additional observations
		0		SP	SAND-Fine-medium grained, light grey, clean.	Indurated layers From 5.5-8.5m.
		2			INDURATED LAYER-Dark brown, very hard.	
				SM	SILTY SAND-Fine-medium grained, brown to dark brown, varies from slightly silty to silty.	
		4				
		6				
	5.34					
		8				
		10		SP/GP	SAND/GRAVEL-Light brown, up to 0.5cm dia. CLAY.	
					Terminated at 10.0m.	

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 28/85

AREA: NARACOOPA

LINE NO: 1780N

HOLE NO: 300W

LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89

METHOD: Rig

280

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, medium - coarse. Well sorted. White.			
1.5 - 3.5		AS ABOVE			
3.5 - 5.5		AS ABOVE			
5.5 - 7.5		AS ABOVE. Brownish grey.			
7.5 - 9.5		AS ABOVE. Some hard induration. H.M. Tr.			
9.5 - 11.5		AS ABOVE, becomes pyritic. Pale clay. 11.5m. E.O.H. 11.5m. PIEZOMETER			

542298

CLIENT: [REDACTED]

NATIONAL MINERAL [REDACTED]S

TIME NO: E 28/ [REDACTED]

AREA: NARACOOPA

LINE NO: 1600N

HOLE NO: 200W

289 LOGGED BY: GRAHAM LEE

DATE DRILLED: 28.1.89 METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, medium - coarse grained. Well sorted, pale grey. H.M. tr.			
1.5 - 3.5		AS ABOVE			
3.5 - 5.5		AS ABOVE. Dark brown, lightly indurated.			
5.5 - 7.5		AS ABOVE			
7.5 - 9.0		AS ABOVE, peaty, dark brown mica clay at 9.0 m.			
9.0 - 11.5 No sample		CLAY E.OH. 11.5m.			
		PIEZOMETER			

542299

TITLE NO. E. 28/8

AREA: NARACOOPA

LINE NO: 1400N

HOLE NO: 380W

LOGGED BY: GRAHAM LEE

DATE DRILLED: 30.1.89

METHOD: Hand

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		PEAT, very wet. Minor sand at 1.3 - 1.5m.			
1.5 - 3.5		SAND, medium grained, well sorted, grey. Indurated layers.			
3.5 - 5.5		AS ABOVE, with some coarse grains at bottom. Indurated.			
5.5 - 5.7		Pyrite layer.			
		E.O.H. 5.7m.			
		PIEZOMETER			

542300

VA (ONAL MINERAL SANDS) E. 1/8

AREA: COWPER POINT - HIGH DUNE

LINE NO: 4350N

HOLE NO: 2320E

291 LOGGED BY: GRAHAM LEE

DATE DRILLED: 9.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, medium grained, brownish amber. Visible H.M.			
1.5 - 3.5		AS ABOVE, then amber with H.M. bands. Good H.M.			
3.5 - 5.5		SAND, pale grey & amber. Rich H.M.			
5.5 - 7.5		SAND, medium to coarse grained with pebbles and shell fragments. Rich H.M.			
7.5 - 8.0		AS ABOVE, but coarser grained. SANDSTONE at 8.0m.			
		E.O.H. 8.0m. SANDSTONE			
		PIEZOMETER HOLE			

542301

... : ... TIO ... MIN ... L S ... LE ... E.L. 41/88

AREA: COWPER POINT - HIGH DUNE

LINE NO: 3750N

HOLE NO: 2520E⁶

292

LOGGED BY: ANDREW DOVE

DATE DRILLED: 15.1.89

METHOD: Rig

Interval (m)	Dry. Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, fine - medium grained, light brown to brown. H.M. base.			
1.5 - 3.5		SAND, fine - medium grained, brown, grades to amber. H.M. >1%.			
3.5 - 5.5		SAND, fine - medium grained, amber. H.M. bands. H.M. 2-5%.			
5.5 - 7.5		AS ABOVE, grades to coarse grained. Shell present. H.M. visible.			
7.5 - 9.1		SAND, coarse - very coarse grained. Light grey. Abundant shell. Coarse H.M. >2%. Hit Sandstone. E.O.H. 9.1m. SANDSTONE PIEZOMETER HOLE			

542302

AREA: COWPER POINT - HIGH DUNE

LINE NO: 3750N

HOLE NO: 2500E²

LOGGED BY: ANDREW DOVE

DATE DRILLED: 15.1.89

METHOD: Rig

93

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, fine - medium grained. Light brown to brown. H.M. trace.			
1.5 - 3.5		SAND, fine - medium grained, brown grades to amber. H.M. >1%.			
3.5 - 5.5		SAND, fine - medium grained, amber. H.M. >1%.			
5.5 - 7.5		AS ABOVE. H.M. >1%.			
7.5 - 9.5		AS ABOVE. H.M. >2%.			
9.5 - 11.5		AS ABOVE, becomes coarser with depth. Abundant shell, Coarse H.M. >1%.			
11.5 - 12.5		SAND, coarse - very coarse grained, light grey. Abundant coarse shell. H.M. visible >1%. Hit Sandstone. E.O.H. 12.5m. SANDSTONE PIEZOMETER HOLE			

542303

MINERAL SANDS

TIME NO. E. 1/8

AREA: COWPER POINT - HIGH DUNE

LINE NO: 3450N

HOLE NO: 2480E

291 LOGGED BY: ANDREW DOVE

DATE DRILLED: 17.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, fine - medium grained, brown. H.M. trace.			
1.5 - 3.5		AS ABOVE, grades to amber. Coarser with depth. H.M. 2-5%.			
3.5 - 5.5		SAND, medium - coarse grained, grey. Abundant fine shell. Coarse shell: H.M. >1%.			
5.5 - 6.25		AS ABOVE, abundant coarse shell. Hit Sandstone. E.O.H. 6.25m. SANDSTONE PIEZOMETER HOLE			

549304

CLIMATE NATIONAL MINERAL SANDS

TITLE NO: E.L. 41/88

AREA: COWPER POINT - HIGH DUNE

LINE NO: 3450N

HOLE NO: 2440E

LOGGED BY: ANDREW DOVE

DATE DRILLED: 16.1.89

METHOD: Rig

295

126

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, fine - medium grained, brown. H.M. base.			
1.5 - 3.5		SAND, fine - medium grained, light brown, grading to amber. H.M. 2-5%.			
3.5 - 5.5		SAND, fine - medium grained, amber. H.M. 2-5%.			
5.5 - 7.2		SAND, fine - medium grained, light grey, abundant fine shell. H.M. >2%. Hit Sandstone. E.O.H. 7.2m. SANDSTONE. PIEZOMETER HOLE			

542305

TITLE NO: E I 41/88

LINE NO: 3450N

HOLE NO: 2400E

DATE DRILLED: 16.1.89

METHOD: Rig

AREA: COWPER POINT - HIGH DUNE

LOGGED BY: ANDREW DOVE

296

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, fine - medium grained. Light brown, grades to light grey. H.M. >2%.			
1.5 - 3.5		SAND, fine - medium grained, light grey with brown bands. H.M. seam. 2 5%.			
3.5 - 5.5		SAND, medium grained, light grey. H.M. 2-5%. Abundant shell.			
5.5 - 6.25		SAND, coarse - very coarse grained, light grey. Abundant shell. H.M. >2%. Hit Sandstone. E.O.H. 6.25m. SANDSTONE PIEZOMETER HOLE			

549306

TITLE NO: E.L. 41/88

P20

AREA: COWPER POINT - HIGH DUNE

LINE NO: 3450N

HOLE NO: 2320E

LOGGED BY: ANDREW DOVE

DATE DRILLED: 16.1.89

METHOD: Rig

297

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, fine - medium grained, brown. H.M. >1%.			
1.5 - 3.5		SAND, fine - medium grained, brown grading to amber. H.M. 2-5%.			
3.5 - 5.5		SAND, fine - medium grained, amber. Grades to grey. Hit indurated at 4.5m. H.M. 2-5%.			
5.5 - 7.5		SAND, fine - medium grained, dark brown. Indurated, silty. Abundant fine shell.			
7.5 - 7.9		SAND, medium - coarse grained. Grey. Abundant fine and coarse shell. Hit Sandstone. E.O.H. 9.0m. sandstone PIEZOMETER HOLE			

542307

AREA: COWPER POINT - HIGH DUNE

TITLE NO: E.L. 41/88

LINE NO: 3450N

HOLE NO: 2240E

LOGGED BY: ANDREW DOVE

DATE DRILLED: 16.1.89 METHOD: Rig

230

Interval (m)	Dry. Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, medium - coarse grained, grey. H.M. >1%.			
1.5 - 3.5		SAND, fine - medium grained, dark brown. Indurated, silty.			
3.5 - 5.5		SAND, fine - medium grained, dark brown, indurated, silty. Abundant fine shell. Hit sandstone. E.O.H. 5.5m. SANDSTONE PIEZOMETER HOLE			

542308

CLIENT:

NATIONAL MINING SANDS

TITLE NO.

E.L. 1/88

P30

AREA: COWPER POINT - BACK BEACH

LINE NO: 3150N

HOLE NO: 1320E

LOGGED BY: ANDREW DOVE

DATE DRILLED: 23.1.89 METHOD: Rig

Interval (m)	Dry. Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, fine - medium grained, dark brown, silty. Organic, indurated.			
1.5 - 3.5		SAND, fine - medium grained, dark brown, indurated, silty.			
3.5 - 5.5		AS ABOVE, coarser with depth. Some gravel. Grades to grey. Abundant fine shell, some coarse shell.			
5.5 - 7.5		SAND, fine - medium grained, light grey. Some gravel. Abundant and coarse shell. Hit sandstone - weathered. E.O.H. 7.5m. SANDSTONE PIEZOMETER HOLE			

542309

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: L. 88

AREA: COWPER POINT - BACK BEACH

LINE NO: 3150N

HOLE NO: 840E

30 LOGGED BY: ANDREW DOVE

DATE DRILLED: 23.1.89 METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, medium - coarse grained, grey, grading to dark brown. H.M. rich >5%.			
1.5 - 3.5		SAND, fine - medium grained, dark brown, silty. Indurated. H.M. 2 - 5%.			
3.5 - 5.25		SAND, medium - coarse grained, dark brown, silty. Clay rich. H.M. >2%. Hit green grey clay. E.O.H. 5.25m. CLAY PIEZOMETER HOLE			

342310

AREA: . COOPER POINT - BACK BEACH

LINE NO:

HOLE NO: 1000E 22000

LOGGED BY: ANDREW DOVE

DATE DRILLED: 23.1.89

Method: Rig

301

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, fine - medium grained, brown, slightly indurated.			
1.5 - 3.5		SAND, fine - medium grained, dark brown, indurated. Clay rich.			
3.5 - 5.5		AS ABOVE, silty, clay rich.			
5.5 - 6.0		AS ABOVE, hit yellow green clay, then sandstone. E.O.H. 6.0m. SANDSTONE PIEZOMETER HOLE			

849311

AREA: COWPER POINT - HIGH DUNE

LINE NO: 2200N

HOLE NO: 1880E

302 LOGGED BY: ANDREW DOVE

DATE DRILLED: 18.1.89

METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, fine - medium grained, grey, grades to dark brown. Poss. indurated.			
1.5 - 3.0		SAND, fine - medium grained, dark brown. Indurated. Hit sandstone. E.O.H. 3.0m. SANDSTONE PIEZOMETER HOLE			

542312

CLIENT: NATIONAL MINERAL SANDS

TIME NO. E.L. /88

P34

AREA: COWPER POINT - BACK BEACH

LINE NO: 1600N

HOLE NO: 1000E

30 LOGGED BY: ANDREW DOVE

DATE DRILLED: 25.1.89

METHOD: Rig

Interval (m)	Dry. Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, medium grained, grey, grading to greyish brown.			
1.5 - 3.5		SAND, medium grained, dark brown, indurated. Clay rich. Hit weathered sandstone. E.O.H. 3.5m. SANDSTONE PIEZOMETER HOLE			

542313

CLIENT: NATIONAL MINERAL SANDS

TITLE NO: E.L. 41/88

AREA: COWPER POINT - HIGH DUNE

LINE NO: 2500N

HOLE NO: ~~2160E~~ 2160E

304

LOGGED BY: ANDREW DOVE

DATE DRILLED: 21.1.89 METHOD: Rig

Interval (m)	Dry Wt. (kg)	Description	% Slime	% 1000 um	% H.M.
0 - 1.5		SAND, fine - medium grained, brown. H.M. trace.			
1.5 - 3.5		AS ABOVE, grades to amber. Medium - coarse grained. H.M. <1%.			
3.5 - 5.5		SAND, fine - medium grained, amber. H.M. >2%			
5.5 - 7.5		AS ABOVE. H.M. >2%.			
7.5 - 9.5		AS ABOVE, some darker bands. H.M. >1%.			
9.5 - 11.5		SAND, medium - coarse grained, amber. H.M. ≈ 1%.			
11.5 - 13.5		AS ABOVE, grades to grey. Abundant fine shell at base. H.M. >1%.			
13.5 - 15.0		SAND, fine - medium grained, grey. Abundant fine shell. H.M. >1%. Hit Sandstone. E.O.H. 15.0m. SANDSTONE PIEZOMETER HOLE			

542314

Engineering log borehole



borehole no.: P37
sheet 1 of 1

office and job no: G65/3 Sydney

hole commenced: 2/2/89
hole completed: 2/2/89
supervised by: R. Wilson
checked by: Dr. L. Drury

NATIONAL MINERAL SANDS PTY LTD
project: KING ISLAND HEAVY MINERAL DEPOSIT
borehole location: O37E 1600N

drill model and mounting: Hand auger & sludging slope: deg.
hole diameter: 56 mm bearing: deg. R.L. surface: approx. 4m datum:

method	penetration	support	water	notes	R.L. depth	graphic log	classification	material	moisture	consistency, density index	hand penetrometer	structure and additional observations
1 2 3				samples, tests, etc.	metres		symbol	soil type: plasticity or particle characteristics colour, secondary and minor components	condition		100 200 300 400	
					2	SP		SAND- fine to medium, white to light grey				
			2.58		4	SP/ SM		SAND- fine to coarse, brown carbonaceous cement				
					4			CLAY- high plasticity, brown, micaceous				
					3.7			END OF HOLE AT 3.7m				
					6			Spearpoint 60mm dia and 810mm long				
					8							
					10							

method
AS auger screwing*
AD auger drilling*
R roller/tricone
W washbore
CT cable tool
*bit shown by suffix
B blank bit
V "V" bit
T TC bit
e.g. ADT

support C casing
M mud
penetration 1 2 3
no resistance ranging to refusal
water 10 Jan 78 water level on date shown
water inflow
water outflow

notes
USU undisturbed sample 50 mm diameter
D disturbed sample
N standard penetration test: figure = result
N' SPT + sample
Nc cone penetrometer

classification symbols
and soil description
based on unified classification system

moisture
D dry
M moist
W wet

consistency/density index
US very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fo friable
VL very loose
L loose
MD medium dense
D dense
VD very dense



borehole no.: P38
sheet 1 of 1

Engineering log borehole

office and job no:

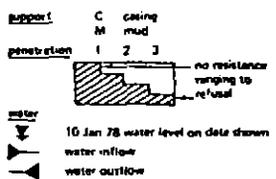
NATIONAL MINERAL SANDS PTY LTD
project: KING ISLAND HEAVY MINERAL DEPOSIT
borehole location: 039E 1600N

hole commenced: 2/2/89
hole completed: 2/2/89
supervised by: R. Wilson
checked by: Dr. L. Drury

drill model and mounting: Hand augering & sludgifier: deg. R.L. surface: app. 4 m
hole diameter: 56 mm bearing: deg. datum:

1	2	3	notes samples, tests, etc.	R.L. depth in metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	hand panetro- meter 0-100 100-200 200-300 300-400	structure and additional observations
				2.4m	SP	SAND- fine to medium, grey _becomes brown, weak carbonaceous cement				
				4		CLAY-high plasticity, brown				
						END OF HOLE AT 3.5m				
						PVC Dia. 30mm.				

method
AS auger screwing
AD auger drilling
R roller/fricone
W washbore
CT cable tool
*bl shown by suffix.
B blank bit
V "V" bit
T TC bit
es ADT



notes
USO undisturbed sample 50 mm diameter
D disturbed sample
N standard penetration test: figure = result
N* SPT = sample
Nc cone penetrometer

classification symbols and soil description
based on unified classification system

moisture
D d.v.
M mos:
N wet

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey & Partners Pty. Ltd.



borehole no.: P39

sheet 1 of 1

Engineering log borehole

office and job no.: Sydney G65/3

NATIONAL MINERAL SANDS PTY LTD

hole commenced: 2/2/89

hole completed: 2/2/89

supervised by: R. Wilson

checked by: Dr. L. Drury

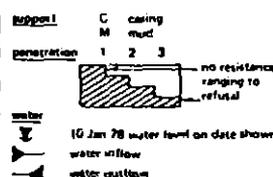
project: KING ISLAND HEAVY MINERAL DEPOSIT

borehole location: O37E 1611N

drill model and mounting: Hand auger & sludging slope: deg. R.L. surface: approx. 4 m
 hole diameter: mm bearing: deg. datum:

m	penetration			notes samples, tests, etc.	depth metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	hand panetro- meter	structure and additional observations
	1	2	3								
0											
2.5					2	SP	SAND- fine to medium, white light grey				2.1-2.3 strongly stained, indurated
						SP/ SM	SAND- fine to coarse, light brown to yellow				
					4		CLAY- high plasticity, brown END OF HOLE AT 3.6m PVC Dia. 30mm.				

notes
 AS auger screwing
 AD auger drilling
 R roller/torque
 W washbore
 CT cable tool
 *bit shown by suffix
 B blank bit
 V 1/2" bit
 T TC bit
 e.g. ADT



notes
 USO undisturbed sample 50 mm diameter
 D disturbed sample
 N standard penetration test: figure = result
 N' SPT 4 sample
 Pc cone penetrometer

classification symbols and soil description
 based on unified classification system

moisture
 D dry
 M moist
 W wet

consistency/density index

VS	very soft
S	soft
F	firm
Sr	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey & Partners Pty. Ltd.



borehole no.: p40
sheet 1 of 1

engineering log borehole

office and job no: Sydney G65/3

NATIONAL MINERAL SANDS PTY LTD
 Project: KING ISLAND HEAVY MINERAL SANDS
 borehole location: 045W 1600N
 hole commenced: 2/2/89
 hole completed: 2/2/89
 supervised by: R. Wilson
 checked by: Dr. L. Drury

drill model and mounting: RC/Truck
 hole diameter: 60 mm
 slope: 90 deg.
 bearing: deg.
 R.L. surface: m
 datum:

method	penetration	support	water	notes samples, tests, etc.	R.L. depth in metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index hand penetro- meter	structure and additional observations
					2.17	SP	SAND- fine to medium, light brown to grey			
						SP/SM	becomes fine to coarse			
						SP/SM	SAND- fine to coarse, dark brown, weak carbonaceous cement			
						SP/GP	GRAVELLY SAND- fine to coarse, dark brown			
						SP	SAND- fine to coarse, dark brown, locally carbonaceous cemented			
						SM	SAND- fine to medium, grey to light grey			
							CLAY- high plasticity, brown stiff, micaceous			
							END OF HOLE AT 13.5m PVC DIA. 50mm			

<p>method</p> <ul style="list-style-type: none"> AS auger screwing AD auger drilling R roller/tricone W washbore CT cable tool <p>*bit shown by suffix: B blank bit V "V" bit T TC bit e.g. ADT</p>	<p>support</p> <p>C casing M mud</p> <p>penetration</p> <p>water</p> <ul style="list-style-type: none"> 10 Jan 78 water level on date shown water inflow water outflow 	<p>notes</p> <p>USO undisturbed sample 50 mm diameter</p> <p>D disturbed sample</p> <p>N standard penetration test: figure = result</p> <p>N* SPT - sample</p> <p>Nc cone penetrometer</p>	<p>classification symbols and soil description based on unified classification system</p> <p>moisture</p> <ul style="list-style-type: none"> D dry M moist W wet 	<p>consistency/density index</p> <ul style="list-style-type: none"> VS very soft S soft F firm Sf stiff VSs very stiff H hard Fh friable VL very loose L loose MD medium dense D dense VD very dense
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Engineering log borehole



borehole no.: P41
sheet 1 of 1

office and job no: Sydney G65/3

NATIONAL MINERAL SANDS PTY LTD

Project: KING ISLAND HEAVY MINERAL DEPOSIT
borehole location: O25W 1600N

hole commenced: 2/2/89
hole completed: 2/2/89
supervised by: R. Wilson
checked by: Dr. L. Drury

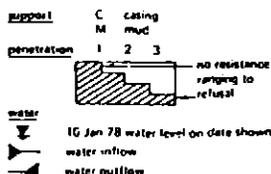
Drill model and mounting: RC/Truck
hole diameter: 60 mm

slope: 90 deg.
bearing: deg.

R.L. surface: m
datum:

penetration 1 2 3	support water	notes samples, tests, etc.	L. depth R. metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	hand penetro- meter	structure and additional observations
			3.31	SP	SAND- fine to medium light grey becomes dark brown, weak carbonaceous cement				
				SP/ GP	GRAVELLY SAND- fine to coarse, dark brown, gravel fine to coarse				
				SP	SAND- fine to coarse, dark brown, weak carbonaceous cement, some gravel				
				SP/ SM	SAND- fine to medium, light brown grey, micaceous				
					CLAY- high plasticity, brown, stiff				
					END OF HOLE AT 12.7m PVC dia. 50mm				

method
AS auger screwing
AD auger drilling
R roller/cone
W washbore
CT cable tool
*bit shown by suffix
B blank bit
V "V" bit
T TC bit
e.g. ADT



notes
USO undisturbed sample 50 mm
diameter
D disturbed sample
N standard penetration test:
figure = result
N* SPT - sample
Fic cone penetrometer

classification symbols
and soil description
based on unified
classification system

moisture
D dry
M moist
W wet

consistency/density index
VS very soft
S soft
F firm
St stiff
VS1 very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

engineering log borehole



borehole no.: P42
sheet 1 of 1

office and job no: Sydney G65/3

NATIONAL MINERAL SANDS PTY LTD
 Project: KING ISLAND HEAVY MINERAL DEPOSIT
 Borehole location: 008W 1600N
 hole commenced: 2/2/89
 hole completed: 2/2/89
 supervised by: R. Wilson
 checked by: Dr. L. Drury

Drill model and mounting: RC/Truck
 hole diameter: 60 mm
 slope: 90 deg.
 bearing: deg.
 R.L. surface: m
 datum:

m	penetration 1 2 3	support water	notes samples, tests, etc.	L.L. depth & metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	hand penetro- meter	structure and additional observations
1.87				2	SP	SAND- fine to medium, light grey.				
				4		becomes dark brown, weak carbonaceous cement				
				8	SP	SAND- fine to medium, dark brown, weak, carbonaceous cement, some fine gravel				
				10						
				12	SM	SILTY SAND- fine, grey, micaceous, some thin gravelly sand layers & Clay pockets				
				14	CH	CLAY- high plasticity, brown stiff, micaceous				
				14		END OF HOLE AT 13.4m				

<p>method</p> <p>AS auger screwing AD auger drilling R roller/tricone W washbore CT cable tool *bit shown by suffix B blank bit V "V" bit T TC bit e.g. ADT</p>	<p>support</p> <p>C casing M mud 1 2 3 penetration</p> <p>no resistance ranging to refusal</p> <p>10 Jan 78 water level on date shown</p> <p>water inflow</p> <p>water outflow</p>	<p>depth</p> <p>USO</p> <p>D disturbed sample N standard penetration test: figure = result N* SPT - sample PK cone penetrometer</p>	<p>classification symbol's and soil description based on unified classification system</p> <p>moisture</p> <p>D dry M moist W wet</p>	<p>consistency/density index</p> <p>TS very soft S soft F firm St stiff VSt very stiff H hard Fb friable VL very loose L loose MD medium dense D dense CD very dense</p>
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borehole no.: P43
sheet 1 of 1

engineering log borehole

office and job no: Sydney G65/3

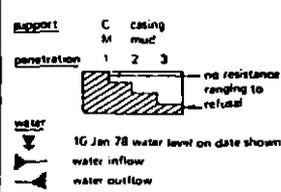
NATIONAL MINERAL SANDS PTY LTD
 Project: KING ISLAND HEAVY MINERAL DEPOSIT
 Borehole location: 200W 1900N

hole commenced: 2/2/89
 hole completed: 2/2/89
 supervised by: R. Wilson
 checked by: Dr L. Drury

Drill model and mounting: R/C Truck
 Hole diameter: 60 mm
 slope: 90 deg.
 bearing: deg.
 R.L. surface: m
 datum:

method 1 2 3	penetration support water	notes samples, tests, etc.	L. depth R. metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	hand penetro- meter 0-100 200 300 400	structure and additional observations
			1.60	SP	SAND- fine to medium, loose, white to light grey				
			2						
			4						
			6	SP	SAND- fine to medium, dark brown, weak carbonaceous cement locally more cemented				
			8		becomes fine to coarse				
			10		CLAY- high plasticity, brown, stiff, micaceous				
			12		END OF HOLE AT 10.3m PVC dia 50mm				

method
 AS auger screening
 AD auger drilling
 R roller tri-cone
 W washers
 CT cable tool
 *bit shown by suffix
 B blank bit
 V "V" bit
 T TC bit
 e.g. ADT



notes
 USO undisturbed sample 50 mm diameter
 D disturbed sample
 N standard penetration test: figure = result
 N* SPT = sample
 fic cone penetrometer

classification symbols and soil description
 based on unified classification system

moisture
 D dry
 M moist
 W wet

consistency/density index
 VS very soft
 S soft
 F firm
 St stiff
 VSt very stiff
 H hard
 Fb friable
 VL very loose
 L loose
 MD medium dense
 D dense
 VD very dense

Handwritten mark resembling a stylized 'S' or 'J'.



borehole no.: P44
sheet 1 of 1

engineering log borehole

office and job no: Sydney G65/3

NATIONAL MINERAL SANDS PTY LTD
 Project: KING ISLAND HEAVY MINERAL DEPOSIT
 Borehole location: 190W 1600N
 hole commenced: 2/2/89
 hole completed: 2/2/89
 supervised by: R. Wilson
 checked by: Dr L. Drury

Drill model and mounting: R/C Truck slope: 90 deg.
 Hole diameter: 60 mm bearing: deg. R.L. surface: m
 datum:

method	penetration	support	water	notes samples, tests, etc.	depth in metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	hand penetro- meter	structure and additional observations
				eg 1.43	2	SP	SAND- fine to medium, white light grey				
					4	SM/ SP	SAND- SILTY SAND, fine to medium, dark grey and brown some coarse sand				
					8	SP	SAND, fine to coarse, dark brown, strong carbonaceous cement				
					10		becomes white non- carbonaceous				
					12		CLAY- high plasticity, brown				
							END OF HOLE AT 11.4m PVC dia. 50mm				

Handwritten mark resembling a stylized 'S' or 'B'.

<p>method</p> <p>AS auger screening* AD auger drilling* R roller/corone W washbore CT cable tool *bit shown by suffix. B blank bit V "V" bit T TC bit e.g. ADT</p>	<p>support</p> <p>C casing M mod</p> <p>penetration 1 2 3</p> <p>no resistance ranging to refusal</p> <p>water</p> <p>IG Jan 78 water level on date shown</p> <p>water inflow</p> <p>water outflow</p>	<p>notes</p> <p>USO samples and tests undisturbed sample 50 mm diameter D disturbed sample hv standard penetration test: figure = result N* SPT 1 sample Nc cone penetrometer</p>	<p>classification symbols and soil description based on unified classification system</p> <p>moisture</p> <p>D dr. M mos. W wet</p>	<p>consistency/density index</p> <p>VS very soft S soft F firm St stiff VS1 very stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense</p>
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borehole no.: P45
sheet 1 of 1

Engineering log Borehole

office and job no: Sydney G65/3

NATIONAL MINERAL SANDS PTY LTD

hole commenced: 3/2/89

hole completed: 3/2/89

Project: KING ISLAND HEAVY MINERAL DEPOSIT

supervised by: R. Wilson

borehole location: 2308E 4378N

checked by: Dr. L. Drury

drill model and mounting: R/C Truck

slope: 90 deg.

R.L. surface: m

hole diameter: 60 mm

bearing: deg.

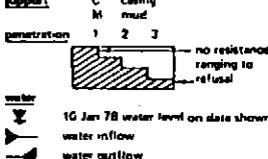
datum:

met. noc	penetration	support	water	notes samples, tests, etc.	L.L. depth in metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency density index	hand penetrometer	structure and additional observations
						SP	SAND- fine to medium, light brown, becomes white				
				2.09m	2	SP/SW	SAND- fine to coarse, light grey, white, trace of fine shell fragments				
					4						
					6		100mm thick shell layer				
					6	SP	SAND- fine to medium, brown weak carbonaceous cement, shell fragments				
					8		SANDY LIMESTONE, white porous, low strength				
					10		END OF HOLE at 8.5m PVC dia. 50mm				

method

- AS auger screwing
- AD auger drilling
- R roller/drill
- W washbore
- CT cable tool
- *bit shown by suffix
- B blank bit
- V "V" bit
- T TC bit
- e.g. ADT

support



notes

- USO undisturbed sample 50 mm diameter
- D disturbed sample
- N standard penetration test: figure = result
- N' SPT + sample
- hc cone penetrometer

classification symbols and soil description

based on unified classification system

moisture

- D dry
- M moist
- W wet

consistency/density index

- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fh friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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542324

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borehole no.:
P46
sheet 1 of 1

Engineering log borehole

office and job no: G65/3

hole commenced: 3/2/89

hole completed: RW

supervised by:

checked by:

project:
borehole location: APPRDX 2329E 4320N

drill model and mounting: RC/TRUCK

slope: 90 deg.

R.L. surface: m

hole diameter: 60 mm

bearing: - deg.

datum:

method 1 2 3	support water	notes samples, tests, etc.	R.L. depth metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer				structure and additional observations
								100 kPa	200 kPa	300 kPa	400 kPa	
			2	SP	SAND fine to medium light orange brown							
			4		becomes mottled light grey white							struck water
		3.57	6		becomes medium to coarse							
			8	SP/ GP	SAND medium to coarse, light grey white, some shells, 100mm GRAVEL layer at base							
			10		LIMESTONE, white cream, porous							
			12		End of Bore at 9.5m							
			14		OBSERVATION STANDPIPE 50mm Ø							
			16									

method
AS auger screwing
AD auger drilling
R roller/tripper
W washbore
CT cable tool
*bit shown by suffix
B blank bit
V "V" bit
T TC bit
e.g. ADT

support C casing
M mud
penetration 1 2 3
no resistance ranging to refusal
water 10 Jan 78 water level on date shown
water inflow
water outflow

notes
USO undisturbed sample 50 mm diameter
D disturbed sample
N standard penetration test: figure = result
N* SPT - sample
PC cone penetrometer

classification symbols and soil description based on unified classification system
moisture
D dry
M mod.
W wet

consistency/density index
VS very soft
S soft
F firm
St stiff
VS1 very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense



borehole no.:

47

sheet 1 of 1

engineering log borehole

office and job no: G65/3

hole commenced: 3/2/89

hole completed: RW

supervised by:

checked by:

project:

borehole location: APPROX 3460N 2430E

drill model and mounting: RC/TRUCK

slope: 90 deg.

R.L. surface: m

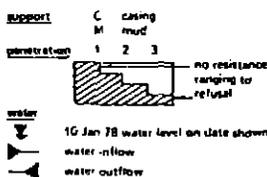
hole diameter: 60 mm

bearing: - deg.

datum:

method 1 2 3	penetration support water	notes samples, tests, etc.	depth metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	hand penetro- meter	structure and additional observations
			2.51	SP	SAND fine to medium light brown orange becomes light grey				
			4		becomes fine to coarse				
			6	SP/ GP	GRAVELLY SAND fine to coarse, grey, gravel to 50mm				
			8		LIMESTONE, white, porous				
					End of Bore at 6.6m				
					OBSERVATION STANDPIPE 50mm Ø				

method
AS auger screwing
AD auger drilling
R roller/torque
W web-bore
CT cable tool
*bit shown by suffix
B blank bit
V "V" bit
T TC bit
e.g. ADT



sample and test
U50 undisturbed sample 50 mm diameter
D disturbed sample
N standard penetration test: figure = result
N* SPT + sample
Nc cone penetrometer

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet

consistency/density index
S very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VLo very loose
L loose
MLD medium dense
D dense
VD very dense



borehole no.:
P48
sheet 1 of 1

engineering log borehole

office and job no: G65/3

project:
borehole location:

hole commenced: 6/2/89
hole completed: 6/2/89
supervised by: RW
checked by:

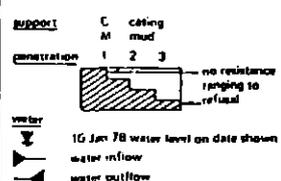
drill model and mounting: CONVENTIONAL/TRUCK
hole diameter: 100 mm

slope: 90 deg.
bearing: - deg.

R.L. surface: m
datum:

penetration 1 2 3	support water	notes samples, tests, etc.	depth metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer			structure and additional observations
								100	300	400	
			2	SP	SAND fine to medium, light orange grey becomes light grey						
			4	SP/ SM	SAND fine to coarse, light grey						
		3.63	6		End at Bore at 5.6m SPEARPOINT 50mmØ 810mm long						
			8								
			10								
			12								
			14								
			16								

method
AS auger screwing
AD auger drilling
R roller/tricone
W wash bore
CT cable tool
*bit shown by suffix
B blank bit
V "v" bit
T TC bit
e.g. ADT



samples and tests
USO undisturbed sample 50 mm diameter
D disturbed sample
N standard penetration test: figure = result
N* SPT + sample
Nc cone penetrometer

classification symbols and soil description based on unified classification system

moisture
D dry
M moist
W wet

consistency/density index
VS very soft
S soft
F firm
St stiff
VS1 very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

10



borehole no.:
P49
sheet 1 of 1

Engineering log borehole

office and job no: G65/3

project:
borehole location:

hole commenced: 3/2/89
hole completed: 3/2/89
supervised by: RW
checked by:

drill model and mounting: CONVENTIONAL/TRUCK slope: 90 deg.
hole diameter: 100 mm bearing: - deg. R.L. surface: m
datum:

m	penetration 1 2 3	support water	notes samples, tests, etc.	R.L. depth metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	hand penetro- meter	structure and additional observations
				2.61	SP	SAND fine to medium, light brown orange becomes light grey white				
				6	GP/SP	GRAVELLY Layer				
				6.5		End of Bore at 6.5m				
						SPEARPOINT 60mm Ø 810mm long				

<p>method</p> <p>AS Auger screening AD auger drilling R roller/winch W washbore CT cable tool *bit shown by suffix B blank bit V "V" bit T TC bit e.p. ADT</p>	<p>support</p> <p>C casing M mud</p> <p>penetration</p> <p>1 2 3</p> <p>no resistance ranging to refusal</p> <p>water</p> <p>10 Jan 78 water level on date shown</p> <p>water inflow</p> <p>water outflow</p>	<p>note</p> <p>USO undisturbed sample 50 mm diameter D disturbed sample N standard penetration test: figure = result N* SPT + sample pic cone penetrometer</p>	<p>classification symbol: and soil description based on unified classification system</p> <p>moisture</p> <p>D dry M moist W wet</p>	<p>consistency/density index</p> <p>VS very soft S soft F firm St stiff VSt very stiff H hard Fp friable VL very loose L loose MD medium dense D dense VD very dense</p>
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10

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borehole no.:
P50
sheet 1 of 1

Engineering log borehole

office and job no: G65/3

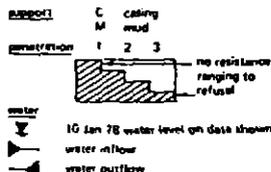
hole commenced: 6/2/89
hole completed: 6/2/89
supervised by: RW
checked by:

project:
borehole location:

drill model and mounting: CONVENTIONAL/TRUCK slope: 90 deg.
hole diameter: 232 mm bearing: - deg. R.L. surface: m
datum:

method	penetration	support	water	notes samples, tests, etc.	L ₁ depth in metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	hand penetro- meter	structure and additional observations
					2.51	SP	SAND fine to coarse, orange grey becomes light grey SAND fine to coarse, dark grey black, weak carbonaceous cement, shells End of Bore at 7.5m				
							PRODUCTION BORE SCREEN 160mm Ø 1.2m long stainless steel CASING 160mm Ø 0.0m long Galvanised Iron PACKING 160kg 8/16 sand				

method
AS auger screwing
AD auger drilling
R roller/tricone
W washbore
CT cable tool
*bit shown by suffix.
B blank bit
V "V" bit
T TC bit
e.g. ADT



sample and test
USU undisturbed sample 50 mm diameter
D disturbed sample
N standard penetration test: figure = result
N* SPT - sample
Nc cone penetrometer

classification symbols
and soil description
based on united
classification system

moisture
D dry
M moist
W wet

consistency/density index
US very soft
S soft
F firm
St stiff
VS very stiff
H hard
Fh friable
VL very loose
L loose
MO medium dense
D dense
VD very dense

Engineering log borehole



borehole no.:
P51
sheet 1 of 1

office and job no: G65/3

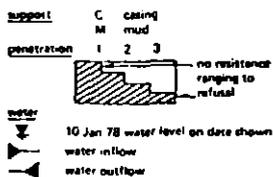
project:
borehole location:

hole commenced: 6/2/89
hole completed: 6/2/89
supervised by: RW
checked by:

drill model and mounting: CONVENTIONAL/TRUCK slope: 90 deg.
hole diameter: 100 mm bearing: - deg. R.L. surface: m
datum:

method 1 2 3	penetration	support water	notes samples, tests, etc.	R.L. depth in metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	penetration				structure and additional observations	
									100	200	300	400		
				2.24	SP	SAND fine to medium, light grey white								
						SAND fine to medium, dark brown, weak carbonaceous cement throughout								
						End of Bore at 11.0m SPEARPOINT 60mm Ø 810m long								

method
AS "super screwing"
AD "super drilling"
R roller/torque
W washbore
CT cable tool
*bit shown by suffix
B blank bit
V "V" bit
T TC bit
e.g. ADT



types
USO undisturbed sample 50 mm diameter
D disturbed sample
N standard penetration test: figure = result
N* SPT - sample
tic cone penetrometer

classification symbols
and soil description
based on unified classification system

moisture
D dry
M moist
W wet

consistency/density index
VS very soft
S soft
F firm
St stiff
VSr very stiff
H hard
Fh friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

engineering log borehole



borehole no.:
P52
sheet 1 of 1

office and job no: G65/3

project:
borehole location:

hole commenced: 6/2/89
hole completed: 7/2/89
supervised by: RW
checked by:

drill model and mounting: CONVENTIONAL/TRUCK slope: 90 deg.
hole diameter: 232 mm bearing: - deg. R.L. surface: m
datum:

1 penetration	2 support	3 water	notes samples, tests, etc.	R.L. depth metres	graphic log classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	hand penetro- meter 100 200 300g 400	structures and additional observations
				2		SAND fine to medium, light grey - white				
				4		SAND, fine to medium, dark brown, weak carbonaceous cement				
			5.30	6		SAND, fine to mediu, light brown grey				
				8		GRAVELLY SAND fine to coarse, dark grey shelly				
				10		End of Bore at 12.5m				
				12		PRODUCTION BORE				
				14		SCREEN 160mm Ø 1.2m long stainless steel				
				16		CASING 160mm Ø 11.7m long galvanised iron				
						PACKING 200kg 8/16 sand				

<p>method</p> <p>AS auger screwing AD auger drilling R roller/cane W washbore CT cable tool "bit shown by suffix B blank bit V "V" bit T TC bit e.g. ADT</p>	<p>support</p> <p>C casing M mud penetration 1 2 3</p> <p>10 Jan 78 water level on date shown</p>	<p>notes</p> <p>USO undisturbed sample 50 mm diameter D disturbed sample N standard penetration test: figures = result N* SP T = sample PC cone penetrometer</p>	<p>classification symbols and soil description based on unified classification system</p> <p>moisture</p> <p>O dry M moist W wet</p>	<p>consistency/density index</p> <p>VS very soft S soft F firm St stiff VSt very stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense</p>
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APPENDIX B
Chemical Analyses

JUDELL PLATT THOMAS & ASSOCIATES

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P.O. BOX 565
CROWS NEST N.S.W. 2065
TELEPHONE (02) 439 4877
FACSIMILE (02) 439 8650
TELEX: AA27466

LABORATORY REPORT

No. 8902036 Page 1

Client: Coffey & Partners Pty. Ltd.,
P.O. Box 125,
NORTH RYDE N.S.W. 2113

Date Received: 14.2.89

Date of Collection: 14.2.89

Attention: Dr. L. Drury

Client Ref: Job No. G65/3

Description of Sample: Water samples from King Island Heavy Mineral Mine, as below:

<u>Reference Number:</u>	147	148	149	150
<u>Sample Origin:</u>	Mouth of Blowhole	Swamp Ck. West of P25	Beach Spearpoint P37 Narracoopa	Production Bore P50 Cowpers Pt.
pH (Method 423*)	8.8	6.2	5.1	7.3
Biochemical Oxygen Demand, BOD ₅ , mg/L (Method 507*)	< 5	17	< 5	< 5
True Colour, Pt-Co units, (Method 204A* Modified - filtration)	29	500	220	26
Suspended solids, mg/L, (Method 209C*)	13	51	< 2	< 2
Specific conductance, at 25°C, microsiemens/cm, (Method 205*)	34 300	1 760	686	1 370
Calcium, Ca, mg/L, (Method 311A*)	500 (24.95)	58 (2.89)	10.3 (0.51)	127 (6.34)
Magnesium, Mg, mg/L, (Method 318A*)	880 (72.42)	36 (2.96)	14.1 (1.16)	21.0 (1.73)
Sodium, Na, mg/L, (Method 325A*)	5 800 (252.30)	225 (9.79)	95 (4.13)	138 (6.00)
Potassium, K, mg/L, (Method 322A*)	64 (1.64)	6.4 (0.16)	1.9 (0.05)	4.2 (0.11)
Nitrate, NO ₃ ⁻ , mg/L, (Method 418D*)	3.1 (0.05)	3.1 (0.05)	2.7 (0.04)	0.9 (0.01)
Bicarbonate, HCO ₃ ⁻ , mg/L, (Method 403*)	102 (1.67)	70 (1.15)	< 1 (<0.02)	247 (4.05)
Carbonate, CO ₃ ²⁻ , mg/L (Method 403*)	25 (0.83)	Nil	Nil	Nil



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TELEX AA2746F

LABORATORY REPORT

No. 8902036 Page 2

Client: Coffey & Partners Pty. Ltd.,
P.O. Box 125,
NORTH RYDE N.S.W. 2113

Date Received: 14.2.89

Date of Collection: 14.2.89

Attention: Dr. L. Drury

Client Ref: Job No. G65/3

Description of Sample: Water samples from King Island Heavy Mineral Mine, as below:

<u>Reference Number:</u>	147	148	149	150
<u>Sample Origin:</u>	Mouth of Blowhole	Swamp Ck. West of P25	Beach Spearpoint P37 Narracoopa	Production Bore P50 Cowpers Pt.
Sulphate, $SO_4^{=}$, mg/L, (Method 426C*)	1 700 (35.39)	2 (0.04)	28 (0.58)	51 (1.06)
Chloride, Cl^- , mg/L, (Method 407C*)	11600 (327.24)	529 (14.92)	188 (5.30)	331 (9.34)
Total Arsenic, As, mg/L (Method 303E*)	0.003	< 0.002	0.002	< 0.002
Total Zinc, Zn, mg/L (Methods 302D*, 328A*)	< 0.01	< 0.01	0.06	0.02
Total Copper, Cu, mg/L (Methods 302D*, 304*)	< 0.01	< 0.01	< 0.01	< 0.01
Total Lead, Pb, mg/L (Methods 302D*, 304*)	< 0.01	< 0.01	< 0.01	< 0.01
Total Cadmium, Cd, mg/L (Methods 302D*, 304*)	0.004	0.002	< 0.001	< 0.001
Total Iron, Fe, mg/L, (Methods 302D*, 315A*)	0.06	0.65	2.16	0.34
Total Chromium, Cr, mg/L (Methods 302D*, 304*)	< 0.01	< 0.01	< 0.01	< 0.01
Total Manganese, Mn, mg/L, (Methods 302D*, 319A* or 304*)	< 0.01	0.07	0.04	0.04
Cations/Anions, %	96.2	97.8	98.7	98.0

* Standard Methods for the Examination of Water and Wastewater
16th Edition, 1985
A.P.H.A. - A.W.W.A. - W.P.C.F.



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TELEX: AA27468

LABORATORY REPORT

No. 8902036 Page 3

Client: Coffey & Partners Pty. Ltd.,
P.O. Box 125,
NORTH RYDE N.S.W. 2113

Date Received: 14.2.89

Date of Collection: 14.2.89

Attention: Dr. L. Drury

Client Ref: Job No. G65/3

Description of Sample: Water samples from King Island Heavy Mineral Mine, as below:

<u>Reference Number:</u>	151	152	153	154
<u>Sample Origin:</u>	Frazer River Mouth Narracoopa	Frazer River Bridge Narracoopa	Swamp 1400N 380W Narracoopa	Production Bore P52 Narracoopa
pH (Method 423*)	7.3	6.8	4.2	4.4
Biochemical Oxygen Demand, BOD ₅ , mg/L (Method 507*)	< 5	8	11	9
True Colour, Pt-Co units, (Method 204A* Modified - filtration)	55	300	260	24
Suspended solids, mg/L, (Method 209C*)	13	18	67	< 2
Specific conductance, at 25°C, microsiemens/cm, (Method 205*)	4 340	480	331	558
Calcium, Ca, mg/L, (Method 311A*)	160 (7.98)	16.6 (0.83)	4.3 (0.21)	5.2 (0.26)
Magnesium, Mg, mg/L, (Method 318A*)	98 (8.06)	12.9 (1.06)	5.4 (0.44)	11.4 (0.94)
Sodium, Na, mg/L, (Method 325A*)	740 (32.19)	61 (2.65)	44 (1.91)	76 (3.31)
Potassium, K, mg/L, (Method 322A*)	18.5 (0.47)	3.0 (0.08)	1.0 (0.03)	1.8 (0.05)
Nitrate, NO ₃ ⁻ , mg/L, (Method 418D*)	3.1 (0.05)	2.2 (0.04)	4.0 (0.06)	3.1 (0.05)
Bicarbonate, HCO ₃ ⁻ , mg/L, (Method 403*)	123 (2.02)	72 (1.18)	N11	N11
Carbonate, CO ₃ ⁻ , mg/L, (Method 403*)	N11	N11	N11	N11 .../4

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TELEX: AA27468

LABORATORY REPORT

No. 8902036 Page 4

Client: Coffey & Partners Pty. Ltd.,
P.O. Box 125,
NORTH RYDE N.S.W. 2113

Date Received: 14.2.89

Date of Collection: 14.2.89

Attention: Dr. L. Drury

Client Ref: Job No. G65/3

Description of Sample: Water samples from King Island Heavy Mineral Mine, as below:

<u>Reference Number:</u>	151	152	153	154
<u>Sample Origin:</u>	Frazer River Mouth Narracoopa	Frazer River Bridge Narracoopa	Swamp 1400N 380W Narracoopa	Production Bore P52 Narracoopa
Sulphate, SO_4^{2-} , mg/L, (Method 426C*)	68 (1.42)	< 1 (<0.02)	2 (0.04)	27 (0.56)
Chloride, Cl^- , mg/L, (Method 407C*)	1 580 (44.57)	118 (3.33)	84 (2.37)	138 (3.89)
Total Arsenic, As, mg/L (Method 303E*)	0.002	0.003	< 0.002	< 0.002
Total Zinc, Zn, mg/L (Methods 302D*, 328A*)	< 0.01	0.02	< 0.01	1.96
Total Copper, Cu, mg/L (Methods 302D*, 304*)	< 0.01	< 0.01	0.013	< 0.01
Total Lead, Pb, mg/L (Methods 302D*, 304*)	< 0.01	< 0.01	< 0.01	0.018
Total Cadmium, Cd, mg/L (Methods 302D*, 304*)	0.003	0.003	0.002	< 0.001
Total Iron, Fe, mg/L, (Methods 302D*, 315A*)	1.28	21.2	0.34	0.28
Total Chromium, Cr, mg/L (Methods 302D*, 304*)	< 0.01	< 0.01	< 0.01	< 0.01
Total Manganese, Mn, mg/L, (Methods 302D*, 319A* or 304*)	0.10	0.79	0.02	0.02

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TELEX AA27668

LABORATORY REPORT

No. 8902036 Page 5

Client: Coffey & Partners Pty. Ltd.,
P.O. Box 125,
NORTH RYDE N.S.W. 2113

Date Received: 14.2.89

Date of Collection: 14.2.89

Attention: Dr. L. Drury

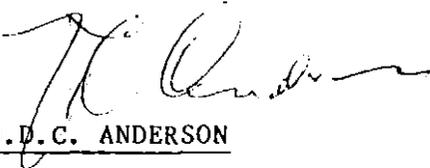
Client Ref: Job No. G65/3

Description of Sample: Water samples from King Island Heavy Mineral Mine, as below:

<u>Reference Number:</u>	151	152	153	154
<u>Sample Origin:</u>	Frazer River Mouth Narracoopa	Frazer River Bridge Narracoopa	Swamp 1400N 380W Narracoopa	Production Bore P52 Narracoopa
Total Coliforms, organisms/100mL (Method 909A*)	-	-	-	TNTC
Faecal Coliforms, organisms/100mL (Method 909C*)	-	-	-	480
Standard Plate Count, organisms/mL (Method 907 ⁺)	-	-	-	59 000
Cations/Anions, %	101.4	101.7	105.0	101.0

+ Standard Methods for the Examination of Water and Wastewater
15th Edition, 1980
A.P.H.A. - A.W.W.A. - W.P.C.F.

* Standard Methods for the Examination of Water and Wastewater
16th Edition, 1985
A.P.H.A. - A.W.W.A. - W.P.C.F.


J.D.C. ANDERSON

QUANTUM

A division of SGS Australia Pty. Ltd. incorporated in N.S.W.

COFFEY & PARTNERS PTY. LTD.

ANALYSIS OF WATER SAMPLES

Analytical Services
21-25 Manilla St, East Brisbane.
P.O. Box 21, East Brisbane, Qld. 4169
Telex AA42876 Fax (07) 391 3404
Phone (07) 391 5366

SAMPLE DESCRIPTION:

WATERS, ORDER NUMBER 25603

DATE RECEIVED:

MAY 4, 1988.

CLIENT SAMPLE REFERENCE:

P 6 X P 6 Y P 6 Z P 9 X P 9 Y P 9 Z

LABORATORY REFERENCE NO.:

QL6774/1 QL6774/2 QL6774/3 QL6774/4 QL6774/5 QL6774/6

SGS Quantum Method No.

Table with 8 columns: Parameter, Unit, P6 X, P6 Y, P6 Z, P9 X, P9 Y, P9 Z, and Method No. Rows include pH, Conductivity, Total Dissolved Salts, Colour, Turbidity, Calcium as Ca, Magnesium as Mg, Sodium as Na, Potassium as K, Alkalinity as CaCO3, Sulphate as SO4, Chloride as Cl, Sulphide as S, Iron as Fe, and Manganese as Mn.

Coffey & Partners Pty. Ltd.,
P.O. Box 118,
EAST BRISBANE. QLD. 4169.



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Signed.....
Date..... 18/5/88

5422337



Department of Health

RADIATION HEALTH SERVICES

Mr J Anderson
 Judall Platt Thomas & Associates
 168 Willoughby Rd
 CROWS NEST 2065 226

Joseph Street
 Lidcombe, N.S.W. 2141
 Address reply to
 P.O. Box 162 Lidcombe, N.S.W.
 2141 Australia

Telex: 72233
 Facs: (02) 646 0333

Our reference: GG:ia

Your reference:

7 April 1989

Phone: 646 0222

RE: WATER SAMPLES - RADIOACTIVITY

The results of gross alpha and gross beta analysis for water samples are as follows:-

Sample	Alpha Bq/l	Beta Bq/l
147	0.64 ± .95	6.56 ± 2.45
148	0.26 ± .83	.89 ± 2.1
149	0 ± 0.7	0.67 ± 2.08
150	0.14 ± .79	0 ± 1.99
151	0 ± .75	1.84 ± 2.6
152	0.13 ± 0.79	1.2 ± 2.12
153	0 ± 0.75	1.22 ± 2.12
154	0.07 ± 0.1	0 ± 0.21

Fifteen ml of each sample was evaporated on a planchette and counted for 50 minutes in a Canberra Low Level Alpha Beta System.

The results are quoted with an associated assessment of the error and from these results it is unlikely that there is any gross alpha or beta concentration in any sample to be of any concern.

Yours faithfully

GEORGE GANDY
 Scientific Officer
 Radiation Health Services