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EL 60

LAKE TORRENS

PROGRESS REPORTS TO LICENCE EXPIRY/RENEWAL FOR THE PERIOD 13/4/1973 TO 12/4/1975

Submitted by
Delhi International Oil Corp.
1975

Enquiries: Customer Services Branch
Minerals and Energy Resources
7th Floor
101 Grenfell Street, Adelaide 5000

Telephone: (08) 8463 3000
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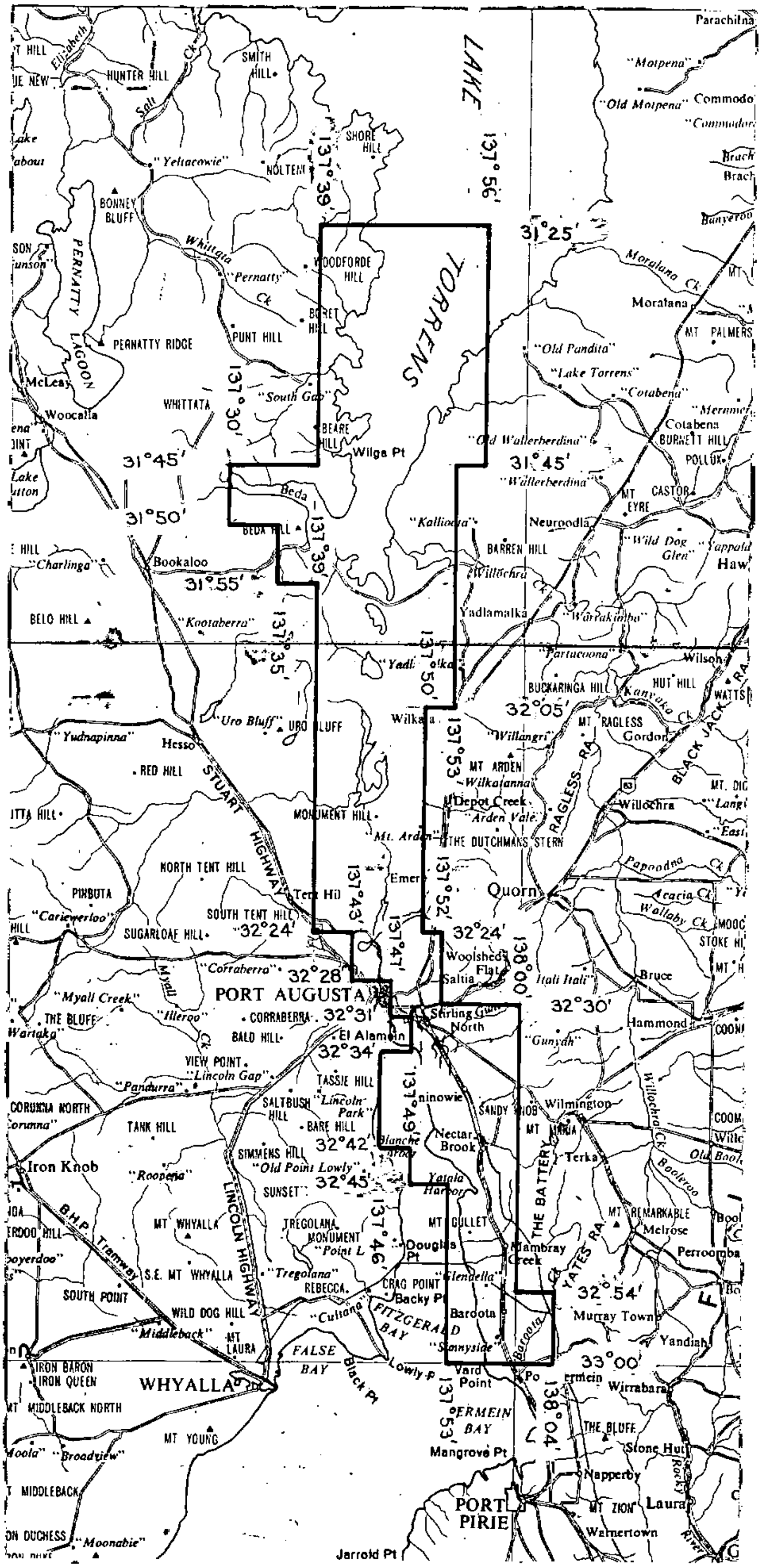
Government of South Australia
Primary Industries and Resources SA

SCHEDULE A



SCALE 1:1,000,000

DELHI INTERNATIONAL OIL CORPORATION

DOCKET DM 1333/72 AREA 3640 km²

1:250000 PLANS .TORRENS

.PORT AUGUSTA

.ORROROO

LOCALITY LAKE TORRENS AREA - APPROX 2 km. E OF PT. AUGUSTA

E.L. No. 60 EXPIRY DATE 12·4·75

CONTENTS ENVELOPE 2299

TENEMENT: E.L. 60 Lake Torrens

TENEMENT HOLDER: Delhi International Oil Corp.

QUARTERLY REPORT

EXPLORATION LICENCE 60

for period

April 13, 1973 to June 30, 1973

During the quarter ending June 30, 1973 Delhi International Oil Corporation implemented a full-scale investigation of the southern part of Lake Torrens as a source of NaCl brine.

The programme included the establishment of a field camp, weather station, fuel supply, purchase of required vehicles and special heavy equipment, and the assignment of personnel. The area was surveyed and samples of brine were taken for chemical analysis.

Camp

A three caravan camp with lighting and power facilities was established between the southern extremity of Lake Torrens and Soakage Swamp on Yadlamalka Station. A 16-mile dirt track was graded from Yadlamalka Homestead to the Lake and Camp.

Weather Station

A complete weather station containing sufficient equipment to record wind, precipitation, evaporation, hours of sunshine, wet and dry minimum-maximum temperatures, was established with the assistance of the Department of Meteorology.

Vehicles and Heavy Equipment

Field vehicles consisting of one International 4 wheel drive, 1½ ton truck, one Toyota 4 wheel drive Landcruiser, and three Honda all-terrain motorcycles were initially assigned to the programme. Additional equipment has since been purchased and assigned.

A purchase order for an amphibious dragline was placed with Quality Marsh Equipment Company; the machine was landed at Port Adelaide in July, 1973.

Exploration

The exploration of Lake Torrens was initiated with the establishment of a survey grid of some 75 square miles. Pickets were placed at every 2,000 foot interval commencing from a 00.EW - 00.NS Basepoint located with respect to known trig stations and with levels carried approximately seven miles from existing benchmarks, see Fig. 1.

The survey grid was levelled with closure maintained to within 3/100 foot and a surface contour map of the area was prepared. See Fig. 2.

Geochemical sampling of the groundwater consisted of establishing power-auger holes 6' deep x 6" diameter, or hand-dug pits, at every third grid intersection.

After allowing approximately 36 hours for the brine level to stabilise the depth from surface was recorded and 66 samples taken for chemical analyses. Total dissolved salts range between 17 and 22 percent by weight and NaCl comprises approximately 92 to 94 percent of the total salts. See Fig. 3 and geochemical data sheets attached.

<u>Expenditures</u>

Field vehicles	$14,374-13
Communications equipment	211-40
Pumps, engines, pipe	485-65
Miscellaneous equipment	836-24
Expendable camp items	1,592-91
Caravan rentals	381-00
Transportation	690-70
Salaries and wages	12,452-04
Consulting fees	4,156-29
Geochemical assays	149-30
Licence	1,845-55
Expenditure April 1 through June 30, 1973	$37,175-21

-/4...

Future Programme

It is proposed to employ the amphibious dragline in excavating a series of experimental trenches on Lake Torrens. The excavations are to be used in conjunction with pumping equipment to determine the feasibility of producing large quantities of brine from near-surface sediments.

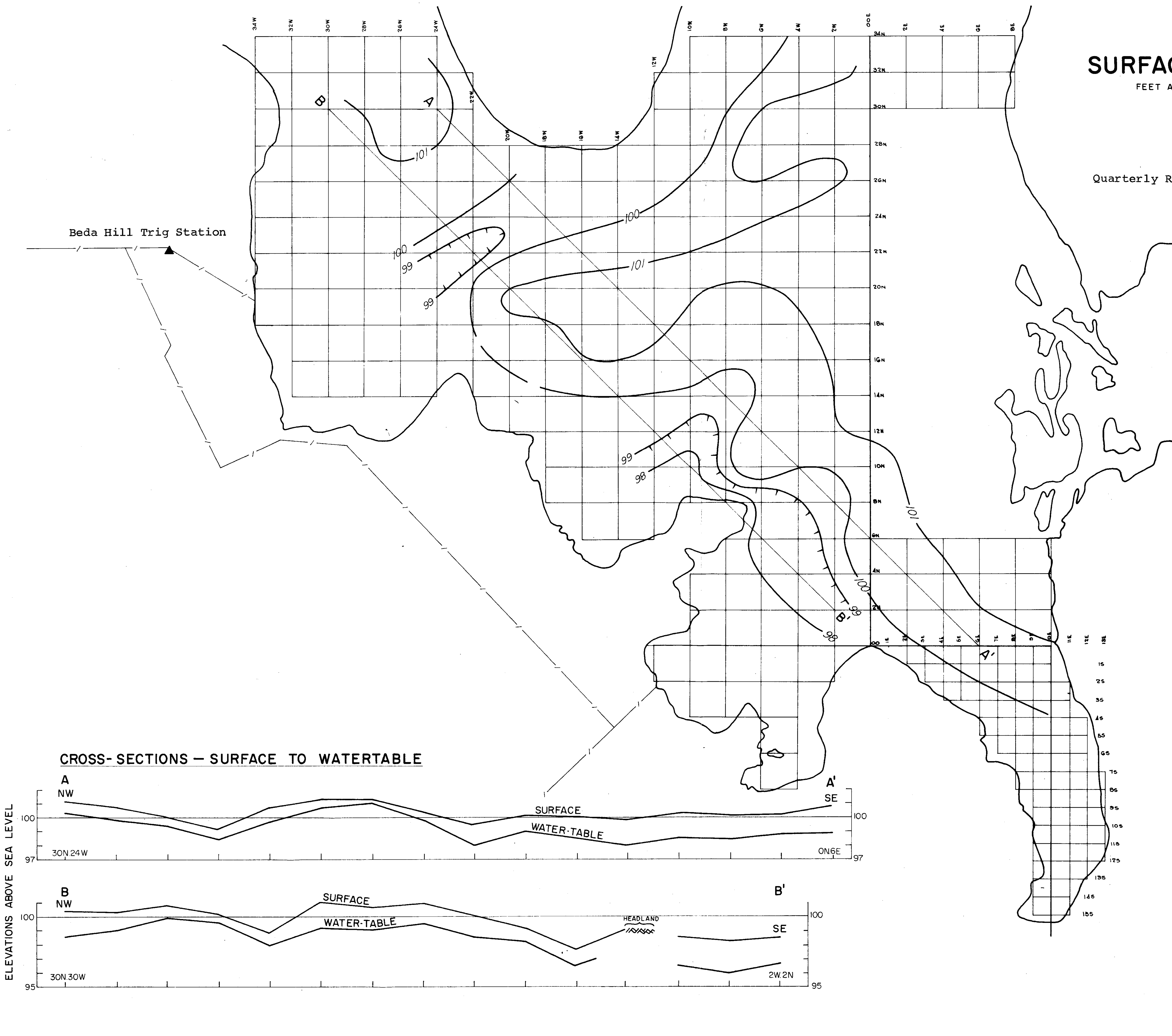
Exploration Licence 60

Quarterly Report April 1, to June 30, 1973

Figure 1.

2299(1)-1

SCALE 1" : 60CHNS.



SURFACE ELEVATION

FEET ABOVE SEA LEVEL

Exploration Licence 60

Quarterly Report April 1, to June 30, 1973

Figure 2.

2299(1)-2

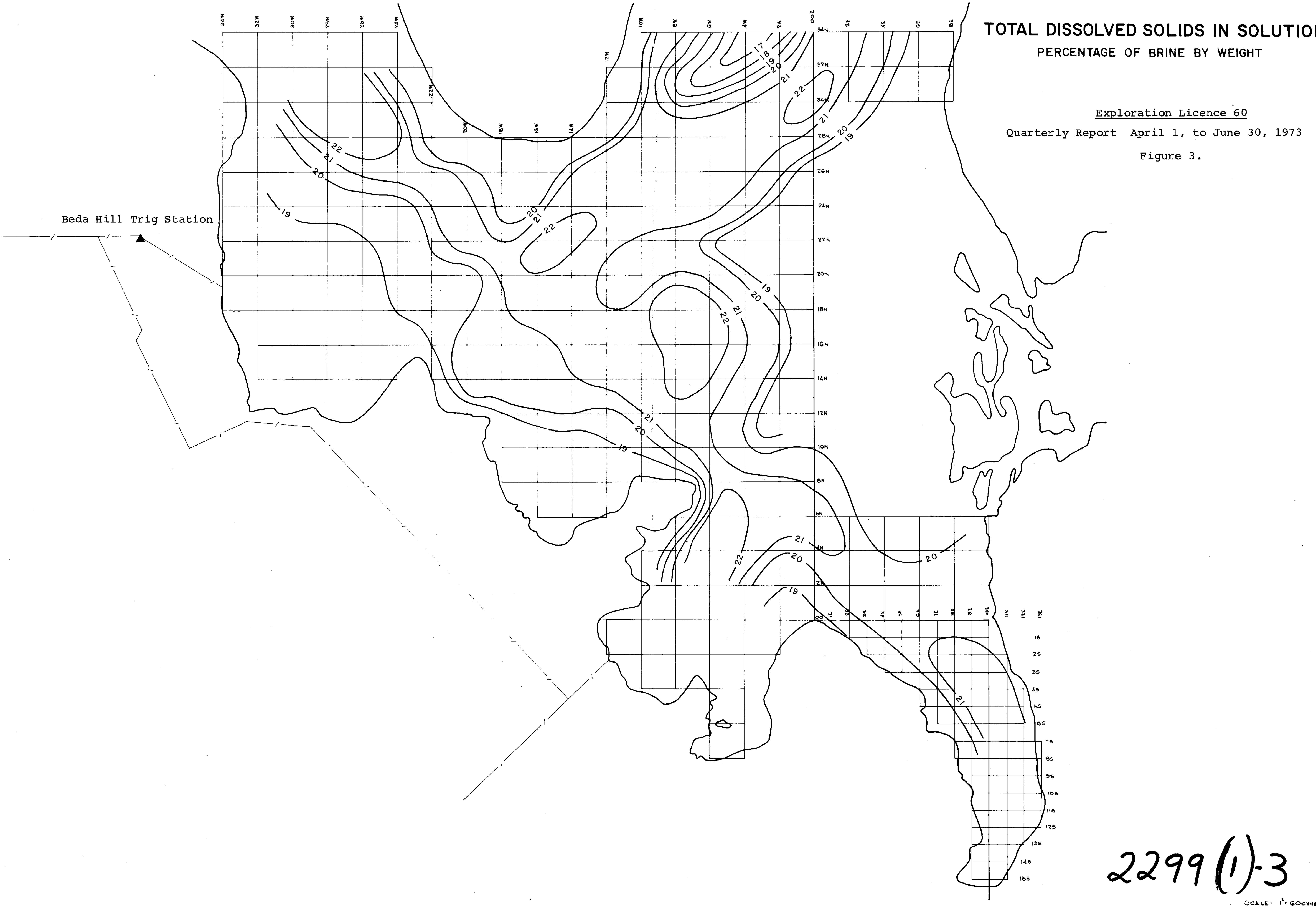
TOTAL DISSOLVED SOLIDS IN SOLUTION

PERCENTAGE OF BRINE BY WEIGHT

Exploration Licence 60

Quarterly Report April 1, to June 30, 1973

Figure 3.



QUARTERLY REPORT

EXPLORATION LICENCE 60

for period

July 1, 1973 to September 30, 1973

EXPLORATION LICENCE 60

Summary of Activities July 1, 1973 to September 30, 1973

During the quarter ending September 30, 1973 Delhi International Oil Corporation continued to explore and evaluate the southern part of Lake Torrens as a source of NaCl brine for the Redcliffs Petrochemical Project.

The programme to date includes the establishment of a field camp, weather station, fuel supply and maintenance depot, purchase of vehicles and special equipment. The area has been surveyed, sampled, five trenches constructed, and observation wells have been drilled and cased. Pump tests are now in progress.

Camp

A three caravan camp with lighting and power facilities was established between the southern extremity of Lake Torrens and Soakage Swamp on Yadlamalka Station. A 16-mile dirt track was graded from Yadlamalka Homestead to the Lake and Camp, and a further 10-mile track was graded from the Camp to the Maintenance and Fuel Area on Lake Torrens.

Weather Station

A complete weather station containing sufficient equipment to record wind, precipitation, evaporation, hours and intensity of sunshine, wet and dry minimum-maximum temperatures, was established with the assistance of the Department of Meteorology. Daily measurements are recorded and forwarded to the Department of Meteorology each month.

Vehicles and Heavy Equipment

Field vehicles consisting of one International 4-wheel drive 1½ ton truck, one Toyota 4 wheel drive Landcruiser, one Toyota 1½ ton truck and six Honda ATC-90 motor-cycles are assigned to the programme.

A 5/8 yard amphibious dragline was imported on July 24 and construction of exploration pits and production-type trenches was commenced on August 4. Three centrifugal pumps of 2000, 400 and 50 g.p.m. capacity were also received and assigned to the programme in August.

Exploration

The survey and 2,000 ft grid system was extended northwards to line 48N (48,000 ft north of basepoint 00N 00W) and now covers an irregular area with maximum dimensions of 62,000 ft NS by 50,000 ft EW. Detailed levelling was also continued; Fig. 2 of the previous Quarterly Report has been revised and is attached hereto.

The dragline was employed on a 20 hours per day, 7 day week whenever weather conditions and maintenance requirements permitted. An initial 1000 ft trench (T-1) was constructed near the Maintenance Depot to assist in control of surface floodwater and to evaluate the stratigraphic section. A series of 20 ft long x 17 ft wide x 12 ft deep pits were subsequently developed over a large part of the Lake surface in order to confirm reconnaissance data.

A second trench (T-2) was constructed beginning near grid coordinates 16N 14W and extending 2000 ft north-west. This area had previously been recognised as one in which the watertable is relatively high. The stratigraphic section at T-2 consists of 5-7 feet of arenaceous, gypsiferous brown clay underlain by dense blue clay. Some 65,000 cubic feet of brine had seeped into T-2 before heavy rain caused surface flooding in the area.

Following completion of T-2 the dragline was moved to grid coordinates 27N 10.250W where a 1250 ft long x 17 ft wide x 9 ft deep trench (T-3) was constructed. The stratigraphic section at T-3 consists of:

Clay 1	2 ft	Clay, brown, arenacous
Sand A	1 ft	Sand, buff-brown, coarse, well rounded, some gypsum crystals.
Clay 2	1½-3ft	Clay, blue, dense.
Sand B	2 ft	Sand, grey, coarse, well-rounded.
	1 ft+	Clay, brown silty.

This section is typical, with variations in respective thicknesses, of an area now known to extend from 26N to 38N and 00W to 10W. The northern limits of Sands A and B have not yet been defined. Analyses of the sands indicate an NaCl reserve of approximately 100 long tons per acre foot. NaCl content of the clays is some 178 long tons per acre foot (see appended data sheets). High-density brine flows occur from Clay 1 and Sands A and B. Brine from the lower sand appears to be under pressure and small springs and gas flows have been observed in T-3 and in exploration pits to the north-east. X

In order to correlate and evaluate the effects of length of trench on brine flow, a short 120 ft excavation (T-4A) was constructed at coordinates 28.250N 9W. This section was paralleled by a 2500 ft x 17 ft x 12 ft trench (T-4B) which extends eastward from coordinates 28.100N 10W. T-4A exposed a water-table at 18 inches below ground level. A pump test was conducted on September 11, 1973 and full recharge was observed on September 22, 1973. Following completion of T-4B the waterlevel in T-4A fell 6 inches; this reaction is considered to be indicative of the continuity of one or more permeable sedimentary units. Detailed drawdown and recharge rates are contained in the accompanying data sheets.

Observation wells have been installed around T-3 and T-4B and are now monitored daily.

Expenditures

Delhi International Oil Corporation has exceeded the guaranteed minimum $57,000 expenditure as follows:

Expenditures to Date

Salaries, wages & associated costs	$ 25,700-18
Employee expenses	435-40
Consultation:-	
Dodd	6,678-54
McPhar	1,203-30
Office Expenses	861-41
Delhi vehicle allocation	190-60
Equipment rental (caravans)	1,210-00
Transport:-	
Road	549-76
Air	637-89
Taxes etc.	4-00
Sundry	2-59
Accomodation	6,334-40
Dragline and spares	18,084-60
Field vehicles	23,695-75
Communication	294-20
Pumps, engine & pipe	766-00
Miscellaneous equipment	3,155-41
Equipment rental (instruments)	219-20
Dragline Operation:-	
Labour	498-50
Fuel	1,489-86
Repairs	1,027-70
Expenditure to September 30, 1973	$ 93,039-19

Future Programme

It is proposed to employ the amphibious dragline in excavating a further series of test pits spaced at 2,000 foot intervals along lines 38N, 42N and 48N. If productive sands are present a series of 2,500 foot long east-west trenches will be constructed.

Observation wells will be established and pump tests will be repeated at all productive trenches as soon as practicable after initial stabilisation or replenishment of the brine occurs.

Trench 4A Pump Test 1

Location: 28.250 N 10 W extending 120' to east

Dimensions:

Above W.L.	120' x 17' x .67 ft	1,367 cubic feet
Upper	120' x 17' x 1.30 ft	2,652 cubic feet
Middle	104' x 12.25' x .83 ft	1,057 cubic feet
Lower	104' x 7.5' x 1.05 ft	819 cubic feet
Slough	104' x 7.5' x 3.37 ft	2,629 cubic feet
	Total Volume est.	8,524 cubic feet
	Total Volume wet est.	4,528 cubic feet

Drawdown rate:

Depth (inches from surface)	Time (11/9/73)	°Be
16	0950 hrs	19.5
18	1030	
22	1130	
27	1230	
31	1330	
36	1430	
39.5	1530	
42.5	1630	
49	1730	20
55	1830	
55.5	1835	20
∴ 39.5	∴ 8.45	

Brine pumped:

4,528 cubic feet estimated from volumes
4,618 cubic feet estimated from pump rate

Quality: 20° Be (S.G. 1.159, or 72.21 lbs/ft^3)

Trench 4A Pump Test 1

Recharge Rate:

Day	Depth inches from surface	Inches x ft3/inch	Volume ft3 brine	Volume cumulative
11.9.73	55.5			
12.9.73	51.0	4.5 x 65	292	292
13.9.73	48.0	3 x 65	195	487
14.9.73	41.5	5 x 65 +		
		1.5 x 106	484	971
15.9.73	34.75	6.75 x 106	716	1687
16.9.73	31.5	1.75 x 106 +		
		1.5 x 170	441	2128
17.9.73	29.25	2.25 x 170	382	2510
18.9.73	26.5	2.75 x 170	468	2978
19.9.73	23.25	3.25 x 170	552	3530
20.9.73	21.25	2.00 x 170	340	3870
21.9.73	20.25	1.00 x 170	170	4040
22.9.73	17.75	3.00 x 170	510	4550

McPHAR GEOPHYSICS PTY. LTD.
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POSTAL ADDRESS: P.O. BOX 42, UNLEY, SOUTH AUSTRALIA 5061
CABLE "PHARGEO" ADELAIDE
TELEX "PHARGEO" AA82623

MINERALOGICAL REPORT NO. 1317

by: I.R. Pontifex — 29th August, 1973.

TO:
Mr. R. R. French,
General Manager,
Delhi Minerals Ltd.,
33 King William Street,
ADELAIDE. S.A. 5000

YOUR REFERENCE: Phone communication 27/8/73.

MATERIAL: Wet sediment samples from Lake Torrens.

IDENTIFICATION: A and B.

WORK REQUESTED: Sieve analysis, quantitative and semi-qualitative determination of various sand, silt and clay fractions. Chemical analysis of NaCl content in the water in the samples.

SAMPLES & SECTIONS: Retained at McPhar.

McPHAR GEOPHYSICS PTY. LTD.

I.R. PONTIFEX
Chief Mineralogist.

SIEVE ANALYSIS:

For the sieve analysis, the sands were wet-sieved through a bank of sieves designed to remove coarse, medium and fine sand sizes. The remaining silt and clay fraction was more-or-less arbitrarily separated in water-the silt fraction being $<$240 mesh and settling after 1 hour in the water, the clay fraction being the solids which remain in suspension.

The resultant weight percent of each of these fractions is given below.

The volume percent for each fraction was determined by measuring its displacement of water in an accurately graduated flask. These figures are given alongside the weight percents.

It is noted that these figures refer only to the "solids" in the sediment and make no reference to the salt water contained in the samples submitted.

		Sample A		Sample B	
mesh size	(microns)	Wt.%	Vol.%	Wt.%	Vol.%
+ 30	(+ 500)	7.83	8.24	19.68	19.47
- 30 + 60	(- 500 + 250)	29.91	30.34	49.35	48.88
- 60 + 120	(- 250 + 125)	32.49	32.42	15.45	15.41
- 120 + 240	(- 125 + 63)	13.88	13.74	1.46	1.22
- 240 (silt)	(- 63)	9.03	8.24	11.14	11.16
- 240 (clay)	(- 63)	6.86	7.02	2.92	3.85

100.00%

MINERALOGICAL COMPOSITION:

Each fraction was investigated under a binocular microscope and/or petrological microscope and an estimate of volume percent of each component in each fraction above siltsize was determined. The abundance of components in the clay fraction was determined by X-ray powder diffraction. The results are as follows:

Sample A:	quartz	white gypsum	clear gypsum	iron oxide grains
+ 30	50	30	20	trace
- 30 + 60	45	30	25	trace
- 60 + 120	50-60	15	25-35	trace
- 120 + 240	50-60	15	25-35	trace
- 240 (silt)	too fine for optical mineralogy			
- 240 (clay)	60% illite, 23% kaolin, 17% quartz, trace calcite.			

Comments:

The gypsum in the + 30 mesh fraction of sample A occurs as crystals of two types, (1) swallow-tail type twinned crystals (orthopinacoid): (2) arrow-head type twinned crystals (hemi-ortho dome as twin plane).

These may be clear-transluscent or clouded by extremely fine white material which.appears to be an earthy to finely fibrous gypsum variety.

The quartz grains are clear or stained by iron-oxide dust. Almost invariably they have a rounded to well rounded form.

The trace iron oxide grains are subangular (lateritic type fragments) to well rounded and polished Fe-Si pellets.

The character of the grains in the finer fractions of Sample A is essentially the same as for the + 30 mesh fraction, with the exception that the quartz grains are slightly less rounded.

Sample B:

The components in all fractions greater than silt size in sample B, consist essentially of quartz grains. An estimated maximum of 3% impurities in each sample includes iron oxide grains, organic fragments, ? calcite, and ? felspar grains. The gypsum seen in sample A is essentially absent.

The grains in each fraction are rounded to well rounded and in the coarsest fraction many are very well rounded. They are variably stained by a very thin coating of iron oxides.

An X-ray powder diffraction determination of the sample B clay indicates:

15% quartz, 65% illite, 20% kaolin.

CHEMICAL ANALYSIS

The amount of NaCl per unit volume was computed from chemical analysis of the filtrate after the sample was suction filtered and from measurements of S.G. and moisture content of the samples as submitted.

These figures are:

	A	B
S.G. of sample as submitted	2.07	2.14
S.G. of liquor	1.13	1.12
NaCl liquor	17.37% wt/wt	16.13% wt/wt
moisture content	18.59 wt%	15.13 wt%
total dissolved solids	18.48 wt/wt	17.22% wt/wt
NaCl tons/acre ft.	99.5	76.6

For sample A, a further equivalent of 51.6 tons/acre ft. was extracted by a single repulp wash of the residue from the first filtration.

For sample B, a further equivalent of 54.1 tons/acre ft. was extracted by a single repulp wash of the residue from the first filtration.

X/c 5 022

AMDEL
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TELEX: "PHARGEO"
AA82623

ASSAYS

Samples from: DELHI MINERALS LTD.
Area:
Samples of: WATERS
Preparation:
Batch No.: CH 5166

Sheet No.: 1
Date: 28.9.73

SAMPLES DISPOSED OF AFTER TWO MONTHS UNLESS WE ARE OTHERWISE ADVISED

Sample Description	K, ppm	Ca, ppm	Mg, ppm	SO_4, ppm	Cl %	T.D.S %	Alkalini as CaCO ppm
RECHARGE 1 DAY T4A	165	1895	1655	4420	12.44	20.69	10

	pH	S.G.
T4A	5.3	1.147

	NaCl %	KCl ppm	$MgCl_2$ ppm	$CaCl_2$ ppm	$CaSO_4$ ppm
		PROBABLE		SALT	ASSEMBLY
T4A	19.66	315	6530	138	6260

N.B. All concentrations on a weight for weight basis.

ANALYTICAL METHODS: K, Ca, Mg by AAS. SO_4, T.D.S. by Gravimetry. Cl by Titrimetry.

DISTRIBUTION: Delhi Minerals Ltd.

☆39930

Signed: [signature]

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New: 272.2133.

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"PHARGEO" ADELAIDE
TELEX
"PHARGEO" AA82623

SAMPLES FROM: DELHI MINERALS
SAMPLES OF: SANDS
BATCH NO: CH 5166

SHEET NO: 2
DATE : 28.9.73

SANDS C AND D.

Samples as received:

		Moisture Content	S.G.	Total Chloride as NaCl
anch 4A				
pr Sd	C. –	16.46% w/w	2.19	4.01% w/w
ws Sd	D.	14.65% w/w	2.09	3.64% w/w

The samples were then suction filtered and moisture content and total chloride (expressed as NaCl) measured. The filtrate volume was insufficient for analysis. However by assuming that the liquor in the samples as received is similar in composition to the filtrate, the composition of the filtrate was calculated. It was also assumed that the proportion of NaCl in the total dissolved salts was similar to that in the initial samples A and B previously submitted; i.e. NaCl is approximately 93.9% of dissolved salts.

Samples after Suction Filtration:

	Moisture Content	Chloride as NaCl
C.	11.16% w/w	2.72% w/w
D.	12.72% w/w	3.10% w/w

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SAMPLES FROM: DELHI MINERALS
SAMPLES OF: SANDS
BATCH NO: CH 5166

SHEET NO: 3
DATE : 28.9.73

From this basic data the probable makeup of the sand and filtrate per acre foot is as follows:

Sand C.

	Sand as Received	Filtrate
H_2O	436.9	163.8
NaCl	106.4	39.8
Other Salts	6.9	2.7
Insolubles	2104.2	
[illegible]	2654.4 tons	206.3 tons
Bulk density	136.5 lbs/cu.ft.	NaCl in filtrate 19.3% w/w.

Sand D.

	Sand as received	Filtrate
H_2O	371.2	58.5
NaCl	92.2	16.0
Other Salts	6.1	1.3
Insolubles	2064.4	
	2533.9 tons	75.8 tons
Bulk density	130.3 lbs/cu.ft.	NaCl in filtrate 21.1% w/w

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SAMPLES FROM: DELHI MINERALS
SAMPLES OF: CLAYS
BATCH NO: CH 5166

SHEET NO: 4
DATE : 28.9.73

CLAYS

Samples as Received

	Moisture % w/w	Total Chloride as NaCl	S.G.
Clay 1.	25.94	7.03 % w/w	1.99
2.	24.71	5.68 % w/w	2.02
3.	31.00	7.10 % w/w	1.76

From this data the following was calculated.

	NaCl tons/acre ft.	Bulk density lbs/cu.ft
Clay 1.	169.7	124.1
2.	139.1	125.9
3.	151.5	109.7

The samples were then suction filtered, and the moisture content measured.

	Moisture % w/w
Clay 1.	26.75
2.	20.79
3.	29.35

The moisture content for Clay 1 after filtration is higher than for the as received sample. However as relatively small samples were used, this could be due to lack of homogeneity in the samples.

NATA

M G Emmett

1973 AUG 14 AM 9:50

MINERAL ASSAYS

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NATA

Samples from: DELHI MINERALS LTD.
Area:
Samples of: WATERS
Preparation:
Batch No.: CH 4970

Sheet No. 1
Date: 13.8.73

SAMPLES DISPOSED OF AFTER TWO MONTHS UNLESS WE ARE OTHERWISE ADVISED

Sample Description		pH	S.G.	K, ppm	Mg, ppm	Ca, ppm	Alkalinity as $CaCO_3$ ppm	SO_4 ppm	Cl %	T.D.S. %
2N	4E	7.03	1.156	130	1680	2060	18	3820	11.98	20.58
2N	2W	7.13	1.143	170	1680	2070	21	4430	11.11	19.11
4N	8E	7.18	1.157	160	2450	1730	20	5040	12.22	20.65
4N	2E	7.20	1.156	160	1610	2110	16	3810	12.21	20.86
4N	4W	7.03	1.169	170	1930	1740	20	4800	12.96	21.94
6N	6E	7.26	1.151	120	2610	2090	18	3960	11.81	19.87
6N	6W	7.12	1.173	190	2290	1710	20	4670	13.21	22.61
8N	2W	7.28	1.160	160	1710	2070	21	3850	12.70	21.26
14N	2W	7.31	1.143	160	1340	2100	18	3640	11.04	18.90
16N	4W	7.24	1.159	180	1830	2000	17	3930	12.39	21.01
20N	2W	7.35	1.131	110	1410	2530	21	3270	10.27	17.49
22N	4W	7.48	1.120	130	1400	2380	36	3760	9.56	16.20
34N	8E	7.64	1.120	130	2110	1190	36	5430	9.38	16.31
34N	2E	7.83	1.159	90	2040	2040	29	3700	12.58	21.26

PROBABLE SALT ASSEMBLY

Sample	$CaCO_3$ ppm	$CaSO_4$ ppm	$CaCl_2$ ppm	$MgSO_4$ ppm	$MgCl_2$ ppm	KCl ppm	NaCl %
2N 4E	18	5410	1280		6590	250	18.78
2N 2W	21	6280	600		6590	320	17.41
4N 8E	20	5880		1120	8720	310	19.04
4N 2E	16	5400	1430		6310	310	19.17
4N 4W	20	5890		810	6930	320	20.48
6N 6E	18	5610	1200		10240	230	18.06
6N 6W	20	5790		730	8400	360	20.71
8N 2W	21	5460	1270		6710	310	19.95
14N 2W	18	5160	1600		5260	310	17.36
16N 4W	17	5570	980		7180	340	19.41
20N 2W	21	4630	3210		5530	210	15.89
22N 4W	36	5330	2210		5490	250	14.83
34N 8E	36	4000		3270	5690	250	14.74
34N 2E	29	5240	1350		8000	170	19.59

Results expressed on a weight for weight basis.

ANALYTICAL METHODS: T.D.S., SO_4 by Gravimetry
K, Ca Mg by AAS.
Cl, Alkalinity by Titration.

DISTRIBUTION: 2 copies Delhi Minerals Ltd.

Signed:

XC/2027

ASSAYS

MPHAR

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TELEX: "PHARGEO" AA82623

NATA

Samples from: DELHI MINERALS LTD 1973 AUG 7 AM 9:29
Area:
Samples of: WATERS
Preparation:
Batch No.: CH 4970

Sheet No.: 1
Date: 6.8.73

SAMPLES DISPOSED OF AFTER TWO MONTHS UNLESS WE ARE OTHERWISE ADVISED

Sample Description	pH	S.G.	K, ppm	Mg, ppm	Ca, ppm	Alkalinity as $CaCO_3$ ppm	SO_4 ppm	Cl %	T.D.S.%
2S 6E	7.07	1.155	150	1600	1680	14	4240	12.03	20.65
2S 10E	7.18	1.160	180	2200	1400	22	5290	12.18	21.12
4S 8E	7.04	1.159	170	1790	1600	19	4790	12.46	21.20
OON 6E	7.07	1.153	120	1590	1840	14	4240	12.31	20.26
1ON 4W	7.18	1.154	170	1600	1800	23	4190	11.94	20.40
1ON 10W	7.19	1.144	160	1530	1590	39	4550	11.43	19.26
1ON 16W	7.26	1.137	180	1510	1740	23	5110	10.73	18.21
12N 6W	7.08	1.158	210	1920	1640	17	4600	12.43	20.98
12N 12W	7.29	1.144	170	1630	1800	28	4770	11.28	19.51
14N 8W	7.26	1.172	140	1880	1460	33	4270	13.14	22.46
14N 20W	7.13	1.159	180	1730	1500	22	5240	12.35	20.82
16N 10W	7.22	1.161	170	1960	1640	24	4670	12.61	21.41
18N 6W	7.13	1.171	150	1900	1490	28	3750	13.76	22.71
20N 8W	7.26	1.161	160	1880	1560	25	4520	12.73	21.70
22N 10W	7.20	1.154	160	2120	1580	35	4840	11.93	20.60
24N 6W	7.12	1.161	170	1760	1640	28	3370	12.87	21.65
30N 30W	7.21	1.172	160	2700	1250	20	5500	13.30	22.84
P12 9-7-73	7.42	1.160	140	1940	1520	45	5950	12.47	21.28

PROBABLE SALT ASSEMBLY

	$CaCO_3$ ppm	$CaSO_4$ ppm	$CaCl_2$ ppm	$MgSO_4$ ppm	$MgCl_2$ ppm	KCl ppm	NaCl %
2S 6E	14	5690		280	6060	290	19.06
2S 10E	22	4730		2450	6690	340	19.22
4S 8E	19	5410		1210	6060	320	19.76
OON 6E	14	6010	180		6240	230	19.48
1ON 4W	23	5940	120		6280	320	18.87
1ON 10W	39	5352		970	5240	310	18.17
1ON 16W	23	5890		1200	4970	340	17.05
12N 6W	17	5570		840	6860	400	19.61
12N 12W	28	6080		600	5920	320	17.84
14N 8W	33	4920		1000	6580	270	20.83
14N 20W	22	5070		2080	5140	340	19.70
16N 10W	24	5540		950	6930	320	19.90
18N 6W	28	5030		250	7250	290	21.76
20N 8W	25	5270		1000	6580	310	20.15
22N 10W	35	5320		1360	7240	310	18.75
24N 6W	28	4780	620		6900	320	20.27
30N 30W	20	4220		3160	8090	310	20.90
P12 9-7-73	45	5110		2940	5280	270	19.88

Results expressed on a weight for weight basis.

ANALYTICAL METHODS: T.D.S., SO_4 by Gravimetry
K, Ca, Mg by AAS.
Cl, Alkalinity by titration.

DISTRIBUTION: Delhi Minerals Ltd.

Signed: W.J. Emmett

*39930

I. 9/2 028 RR

MEPHAR 3 AUG 1 AM 9:38

ASSAYS

50-52 MARY STREET
UNLEY, S.A. 5061
PHONE: 72 2133
CABLE: "PHARGEO"
ADELAIDE
TELEX: "PHARGEO"
AA82623

NATA

Samples from: DELHI MINERALS
Area:
Samples of: WATERS
Preparation:
Batch No.: CH 4970

Sheet No.: 1
Date: 31.7.73

SAMPLES DISPOSED OF AFTER TWO MONTHS UNLESS WE ARE OTHERWISE ADVISED

Sample Description		pH	S.G.	K, ppm	Mg, ppm	Ca, ppm	Alkalinity as $CaCO_3$ ppm	SO_4 ppm	Cl %	T.D.S. %
18N	18W	7.20	1.158	170	2090	1590	39	4950	12.28	20.88
18N	24W	7.18	1.143	190	1610	1860	17	4700	11.16	19.00
20N	20W	7.12	1.144	190	1630	1820	17	4700	11.10	10.16
22N	16W	7.10	1.168	180	2070	1480	32	4760	13.04	22.36
22N	22W	7.14	1.157	180	1870	1500	21	5190	12.16	20.92
24N	12W	7.09	1.164	170	1920	1560	27	4720	12.76	21.73
24N	18W	7.19	1.142	170	1580	1720	20	5000	11.09	19.00
24N	24W	7.28	1.147	190	1730	1710	22	4710	11.38	19.45
24N	30W	7.20	1.146	220	1888	1690	17	4890	11.37	19.40
26N	26W	7.18	1.159	170	2170	1600	22	4990	12.29	21.09
28N	28W	7.10	1.170	170	2510	1330	26	5480	13.15	22.40
30N	24W	7.14	1.151	180	1980	1700	200	4920	11.65	20.18

PROBABLE SALT ASSEMBLY

Sample	$CaCO_3$ ppm	$CaSO_4$ ppm	$MgSO_4$ ppm	$MgCl_2$ ppm	KCl ppm	NaCl %
18N 18W	39	5350	1470	5030	320	19.35
18N 24W	17	6300	320	6060	360	17.62
20N 20W	17	6160	440	6050	360	17.52
22N 16W	32	4990	1550	6890	340	20.62
22N 22W	21	5070	2020	5740	340	19.31
24N 12W	27	5270	1260	6530	320	20.20
24N 18W	20	5820	1120	5310	320	17.60
24N 24W	22	5780	790	6160	360	17.97
24N 30W	17	5720	1070	6530	420	17.90
26N 26W	22	5410	1470	7350	320	19.33
28N 28W	26	4490	2900	7550	320	20.72
30N 24W	20	5750	1080	6910	340	18.32

Results expressed on a weight for weight basis.

ANALYTICAL METHODS: T.D.S., SO_4 by Gravimetry
Ca, Mg, K by AAS
Cl, $CaCO_3$ by Titration.

DISTRIBUTION: Delhi Minerals.

*39930

Signed: K Bewes

McPHAR

50-52 MARY STREET
UNLEY, S.A. 5061
PHONE: 72 2133
CABLE: "PHARGEO"
ADELAIDE
TELEX: "PHARGEO"
AA82623

GEOCHEMICAL RESULTS

Samples from: DELHI PETROLEUM LTD.
Area:
Samples of: WATERS
Batch No.: CH 4033

Sheet No.: 1
Date: 24/7/72

SAMPLES DISPOSED OF AFTER TWO MONTHS UNLESS WE ARE OTHERWISE ADVISED

	Sample Description	Cu, ppm	Zn, ppm	Mn, ppm	Cr, ppm	Ni, ppm	V, ppm	
	TH1	<0.01	<0.02	0.16	<0.01	<0.02	<0.02	
	T1	<0.01	<0.02	0.04	<0.01	<0.02	<0.02	
	T5	<0.01	<0.02	<0.02	<0.01	<0.02	<0.02	

ANALYTICAL METHODS: Cu, Zn, Mn, Ni, Cr by AAS following ~~xxx~~ hot HCl leach and HCl/HNO_3 leach in latter stages for 1 hour on 0.25 g sample.
V determined by colorimetr

PREPARATION: Nil

DISTRIBUTION: 2 copies to Delhi Petroleum.

Signed: K Seller

★37007

MEPHAR

ASSAYS

030

50-52 MARY STREET
UNLEY, S.A. 5061
PHONE: 72 2133
NATA
CABLE: "PHARGEO" ADELAIDE
TELEX: "PHARGEO" AA82623

Samples from: DELHI MINERALS LTD.
Area:
Samples of: WATERS
Preparation:
Batch No.: CH 4970

Sheet No.: 2
Date: 24.7.73

SAMPLES DISPOSED OF AFTER TWO MONTHS UNLESS WE ARE OTHERWISE ADVISED

Sample Description	pH	S.G.	K, ppm	Mg, ppm	Ca, ppm	Alkalinity as $CaCO_3$ ppm	SO_4 ppm	Cl %	T.D.S. %
14N 14W	7.23	1.160	190	1870	1660	37	4710	12.25	20.91
16N 16W	7.27	1.156	190	2020	1610	28	4860	11.98	20.49
18N 12W	7.19	1.160	170	2030	1620	29	4790	12.35	21.06
20N 14W	7.21	1.163	180	2130	1530	34	4940	12.25	21.31
20N 26W	7.07	1.141	190	1530	1810	18	4930	10.52	18.35
22N 28W	7.33	1.135	190	1500	1940	26	4890	10.05	17.81

PROBABLE SALT ASSEMBLY

	$CaCO_3$ ppm	$CaSO_4$ ppm	$MgSO_4$ ppm	$McCl_2$ ppm	KCl ppm	NaCl %	
14N 14W	37	5590	960	6580	360	19.35	92.58%
16N 16W	28	5440	1280	6910	360	18.87	92.09
18N 12W	29	5470	1170	7040	320	19.46	92.40
20N 14W	34	5150	1630	7060	340	19.29	90.52
20N 26W	18	6130	760	5400	360	16.65	90.74
22N 28W	26	6560	320	5630	360	15.84	88.94

Results expressed on a weight for weight basis.

ANALYTICAL METHODS: T.D.S., SO_4 by Gravimetry
K, Ca Mg by AAS.
Cl, Alkalinity by titration.

DISTRIBUTION: 2 copies Delhi Minerals

Signed: K Bewley

*99930

MIDBAR

ASSAYS

031

50-52 MARY STREET
UNLEY, S.A. 5061
PHONE: 72 2133
CABLE: "PHARGEO"
ADELAIDE
TELEX: "PHARGEO"
AA82623

NATA

Samples from: DELHI MINERALS LTD.
Area:
Samples of: WATERS
Preparation:
Batch No.: CH 4874 (REVISED)

Sheet No.: 1
Date: 19.7.73

SAMPLES DISPOSED OF AFTER TWO MONTHS UNLESS WE ARE OTHERWISE ADVISED

Sample Description	pH.	S.G.	T.D.S. %	K ppm	Mg ppm	Ca ppm	SO_4 ppm	Alkalinity as $CaCO_3$ ppm	Cl %
6N 00E	7.68	1.14	17.81	150	1180	2130	3980	32	10.35
12N 00E	7.75	1.15	19.27	130	1140	2140	3420	25	11.38
18N 00E	7.78	1.13	16.64	110	1240	2380	3660	35	9.77
24N 00E	7.62	1.14	18.54	110	1280	2340	3450	25	11.01
26N 14W	7.24	1.16	20.96	170	1740	1590	4840	29	12.09
26N 8W	7.24	1.17	21.60	170	1780	1720	3910	29	12.66
26N 20W	7.26	1.16	20.56	180	1930	1660	4390	27	12.09
28N 22W	7.26	1.15	19.83	180	1840	1680	4700	26	11.67
28N 4W	7.40	1.16	21.22	140	1780	1660	2960	39	12.52
28N 10W	7.36	1.17	21.56	160	1660	1560	4730	34	12.44
30N 6W	7.42	1.15	20.00	200	1540	1920	4010	24	11.68
30N 00E	7.45	1.17	22.65	100	1790	2220	3140	23	13.41
32N 2W	7.39	1.15	20.00	140	1410	1460	2160	55	11.86
32N 8W	7.57	1.15	19.22	170	1410	1790	4680	36	11.32
34N 4W	7.48	1.13	16.58	140	1300	2250	4340	31	9.66
34N 9W	7.34	1.17	21.24	130	2170	1260	4530	34	12.55

PROBABLE SALT ASSEMBLY

Sample	$CaCO_3$ ppm	$CaSO_4$ ppm	$CaCl_2$ ppm	$MgSO_4$ ppm	$MgCl_2$ ppm	KCl ppm	NaCl %
6N 00E	32	5640	1270	-	4630	290	16.33
12N 00E	25	4850	1950	-	4470	250	17.98
18N 00E	35	5190	2330	-	4860	210	15.24
24N 00E	25	4890	2470	-	5020	210	17.25
26N 14W	29	5370	-	1320	5780	320	19.19
26N 8W	29	5540	220	-	6980	320	19.96
26N 20W	27	5610	-	540	7140	340	19.02
28N 22W	26	5680	-	870	6530	340	18.40
28N 4W	39	4190	1140	-	6980	270	19.63
28N 10W	34	5260	-	1280	1010	310	20.35
30N 6W	24	5680	660	-	6040	380	18.41
30N 00E	23	4450	2500	-	7020	190	20.96
32N 2W	55	3060	1490	-	5530	270	18.69
32N 8W	36	6040	-	520	5110	320	18.00
34N 4W	31	6150	1190	-	5100	270	15.15
34N 9W	34	4236	-	1930	6980	250	19.81

All results expressed on a weight for weight basis.

ANALYTICAL METHODS: T.D.S. and SO_4 by Gravimetry
Ca Mg K by AAS. Cl and $CaCO_3$ by Titration.

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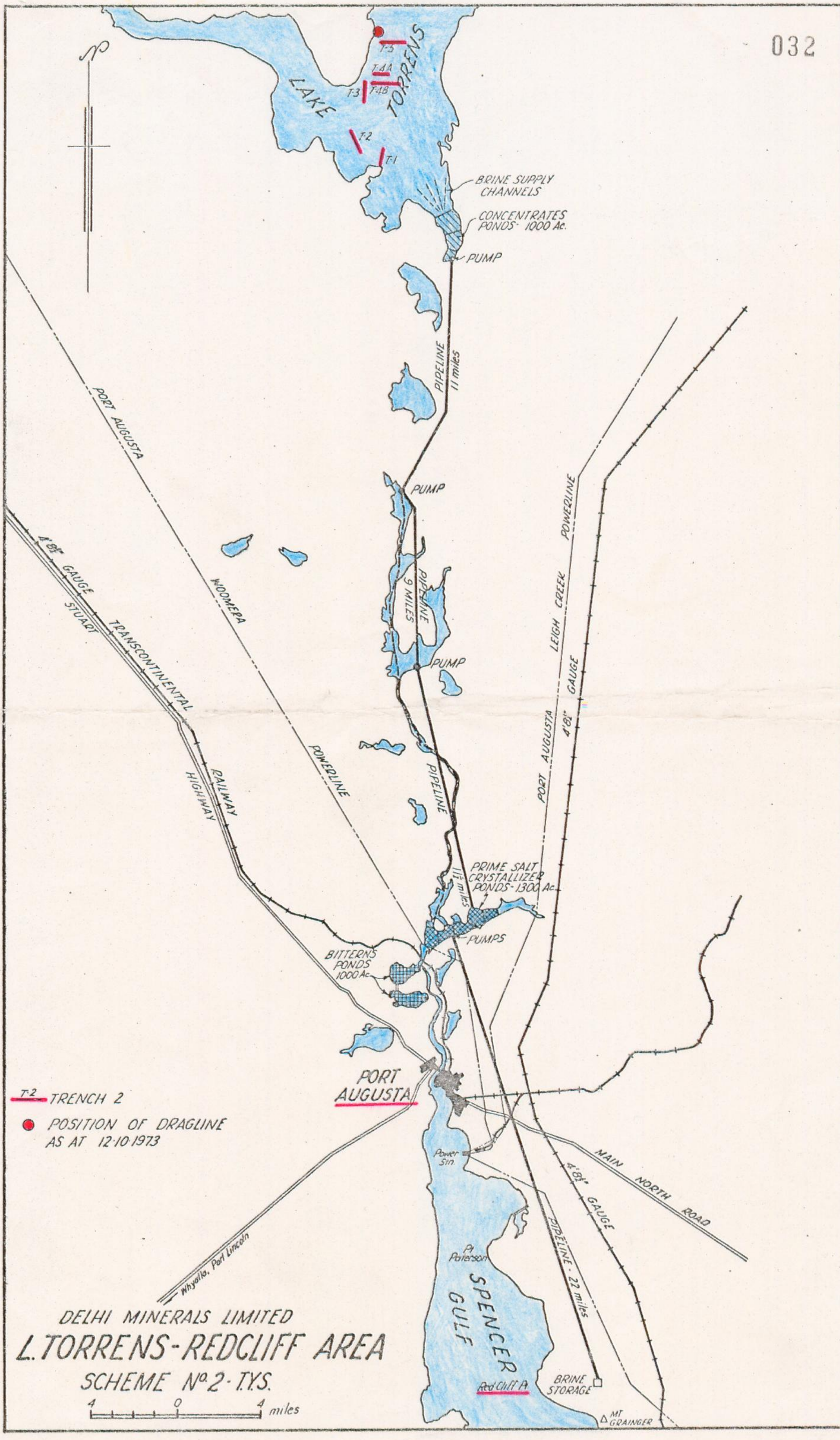
Signed: [signature]

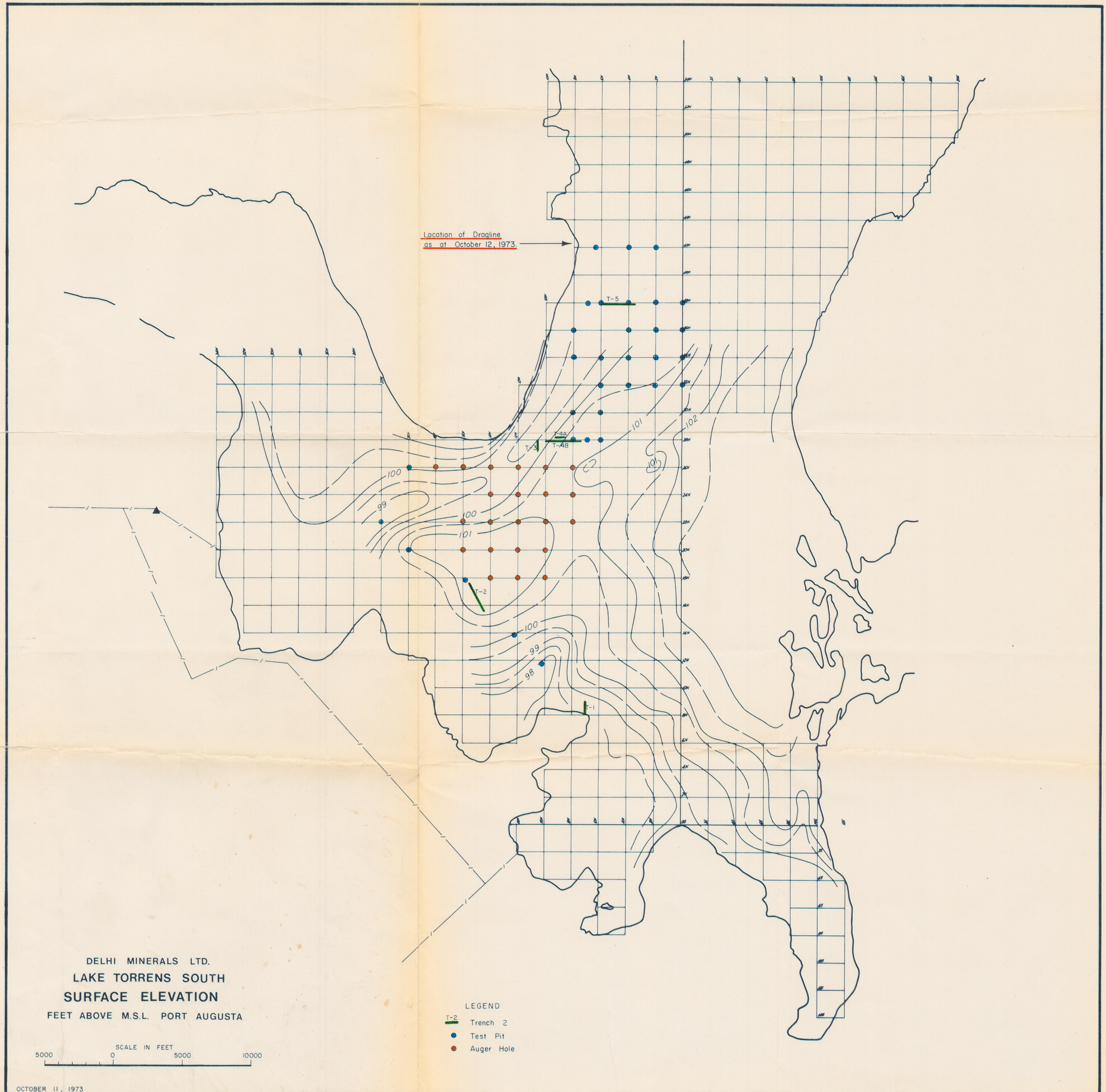
*39930



DELHI MINERALS LIMITED

L. TORRENS - REDCLIFF AREA

SCHEME No. 2 - T.Y.S.


Location of Dragline
as at October 12, 1973.
T-5
T-4A
T-4B
T-3
T-2
T-1
100
99
101
102
98
DELHI MINERALS LTD.
LAKE TORRENS SOUTH
SURFACE ELEVATION
FEET ABOVE M.S.L. PORT AUGUSTA
SCALE IN FEET
5000
0
5000
10000
LEGEND
T-2
Trench 2
Test Pit
Auger Hole
OCTOBER 11, 1973

2299(1)-4

QUARTERLY REPORT

EXPLORATION LICENCE 60

for period

October 1, 1973 to December 31, 1973

EXPLORATION LICENCE 60

Summary of Activities October 1, 1973 to December 31, 1973

During the quarter ending December 31, 1973 Delhi International Oil Corporation continued to explore and evaluate the southern part of Lake Torrens as a source of NaCl brine for the Redcliffs Petrochemical Project.

The programme to date includes the establishment of a field camp, weather station, fuel supply and maintenance depot, purchase of vehicles, pumps, dragline and special equipment. The area has been surveyed, sampled, ten trenches constructed, and observation wells have been drilled and cased. Eleven pump tests have been conducted and others are now in progress.

Camp

A three-caravan camp with lighting and power facilities was previously established between the southern extremity of Lake Torrens and Soakage Swamp on Yadlamalka Station. A 16-mile dirt track was graded from Yadlamalka Homestead to the Lake and Camp, and a further 10-mile track was graded from the Camp to the Maintenance and Fuel Area on Lake Torrens. A service and maintenance depot was established at the southern edge of Lake Torrens.

Weather Station

A complete weather station containing sufficient equipment to record wind, precipitation, evaporation, hours and intensity of sunshine, wet and dry minimum-maximum temperatures, was established with the assistance of the Department of Meteorology. Daily measurements are recorded and forwarded to the Department of Meteorology each month.

Vehicles and Heavy Equipment

Field vehicles consisting of one International 4-wheel drive 1½ ton truck, one Toyota 4 wheel drive Landcruiser, one Toyota 1½ ton truck and seven Honda ATC-90 motor-cycles are assigned to the programme.

A 5/8-yard amphibious dragline was imported on July 24 and construction of exploration pits and production-type trenches was commenced on August 4. Three centrifugal pumps of 2,000, 400 and 50 g.p.m. capacity were also received and assigned to the programme.

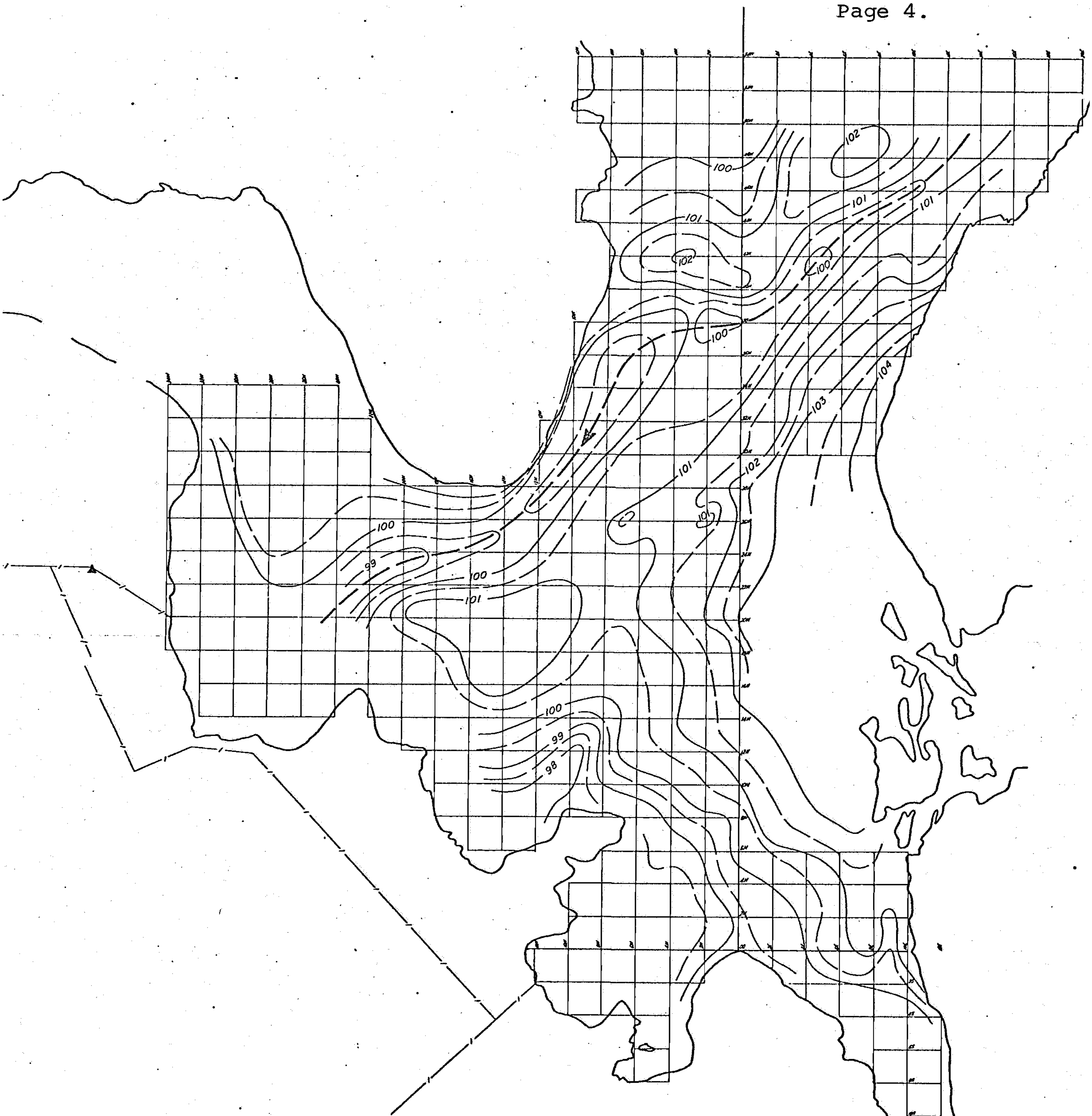
Exploration

The survey and 2,000 ft. grid system was extended northwards to line 48N (48,000 ft. north of basepoint 00N 00W) and now covers an irregular area with maximum dimensions of 62,000 ft. NS by 50,000 ft. EW. Detailed levelling was also continued; the revised surface contour map is appended hereto as Figure 1.

The dragline was employed on a 20 hours per day, 7 day week whenever weather conditions and maintenance requirements permitted.

Ten trenches, ranging from 1,000 to 2,500 feet long, were constructed prior to December 20; each trench was located in order to test a specific area or anomaly, and observation wells were drilled and cased around each trench. In addition, 87 test pits (17' wide x 20' long x 14' deep) were excavated with the dragline to evaluate the brine-delivery capability of various stratigraphic sections. Samples of a number of lithologic units were obtained and analysed; brine samples were analysed; and a cross-section was compiled from the resulting data. See Figures 2, 3, and 4.

Interpretation of the above data indicates that an elongated sand body exists in the foreset area of Willochra Creek delta, the sand diminishes westward into the sub-basin, but continues northward as discreet sand layers into the main Torrens basin, see Figures 4 and 5. These generalities describe only the upper 14 feet of sediment as excavated with the dragline.



Topography of Lake Torrens

(elevation in feet above sea-level)

Scale: Approx. 8,000' : 1"

Figure 1.

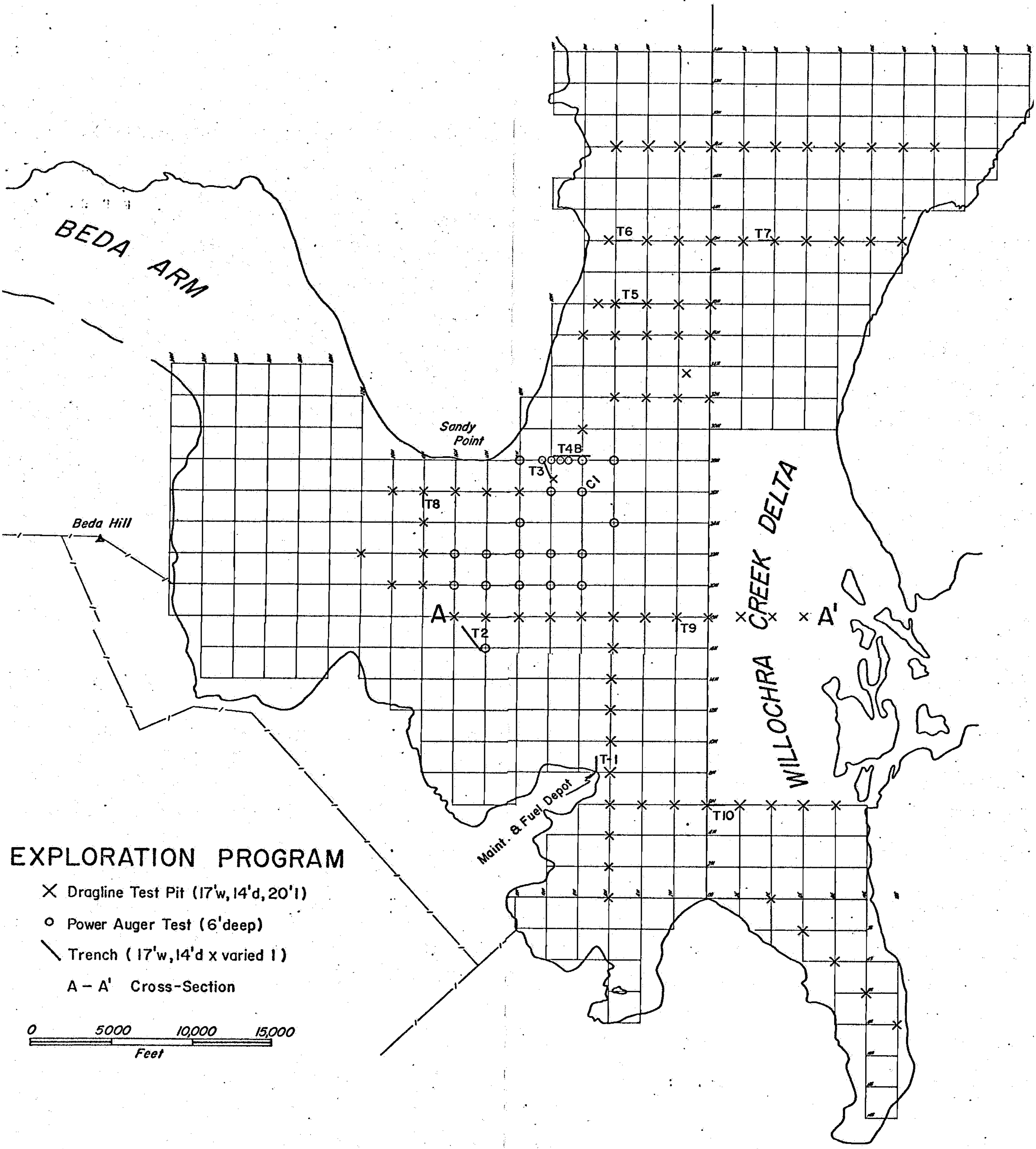

BEDA ARM
Beda Hill
Sandy Point
T4B
T3
C1
T8
T6
T7
T5
A
A'
T2
T9
T10
T-1
Maint. & Fuel Depot
WILLOCHRA CREEK DELTA
EXPLORATION PROGRAM
Dragline Test Pit (17'w, 14'd, 20'l)
Power Auger Test (6'deep)
Trench (17'w, 14'd x varied l)
A – A' Cross-Section
0
5000
10,000
15,000
Feet

Figure 2.

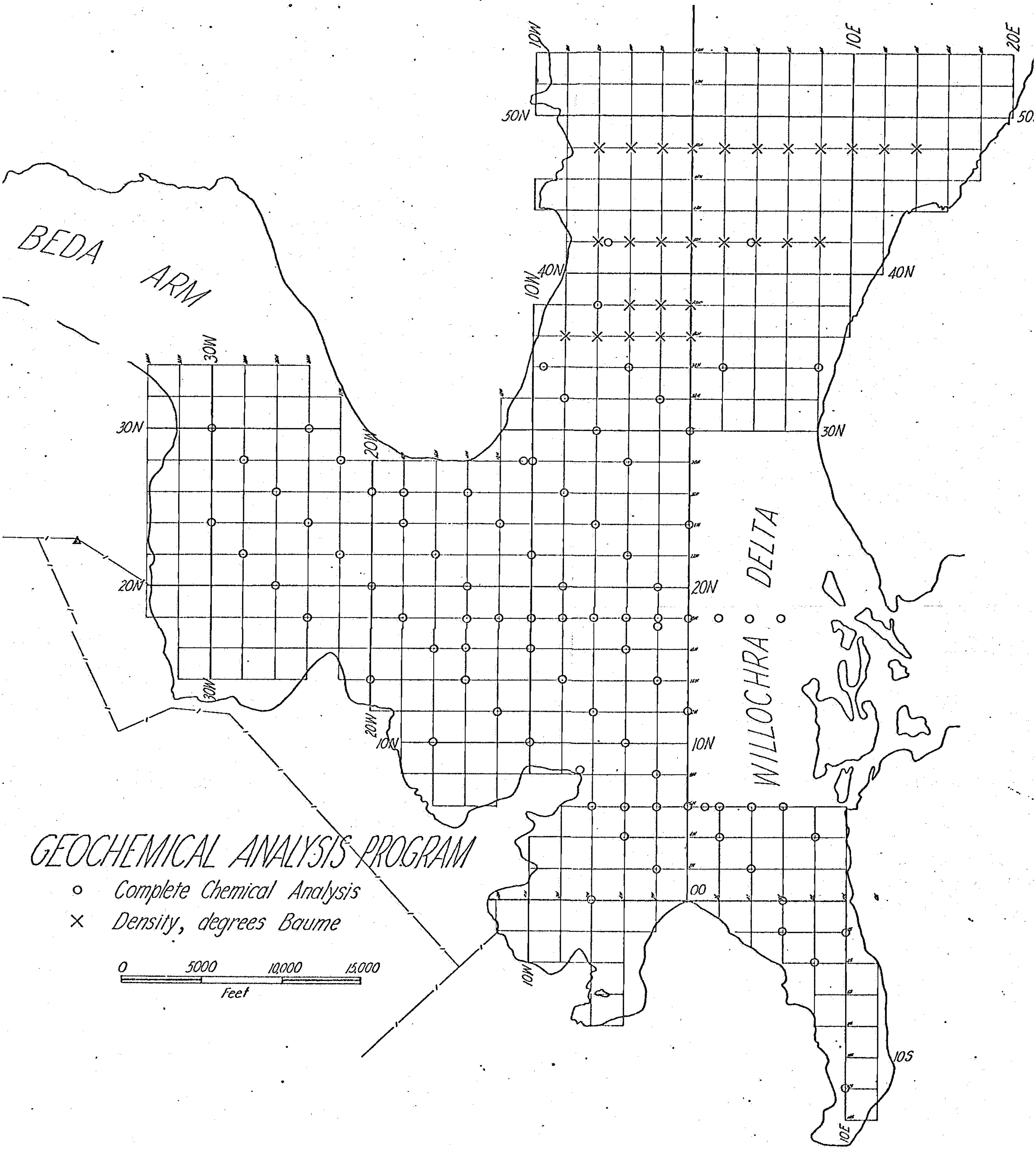
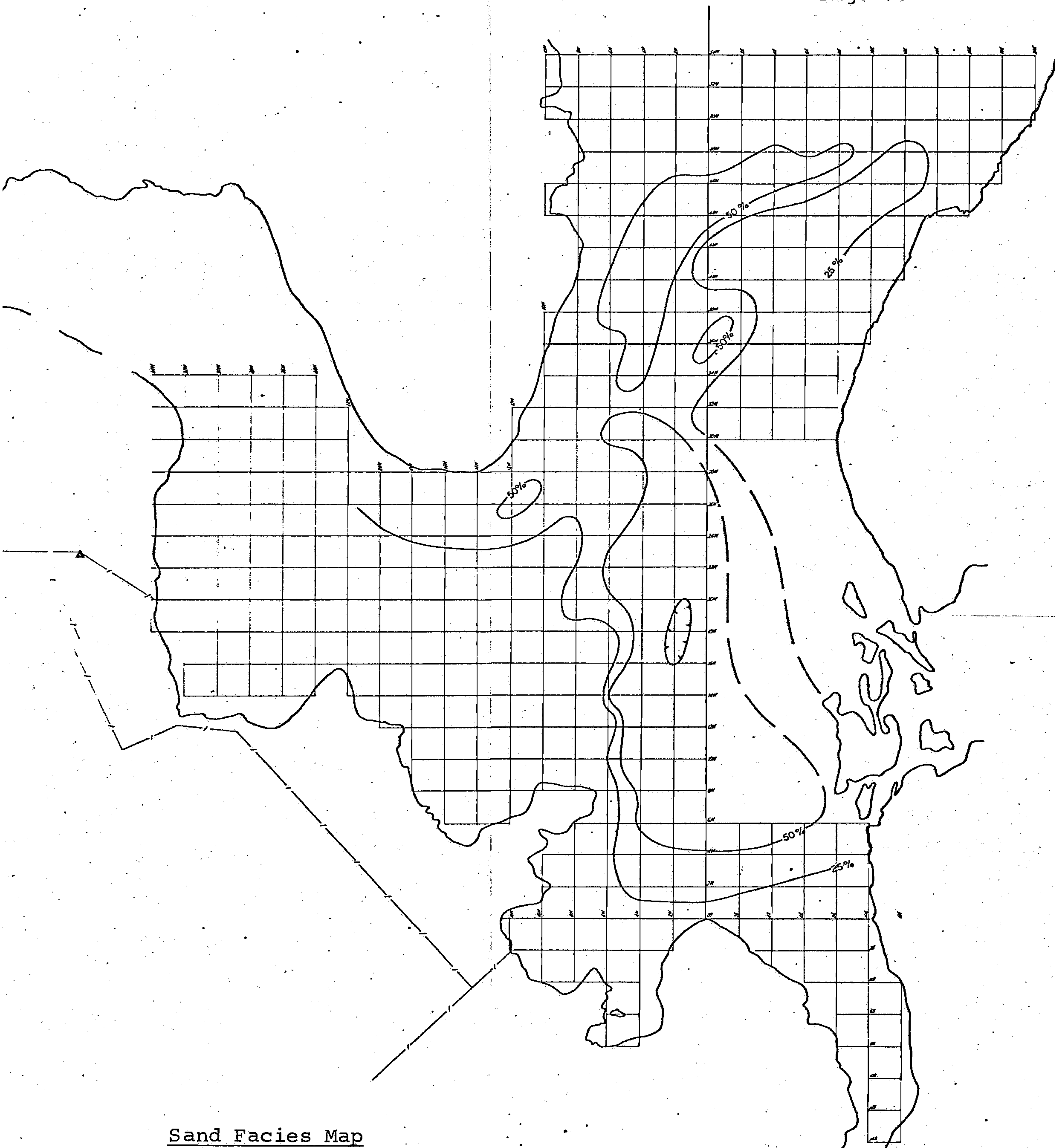

BEDA ARM
WILLOCHRA DELTA
GEOCHEMICAL ANALYSIS PROGRAM
o Complete Chemical Analysis
× Density, degrees Baume
0 5000 10,000 15,000
Feet
50N
40N
30N
20N
10N
00
10S
10W
20W
30W
10E
20E

Figure 3.



Sand Facies Map

(percent sand in upper 14' section)

Scale: Approx. 8,000' : 1"

Figure 4.

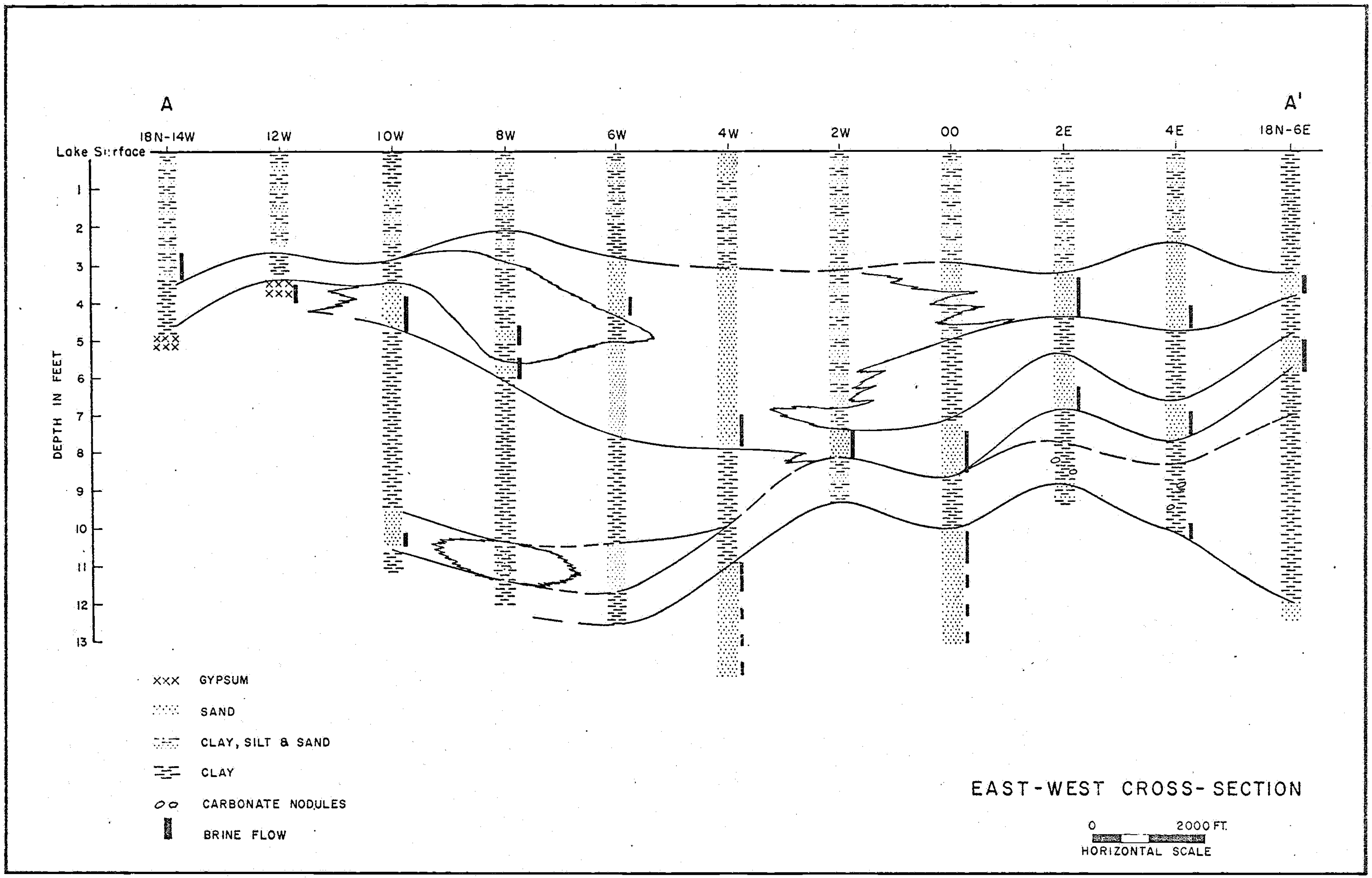

A
A'
18N-14W
12W
10W
8W
6W
4W
2W
00
2E
4E
18N-6E
Lake Surface
1
2
3
4
5
6
7
8
9
10
11
12
13
DEPTH IN FEET
XXX GYPSUM
SAND
CLAY, SILT & SAND
CLAY
CARBONATE NODULES
BRINE FLOW
EAST-WEST CROSS-SECTION
0
2000 FT.
HORIZONTAL SCALE

Figure 5.

Pump Tests

Eleven pump tests were conducted during the last quarter of 1973.

Each trench was allowed to reach nominal stability and was then continuously pumped until all free brine was removed. The depth and volume of brine varied with the watertable, with the original dimensions of the trench, and with the amount of sediment sloughing back into the excavation. Brine densities tended to increase with time. The trenches produced a minimum of 3.98 tonnes and maximum of 13.02 tonnes NaCl per day per 1,000 ft. of trench. It is believed this production rate could be increased by excavating wider and deeper trenches.

A total of 3,872,668 U.S. gallons of brine containing 3,682.81 tonnes NaCl were recovered during the initial test period.

PUMP TEST DATA

TRENCH	TEST	RECHARGE TIME (DAYS)	RECOVERY U.S. GALLONS	S.G.	T.D.S.	TONNES BRINE	TONNES NaCl	TONNES NaCl per day per 1,000'
3	1	35	231,200	1.152	20.3	1,000.2	188.83	4.28
3	2	34	166,025	1.184	24.6	744.1	170.24	3.98
4	1	40	1,033,000	1.165	22.0	4,555.4	932.04	9.32
4	2	40	589,420	1.193	25.7	2,670.8	638.35	6.38
5	1	32	388,460	1.175	23.4	1,727.8	376.01	5.87
6	1	21	241,000	1.165	22.0	1,062.8	217.45	10.59
6	2	33	239,730	1.158	21.1	1,050.8	206.20	6.40
7	1	62	279,225	1.198	26.4	1,266.2	310.88	5.01
8	1	23+	129,550	1.193	25.7	585.1	139.84	6.11
9	1	22	267,933	1.165	22.0	1,181.6	241.75	10.77
10	1	20	307,125	1.156	20.9	1,343.9	261.22	13.02

Brine Reserves

Petrographic and chemical analyses of samples taken from various stratigraphic units in Trenches 3, 4, 7, 9, and 10, indicate a minimum of 72 tonnes and maximum of 141 tonnes NaCl per acre/foot sand in situ. A single filtration of the samples provided 16 tonnes minimum, 80 tonnes maximum and an average of 38 tonnes per acre/foot.

The various sand units grade up to 89 percent sand (+ 240 mm) and contain up to 25 percent fluids measured on a weight:weight basis.

BRINE RESERVES

Summary of Petrographic and Chemical Analyses

Location Trench No.	Sand % W:W, + 240 mm	Fluid in Place % W:W	Fluid after filtration % W:W	Recovery, after one filtration % W:W	NaCl, in Situ (tonnes/acre/ft)	NaCl, in filtrate (tonnes/acre/ft)
3	84.11	18.59	8.95 (c)	48.14 (c)	101.09	48.67
3	84.74	15.13	4.44 (c)	29.35 (c)	77.82	22.86
4	75.80	16.46	11.16	32.20	108.10	40.44
4	83.80	14.65	12.72	13.17	93.68	16.26
4	65.30	24.71	20.79	15.86 (c)	141.32	20.85
4	23.40 (b)	25.94	N.D.	N.D.	172.42 (b)	N.D.
4	3.40 (b)	31.00	29.35	5.32 (c)	153.92 (b)	7.62 (b)
7	70.62	22.03	16.10	26.97	124.87	34.64
7	87.90	18.81	12.33	34.45	108.92	35.26
7	88.70	22.29	18.85	15.43	121.31	17.58
7	64.80	16.12	15.72	2.48	86.16	N.D.
9	(a)	18.37	12.78	30.43	72.03	21.64
9	(a)	16.61	9.79	41.06	102.01	43.28
9	(a)	20.08	7.60	62.15	126.19	79.96
10	(a)	17.95	8.95	50.14	115.11	54.86
10	(a)	22.98	14.78	35.68	137.77	55.78
					Average 108.31	Average 37.85

Note:
(a) ...to be analysed
(b) ...clays analysed for comparison only, not included in averages.
(c) ...calculated
N.D. ...No data

Expenditures

Delhi International Oil Corporation has exceeded the guaranteed minimum $57,000 expenditure as follows:

Expenditures to Date

Salaries, Wages & Assoc. Costs	38,807.42
Travel & Accommodation	3,026.26
Entertainment	164.95
Consultants	19,044.96
Operating Expenses:	
(a) Dragline	31,086.17
(b) Pumps	684.76
(c) Camp	10,966.96
(d) Other	4,731.18
Equipment Rental	2,620.00
Assays	2,391.30
Capital Equipment Purchase:	
(a) Dragline	30,894.11
(b) International Pick Up	6,759.50
(c) Toyota swb	4,141.80
(d) Toyota 1½ ton flat bed	3,488.25
(e) BUE Earth Cruiser	2,862.78
(f) Honda ATC 90 bikes x 6	3,442.00
(g) ATV Vehicle	745.00
(h) Walkie Talkies x 4	257.20
(i) 2 way Radio	898.75
(j) Generator-Petbowlister	2,406.20
(k) Pumps K & L Diesel	5,175.53
(l) Camp Equipment	1,244.05
(m) Survey gear	700.00
(n) Power auger	485.65
(o) Miscellaneous	1,224.00
Expenditure to December 31, 1973:	$178,248.78

Future Programme

Pump testing and analysis of brine production from the trenches will be continued, especially attention being paid to those trenches located within the main sand area, ie. T - 9 and T - 10, where productivity is highest.

Brine levels and recovery rates and weather conditions will continue to be recorded daily.

Laboratory analysis and brine concentration-precipitation data are currently being conducted and compiled. These data will indicate the purity and rate of recovery of NaCl from Torrens brine and will provide basic controls for subsequent pond design.

Miscellaneous

Technical meetings have been held with personnel from the Commonwealth Railways and preliminary proposals for transporting solid salt from Yadlamalka to Point Paterson have been outlined.

Exploration Licence 60

Summary of Activities April 13, 1973 to March 31, 1974

During the 12 months ending March 31, 1974 Delhi International Oil Corporation conducted an exploration programme over the southernmost 90 square miles of Lake Torrens, South Australia. The purpose of said programme was to determine the availability of high-quality brine to be used as a source of NaCl for the proposed Red Cliff Petrochemical Project.

The programme conducted during the first year of exploration consisted of establishment of a field camp, weather station, fuel supply and maintenance depot, and purchase of field vehicles, pumps, amphibious dragline and special equipment. A survey grid was established and samples of brine and sediments were recovered from hand-dug pits, auger holes, and dragline excavations. Ten trenches (approximately 17 feet wide x 14 feet deep x 1,000 to 2,500 feet long) were excavated and 20 pump tests were conducted during the initial period.

049

INDEX MAP

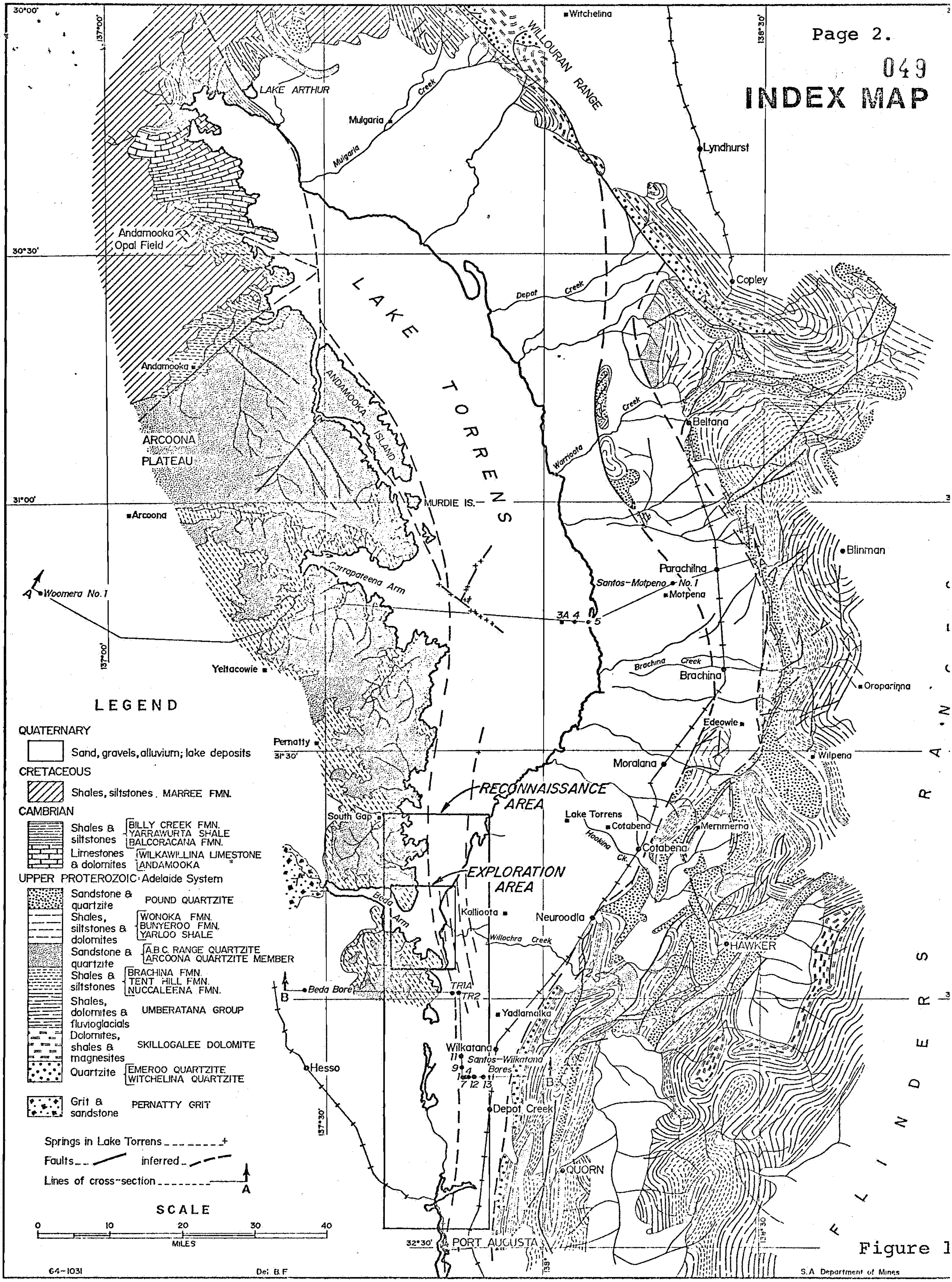


Figure 1

Camp

A three-caravan camp with lighting and power facilities was established between the southern extremity of Lake Torrens and Soakage Swamp on Yadlamalka Station. A 16-mile dirt track was graded from Yadlamalka Homestead to the Lake and Camp, and a further 10-mile track was graded from the Camp to the Maintenance and Fuel Area on Lake Torrens. A service and maintenance depot was established at the southern edge of Lake Torrens.

Survey

Levels to within 0.01 foot were carried from existing S.A. Department of Lands third order bench marks, for a distance of approximately seven miles to base reference 00N 00W on Lake Torrens. A 2,000' x 2,000' N/S-E/W oriented grid was established from 8,000S to 50,000N and from 14,000E to 32,000W and fixed by angles to existing S.A. Department of Lands geodetic stations. Surface level elevations were run NW-SE, diagonally across the grid, and were closed to within 0.01 foot.

Figure 2 is the resulting topographic map and shows the major drainage to be NE to SW across the Lake. During and after moderate rains (60 points) the Willochra Creek may flow and several minor flows occur within and from the delta area in distributory patterns. It is a common occurrence for free water to pond on the lake surface after nominal rains of 10-15 points. High winds are capable of driving such surface water a distance of more than 5 miles over the lake bed irregardless of the subtle topographic features.

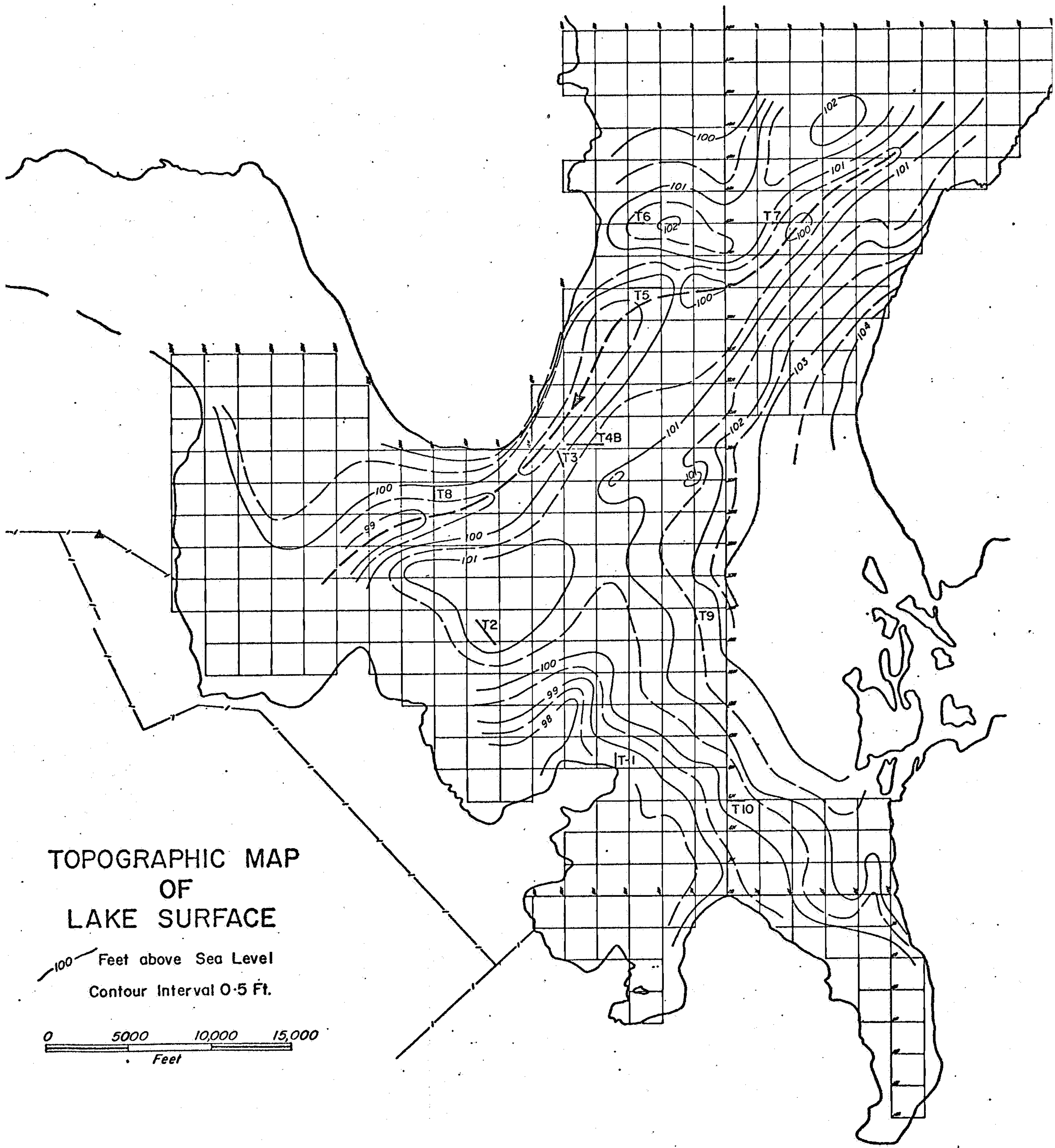

TOPOGRAPHIC MAP
OF
LAKE SURFACE
100 Feet above Sea Level
Contour Interval 0·5 Ft.
0 5000 10,000 15,000
Feet
T1
T2
T3
T4B
T5
T6
T7
T8
T9
T10
98
99
100
101
102
103
104

Figure 2

Weather Conditions

A class "B" meteorological station was established on shore near the southern end of Lake Torrens. The Commonwealth Bureau of Meteorology loaned equipment comprised of a Stevenson Screen with wet-dry and maximum-minimum thermometers, a class "A" evaporimeter, a cup-counter anemometer, rain gauge and a sunshine recorder. A daily log has been maintained since June 11, 1973.

Table 1 and Figure 3 show that the period June 73 - February 74 has been one of exceptionally high rainfall for this area. This phenomenon may have influenced brine recovery and production data in a favourable manner but previous reconnaissance work indicated a similar and relatively stable waterlevel in 1972 and early 1973.

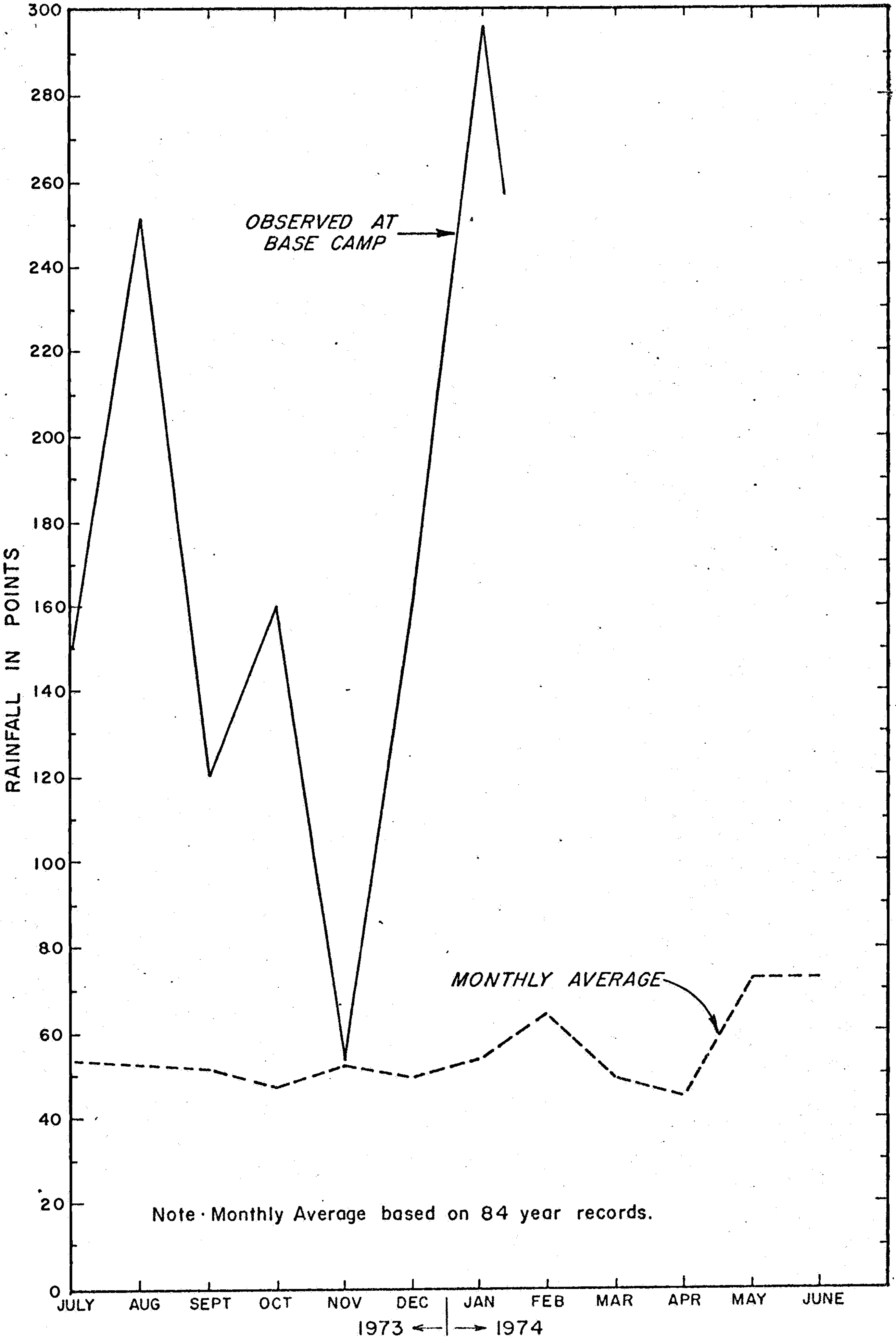
Observed evaporation data, which are necessary for calculating pond acreage requirements, are relatively close to the estimated averages.
Lake Torrens crystallising and concentrating ponds

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
June																																
Rainfall											36	0	0	72	2	0	0	0	3	0	23	0	10	0	0	3	0	0	0	0		149
Evaporation												14	2	4	6	5	5	6	5	2	1	9	7	5	10	7	9	10	8	7		122
July																																
Rainfall	0	0	0	0	0	0	0	0	0	0	0	10	9	28	0	75	6	0	8	0	0	0	0	0	0	10	0	0	0	0	4	150
Evaporation	10	6	10	7	15	9	15	12	10	8	9	5	1	2	6	8	8	8	13	12	9	7	6	8	10	9	14	11	13	17	10	288
August																																
Rainfall	0	0	0	2	19	0	39	0	5	2	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	58	123	1	0	0	0	252
Evaporation	14	12	8	11	3	21	11	12	11	8	8	11	15	22	16	17	21	13	11	11	13	22	11	8	14	2	13	14	10	10	15	388
September																																
Rainfall	63	2	2	1	0	0	0	0	0	3	0	2	0	14	0	0	0	0	0	0	0	0	33	0	0	0	0	0	0	0		120
Evaporation	29	13	12	19	16	13	11	14	21	22	26	42	25	22	16	12	23	34	42	19	18	37	18	18	27	25	20	20	30	53		697
October																																
Rainfall	4	0	0	0	0	0	0	0	4	0	3	0	0	0	0	0	19	56	34	2	1	0	0	0	2	35	0	0	0	0	0	160
Evaporation	18	15	20	23	30	35	33	27	35	30	23	25	26	28	44	53	3	33	10	33	16	24	36	44	32	13	30	26	20	36	51	872
November																																
Rainfall	0	1	22	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0		54
Evaporation	45	23	9	22	22	10	35	28	45	37	35	56	36	35	66	15	45	47	55	82	48	53	43	45	45	57	34	41	32	36		1182
December																																
Rainfall	0	5	0	0	0	0	0	0	0	0	0	5	7	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	11	120	0	151
Evaporation	79	80	50	41	43	43	57	50	50	54	63	60	82	2	32	40	55	45	45	53	49	106	45	32	44	56	62	60	28	11	35	1552
January																																
Rainfall	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	82	116	56	296
Evaporation	52	49	38	69	42	52	63	70	58	50	60	55	42	49	55	45	45	44	52	45	49	53	61	65	75	64	71	14	13	16	19	1535
February																																
Rainfall	......total:209				0	0	0	0	0	0	0	0	0	0	0	0	8	7	47	0	0	0	0	0	0	0	0	0	0	0	0	271
Evaporation	......total:154					59	38	39	34	34	54	53	47	47	35	40	42	24	11	35	28	18	21	25	28	0	0	0	0	0	0	866

Rainfall and Evaporation Recorded Lake Torrens Camp

Table 1

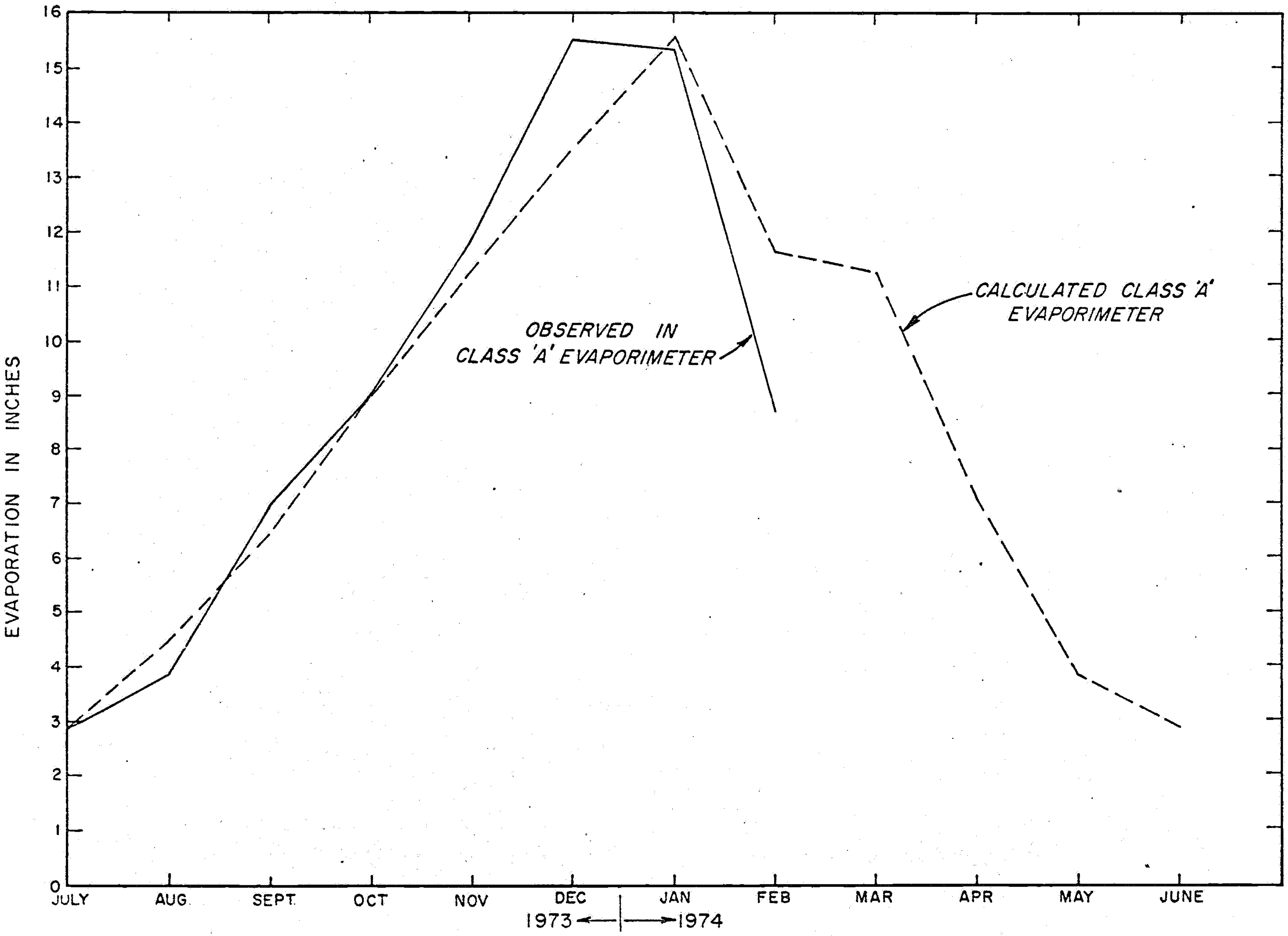
055



RAINFALL - LAKE TORRENS

SOUTH GAP STATION

Figure 3



EVAPORATION – LAKE TORRENS

Figure 4

should be among the most productive of any known salt field (Figure 4).

Wet conditions, further complicated by the lack of sufficient equipment and time within which to construct adequate roads, resulted in the loss of some 30 working days during the exploration period.

Special Equipment

An amphibious dragline with 5/8 yard levee bucket was purchased in May 1973 from Quality Marsh Equipment Company, Thibodaux, La. Delivery was made in Adelaide on July 25, 1973 and the unit was assembled at Lake Torrens by August 2, 1973.

A working schedule of 20 hours/day, 7 days/week was maintained whenever weather conditions and mechanical requirements allowed. This schedule was implemented between August 5 and December 22, 1973, a period of 139 days. Approximately thirty working days were lost because of weather and maintenance problems. The dragline performed satisfactorily, although subjected to difficult working conditions, and a total of approximately 150,000 cubic yards of clay and sand was excavated from ten trenches and 83 exploration pits (Figure 5). The area explored is approximately 90 square miles and the dragline's mobility and the ease with which it walked more than 75 miles was a significant factor in the success of the programme.

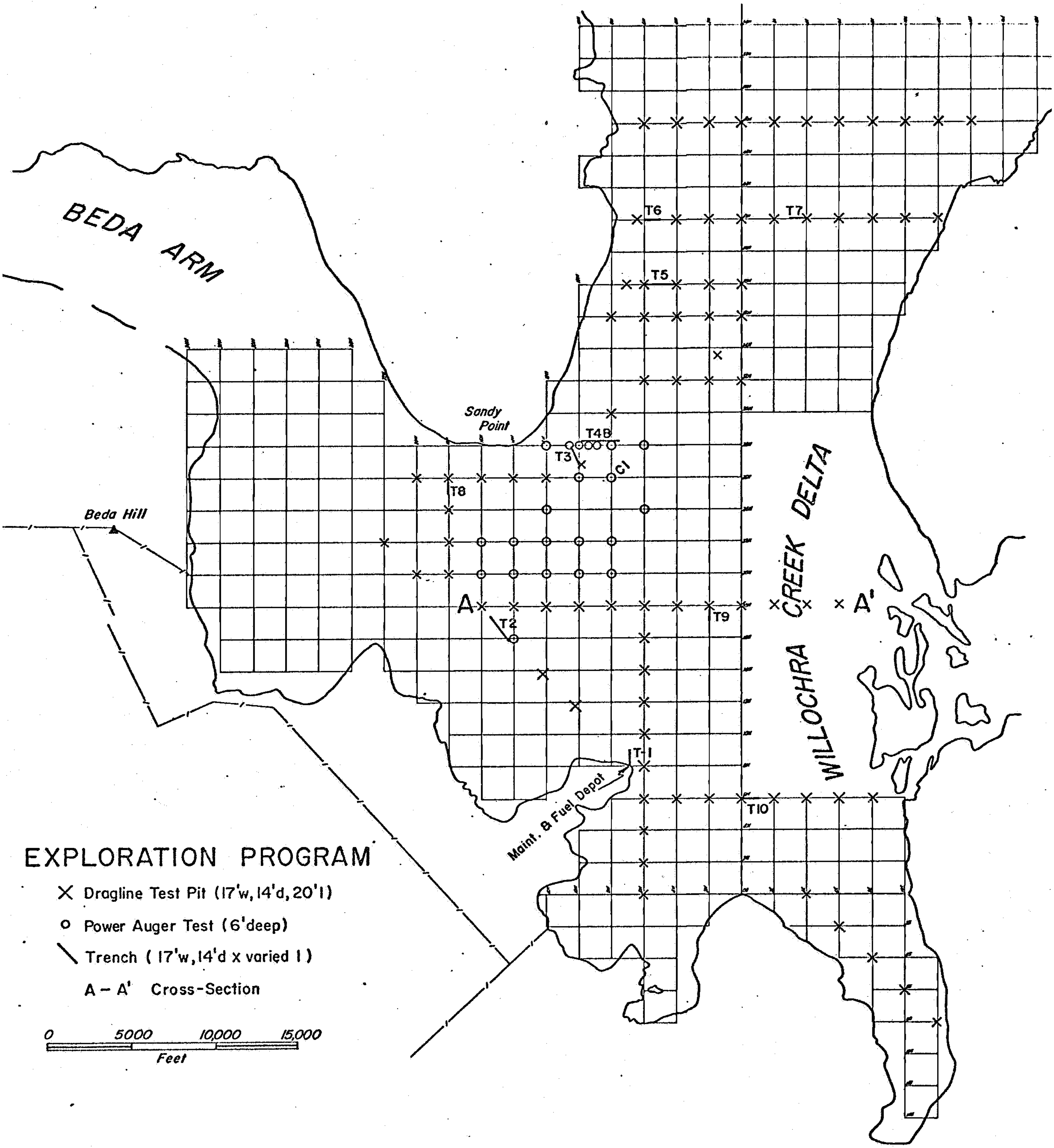

BEDA ARM
Sandy Point
Beda Hill
T4B
T3
C1
T8
T6
T7
T5
T9
T2
T-1
T10
A
A'
WILLOCHRA CREEK DELTA
Maint. & Fuel Depot
EXPLORATION PROGRAM
Dragline Test Pit (17'w, 14'd, 20'l)
Power Auger Test (6'deep)
Trench (17'w, 14'd x varied l)
A – A' Cross-Section
0
5000
10,000
15,000
Feet

Figure 5

Access to the lake by personnel was accomplished with the aid of seven Honda ATC-90cc three-wheel balloon-tyred motorcycles. These units proved to be extremely reliable when new but are subject to corrosion under the severe conditions existing on Lake Torrens. Two units were adapted to pull trailers on which a 450 lb K & L 2½" centrifugal pump and a fuel drum (440 lbs) are mounted.

Exploration

Brine and sediments were sampled from hand-dug pits, auger holes and 83 pits and 10 trenches excavated to a depth of 14 feet with an amphibious dragline, Figure 5 .

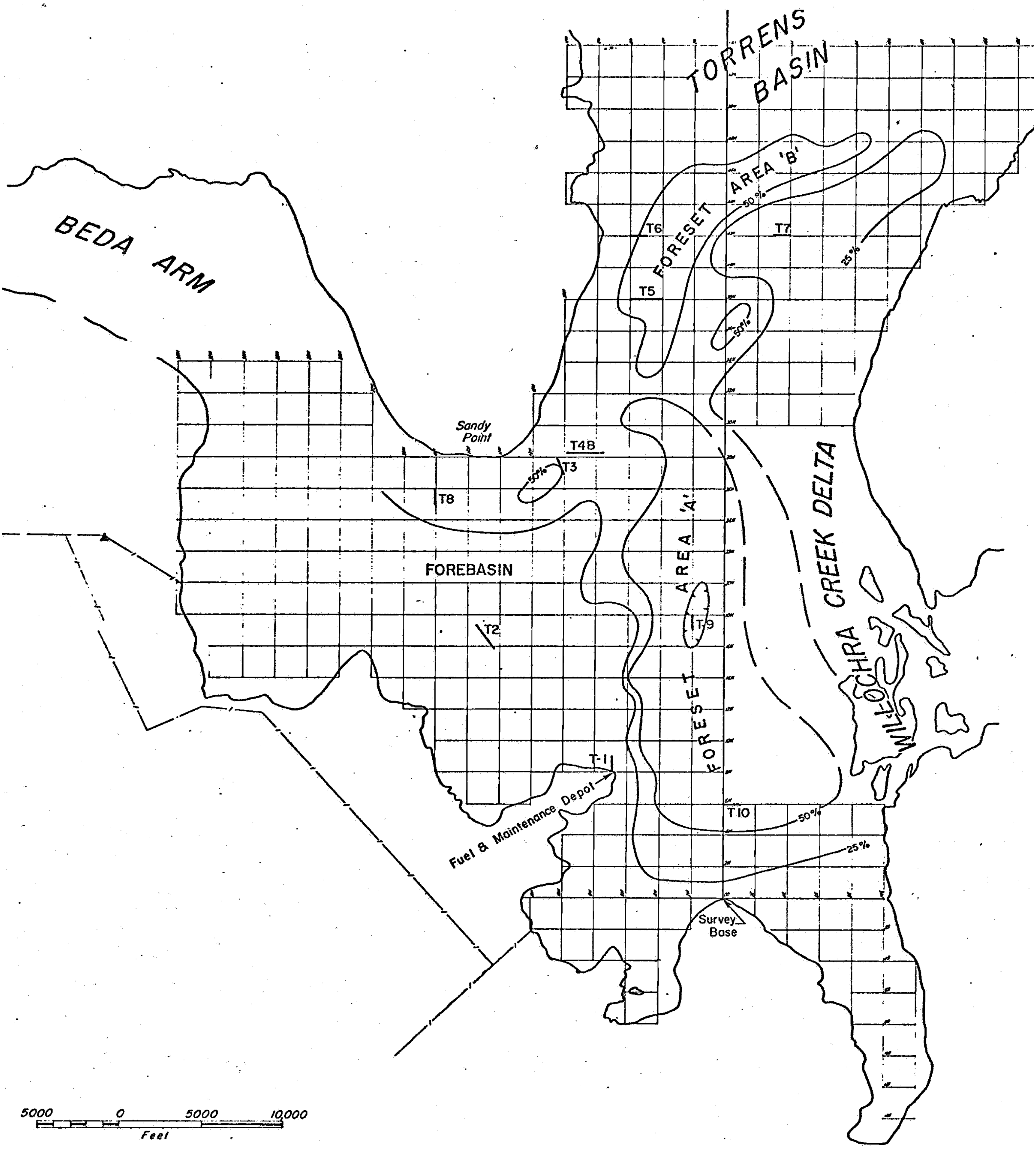
For the purposes of exploration the area was arbitrarily divided into three sedimentary provinces.

1. Willochra Creek Delta:- The Willochra Creek drainage basin covers an area of some 700 square miles in the Flinders Ranges and associated alluvial fans. Although defined as "intermittent" the Willochra Creek often floods and carries surface water and detritus to Lake Torrens where the resulting delta forms a significant physiographic feature. Quartz sands, silts and fine-grained rock fragments are most prevalent around the periphery or "foreset area" of the delta where they constitute up to 50% and 40%, respectively, of the upper 14 feet of

sediment, Figure 6. The high sand content of the foreset area provides for the maximum brine recovery rates yet identified.

2. Fore Basin:- A generally low-energy area lies immediately to the west and at the edge of the present delta. The Basin is a subtle physiographic area about 20,000 feet in diameter, having a low relief of about three feet with minor runoff channels, and is bordered on the south by several sub-basins. Fine-grained clastics, especially blue-grey and brown clays, dominate the near-surface sediments but the general stratigraphic section is commonly recognisable. The upper brown arenaceous and gypsiferous surface clays contain substantial amounts of recoverable brine but the lower blue clay appears to be less permeable. Both clays are basically an illite (50-60%)-kaolin (20-30%) mixture. Beneath the middle clay section a widespread buff-grey, medium-grained, well-rounded sand also appears to be saturated with dense brine.

3. Torrens Basin:- The major part of Lake Torrens proper begins at about the 32,000' north line.



Lithofacies Map (Percentage Sand in Upper 14 feet)

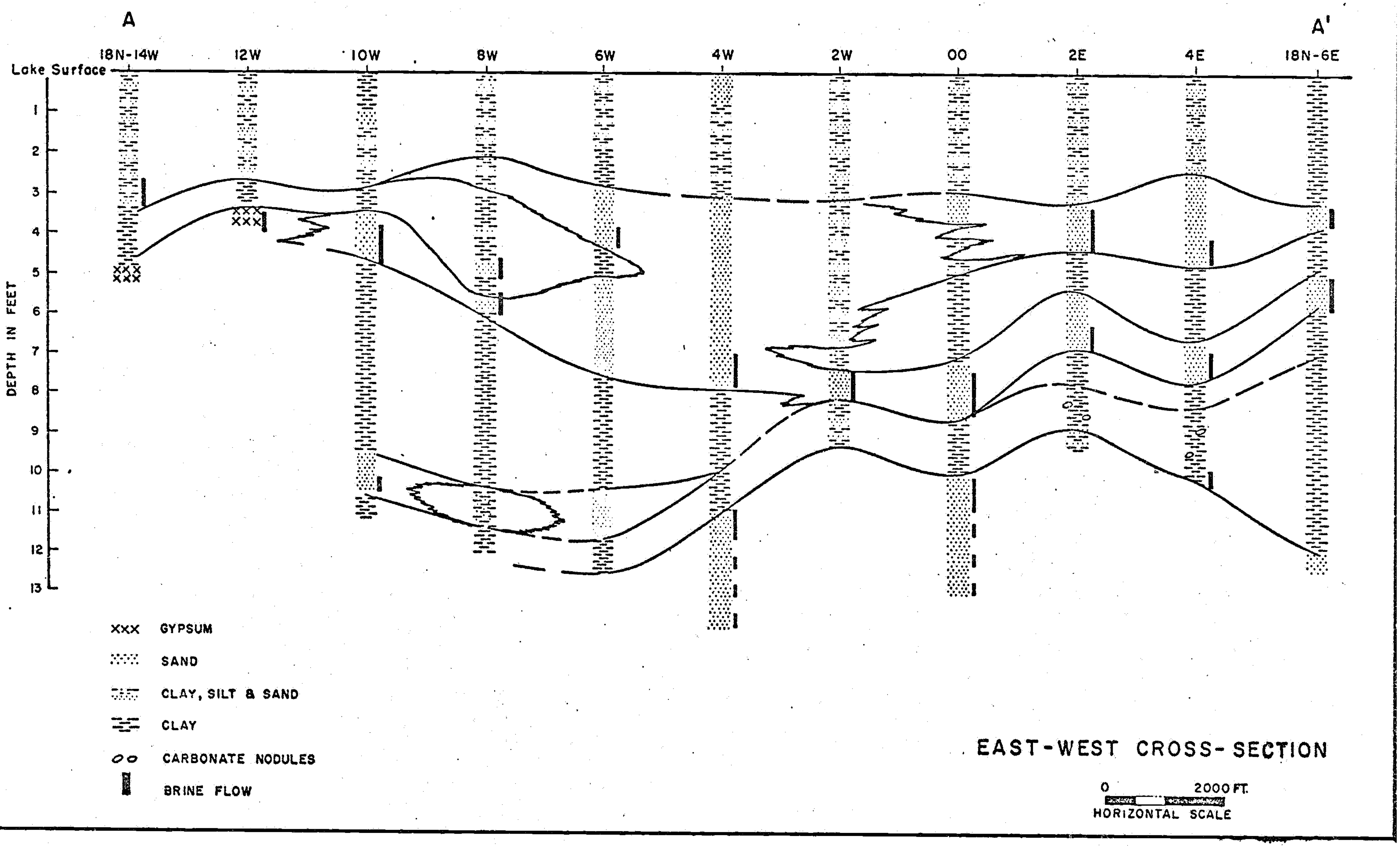
Figure 6

near Sandy Point although some sporadic transitional delta-basin sediments also occur north to 48,000'. A general increase in continuous, but thinner unconsolidated, well-rounded quartz sand beds, and a thinning of the blue-grey clay generally occurs northwards from this area.

Sedimentation

Near-surface sediments of Lake Torrens are lacustrine clays, silts, sands and evaporites that extend to a depth of up to 1,000 feet. Mud cracks, carbonaceous root-tubes, old erosion surfaces and soil profiles are common in the upper 14 feet of section and provide for rapid infiltration of surface floodwaters.

Two to five discreet beds of uncemented sand may occur in the upper section but clay-silt or silt-sand transitional facies are common over short lateral and vertical distances (Figure 7). The sands are probably part aeolian in origin and are composed mostly of multi-cyclic quartz. Petrographic analyses of the brine-saturated sands indicate grain sizes within the .063 - .420 m.m. range and moderate to well-sorting (Table 2); this compares reasonably well with normal aeolian sands of .05 - .5 m.m. range. Grade size tends to be greatest within the Foreset Area where concentration of rock fragments (10-40%) and total thickness of sands (+ 50%) are best developed (Figure 6). It is from this area that the highest flow rates and maximum recovery of NaCl has been obtained.



EAST-WEST CROSS-SECTION

Figure 7

Table 2

Composition of Modal Class

Location	Mode mm	Quartz	Rock Fragments	Iron Oxides	Mica	Clay	Carb.	Glauc. Tourm. MnO	Shell Frag.
Trench 3 (B)	.420	98	tr.	tr.	–	–	tr.	–	tr.
Trench 4 (C)	.094	95	1-2	3	–	–	–	–	–
(D)	.188	95	2-3	2-3	–	–	–	–	–
Trench 7 (E)	.094	90-95	–	5-7	–	–	–	2-3	–
(F)	.420	90-95	3-5	3-5	–	–	–	1-2	–
(G)	.063	85-90	3-5	3-5	–	–	–	4	–
	.188	95-100	1-2	1-2	–	–	–	–	–
(H)	.063	10-50	tr.	–	–	10-50	–	–	–
	.250	95	1-2	2-3	–	–	–	–	–
Trench 9 (J)	.094	70-75	20-25	2-3	3-5	–	–	–	–
(K)	.188	50-60	35-40	1-2	3-5	–	–	–	tr.
(L)	.250	65-70	30-35	2-3	–	–	–	–	–
Trench 10 (M)	.094	80-85	10-15	3-5	tr.	–	–	–	–
(N)	.420	55-60	30-35	3-5	–	–	1-2	–	–

Evaporites are predominantly gypsum with bladed crystals (selenite) normally of ¼-inch or less diameter but with occasional specimens ranging up to 12 inches in length. A few carbonate nodules have been recognised in the Willochra delta area where brines are generally slightly fresher.

Brine Chemistry

High-density brine of 18^{o}-22^{o} Baume quality is present at least throughout the upper 15 feet of the Lake sediments. This confirms previous reconnaissance sampling by Delhi, and an earlier S.A. Department of Mines report which recorded similar brine throughout the upper 85 feet of section.

Source of most of the NaCl is believed to be the result of storm-borne seawater being carried into the drainage area of Lake Torrens. Estimates made by the S.A. Department of Mines suggest some 97 lbs NaCl per acre per year may be deposited in this manner. The NaCl is transported as a weak solution into the Lake proper by subsequent rains and concentrated by evaporation assisted perhaps by the filtration effect of the clays. Direct rain or runoff leaches the extremely saline sediments and seeps into the subsurface of the Lake to provide the most rapid recharge system. Other probable contributing sources of brine in the near-surface are upward seepage through sediments or fault-line springs from deeper deposits within the Lake, and from saline springs on the flanks of the Flinders at the northern extremities of Lake Torrens.

Brine samples were collected at various times in the following manner:

1. Pits, hand-dug to 3 feet deep during reconnaissance in 1971 and 1972.
2. Auger holes drilled to 6 feet during grid sampling in 1973.
3. Dragline pits excavated to 15 feet during sampling in 1973.
4. Filtrate from sand samples obtained from dragline pits in 1973.
5. Recharge brine from trenches after one or more pump tests in 1973-74.

Brine samples recovered from auger holes, pits and trenches have been of generally high-purity, high-density quality. Density varies slightly with location being fresher (18 percent) within the Delta, 18-24 percent within the Basin, and 18-20 percent total dissolved salts in the north. Qualitative analyses show the samples to be normally about 92-94% NaCl. The sampling programme is illustrated in Figure 8 and a summary of analyses is contained in Table 3.

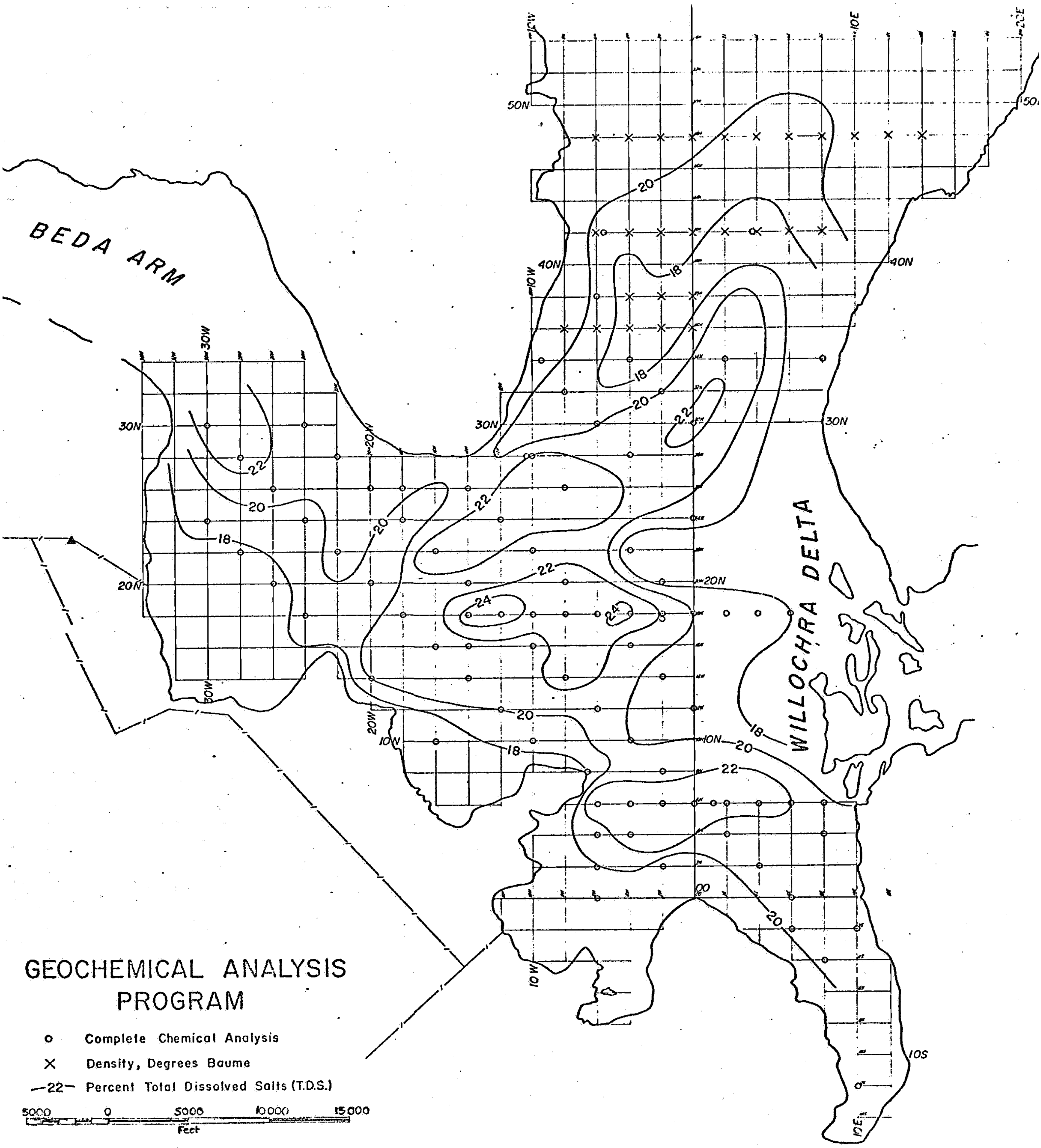

BEDA ARM
WILLOCHRA DELTA
GEOCHEMICAL ANALYSIS PROGRAM
o Complete Chemical Analysis
X Density, Degrees Baume
—22— Percent Total Dissolved Salts (T.D.S.)
5000 0 5000 10000 15000
Feet
50N
40N
30N
20N
10N
10S
30W
20W
10W
10E
20E
00

Figure 8

Summary of Chemical Analyses of Brine

in % ?

Samples	Sp. G.	CaSO4	MgSO4	KCl	MgCl2	NaCl	T.D.S.
Reconnaissance, May, 1972							
10	1.153	0.547	0.275	0.048	0.625	21.00	22.49
Test Pits - November, 1973.							
11	1.154	0.435	0.088	0.038	0.584	20.14	21.56
- January, 1974.							
10	1.154	0.555	0.039	0.036	0.777	19.68	21.26
Auger Holes, July, 1973.							
68	1.120	0.520	0.080	0.030	0.612	18.19	19.68
August, 1973.							
32	1.154	0.536	0.082	0.030	0.662	18.96	20.47
Trenches, - December, 1973.							
9	1.160	0.460	0.156	0.048	0.524	21.41	22.92
Surface Water*							
2	1.080	0.673	-	0.027	0.347	9.24	10.30

Base Metals, p.p.m.	Cu	Zn	Mn	Cr	Ni	U
3	<0.01	<0.02	<0.07	<0.01	<0.02	<0.02

*collected 1 week after 1.72 inches rain July, 1973.

Table 3

Production Tests

Brine flows from 'channels' in the sands, and to a lesser extent from the associated silts, gypsiferous clays, and clays. At Trench 3 brine also flows from springs in the bottom of the excavation. In order to evaluate the quality and quantity of available brine a series of trenches was constructed. Each trench is approximately 18 feet wide by 12-14 feet deep, which represent the reach limitations of the amphibious dragline when operated from one position only. Time and data requirements prohibited more definitive and costly work. Initially a short trench 120 feet long was tested but the ratio of drainage area to volume excavated was so great that flow rates were obviously exaggerated.

Ten trenches ranging from 977 to 2,500 feet long were excavated between August 5 and December 22, 1973. Eight of these were subject to multiple pump tests.

Pump tests were conducted on a 20-65 hour continuous basis using a Kelly Lewis/Southern Cross unit operating at a rate of approximately

200 U.S. gallons per minute to draw the brine down from a near-stable level to the slurry level. Volumes, densities, chemistry, and recharge rates were calculated after each test.

Data from 19 tests are summarised in Table 4. It is clear from the available information that the greatest rate of NaCl production may be expected from the foreset sand area, as indicated by Trenches 9 and 10. Both trenches are subject to continuing tests.

Assuming that an average production rate of 12.70 tonnes per day per 1,000 feet of trench can be indefinitely maintained then the proposed
m = 1000 460,000 m.t.p.y. requirement could be met from a minimum of 18.8 miles of trench. It is believed that production rates from all trenches can be significantly improved if the trenches are maintained to their original depth of 14 feet, the lowermost sands kept unimpeded, and if surface floodwaters can be controlled and ponded near production trenches.

Brine quality before, during, and after recharge appears to be reasonably constant but densities

PUMP TEST DATA

TRENCH	TEST	RECHARGE TIME (DAYS)	RECOVERY U.S. GALLONS	S.G.	T.D.S.	TONNES BRINE	TONNES NaCl	TONNES NaCl per day per 1,000'
3	1	35	231,200	1.152	20.3	1,000.2	188.83	4.28
3	2	34	166,025	1.184	24.6	744.1	170.24	3.98
3	3	29	186,000	1.181	24.1	831.5	186.36	5.10
4	1	40	1,033,000	1.165	22.0	4,555.4	932.04	9.32
4	2	40	589,420	1.193	25.7	2,670.8	638.35	6.38
4								
5	1	32	388,460	1.175	23.4	1,727.8	376.01	5.87
5	2	43	283,050	1.199	26.5	1,284.6	316.59	3.67
6	1	21	241,000	1.165	22.0	1,062.8	217.45	10.59
6	2	33	239,730	1.158	21.1	1,050.8	206.20	6.40
6	3	19	223,300	1.163	21.8	983.0	199.29	10.74
7	1	62	279,225	1.198	26.4	1,266.2	310.88	5.01
8	1	23+	129,550	1.193	25.7	585.1	139.84	6.11
8	2	26	174,700	1.201	26.7	794.0	197.18	7.62
9	1	22	267,933	1.165	22.0	1,181.6	241.75	10.77
9	2	24	286,000	1.181	24.1	1,278.5	286.55	11.71
9	3	12 *	148,642	1.152	20.3	637.9	125.18	10.43
10	1	20	307,125	1.156	20.9	1,343.9	261.22	13.02
10	2	18	265,100	1.176	23.5	1,180.1	257.91	14.29
10	3	8 *	123,951	1.176	23.5	543.1	127.63	15.95

* Excludes period of high rainfall

Table 4

are gradually increasing. Some trenches that filled originally with 18-19.5° Be brine now contain 25.9 % T.D.S. brine from which some salts are precipitating. Evaporation rates have reached 106 points (1.06 inch) per day.

Reserves

Reserves were estimated from chemical and petrographic analysis of field samples, and from comparison of these data with published known values.

Field samples were obtained from various lithologic units during the construction of Trenches 3, 4, 7, 9 and 10. Fresh samples were taken from the walls and floor of the excavation, sealed in plastic bags and sealed again in vacuum jars. McPhar Geochemical Laboratories measured and analysed the total NaCl brine in-situ and the amount of brine recoverable by filtration. Chemical analyses of field samples indicate a total of 9,464,000 tonnes NaCl in situ in main Foreset Areas A and B. Of this total it appears that some 2,810,000 tonnes (29%) is recoverable from the first filtration or drainage of brines. Area C with some 25% sand content has a total of 15,593,000 tonnes NaCl of which 2,148,000 (13.8%) appears to be immediately recoverable. Area D, the low-energy area, contains some 7,249,000 tonnes of which 1,023,000 tonnes (14%) is recoverable, Table 5 .

Map of Areas A+B on pg 16.
Area C between 25% & 50% sand content pg 16
Area D < 25%
No boundaries for (C+D) ?

ESTIMATED NaCl RESERVES *1

Area	Acres	Lithology	Thickness (feet)	NaCl in situ (per acre/foot)	NaCl in filtrate (per acre/foot)	NaCl (in situ) (x 000's tonnes)	NaCl (Recoverable)*2 (x 000's tonnes)
A	4200	Sand	7.0	120.27	58.47	3,536	1,719
		Silt	2.8	72.03	21.64	847	254
		Clay	4.2	153.92	7.62	2,715	134
						7,098	2,107
B	1400	Sand	7.0	120.27	58.47	1,179	573
		Silt	2.8	72.03	21.64	282	85
		Clay	4.2	153.92	7.62	905	45
						2,366	703
C	9200	Sand	3.5	104.40	29.82	3,362	960
		Silt	3.5	72.03	21.64	2,319	697
		Clay	7.0	153.92	7.62	9,912	491
						15,593	2,148
D	3200	Sand	1.75	118.37	29.16	663	162
		Silt	3.5	72.03	21.64	807	242
		Clay	8.75	153.92	7.62	4,210 ~~5,779~~	213 ~~619~~
						7,249	1,023
					Totals:	32,306,000 30,837,000	5,981,000 5,575

*1 estimated, January 1974

*2 recoverable with one filtration

C & D total 50% + of reserves.

C gives 7 tonnes NaCl/day (5 trenches)

D gives 5 tonnes NaCl/day (1 trench)

Table 5.

Grain size, modal and median classes and types were obtained by petrographic examination and sieve analyses, Figure 9. Foreset Areas A and B contain sands with median grain sizes in the 0.094 to 0.420 m.m. class. Published data relate such a range to approximate Specific Yields of 32% - 28%. Area C sands and silts vary from 0.063 to 0.420, average 0.22 m.m., or about 23.5% to 32% Specific Yield. Area D contains sands of slightly coarser grain size 0.29 m.m. (31% S.Y.) but is comprised of substantially less arenaceous material than are the other areas considered.

Average grain size data for all arenaceous samples may be equated to a specific yield of about 30%, and argillaceous samples to about 5.9%, as based on published data. However, field data reduce these estimates to 16.3% for all silts and sands (20.5% in Foreset Area A), and 4.6% for the clays.

PRODUCTIVE STRATA

GRAIN SIZE DISTRIBUTION OF NON-CEMENTED SANDS

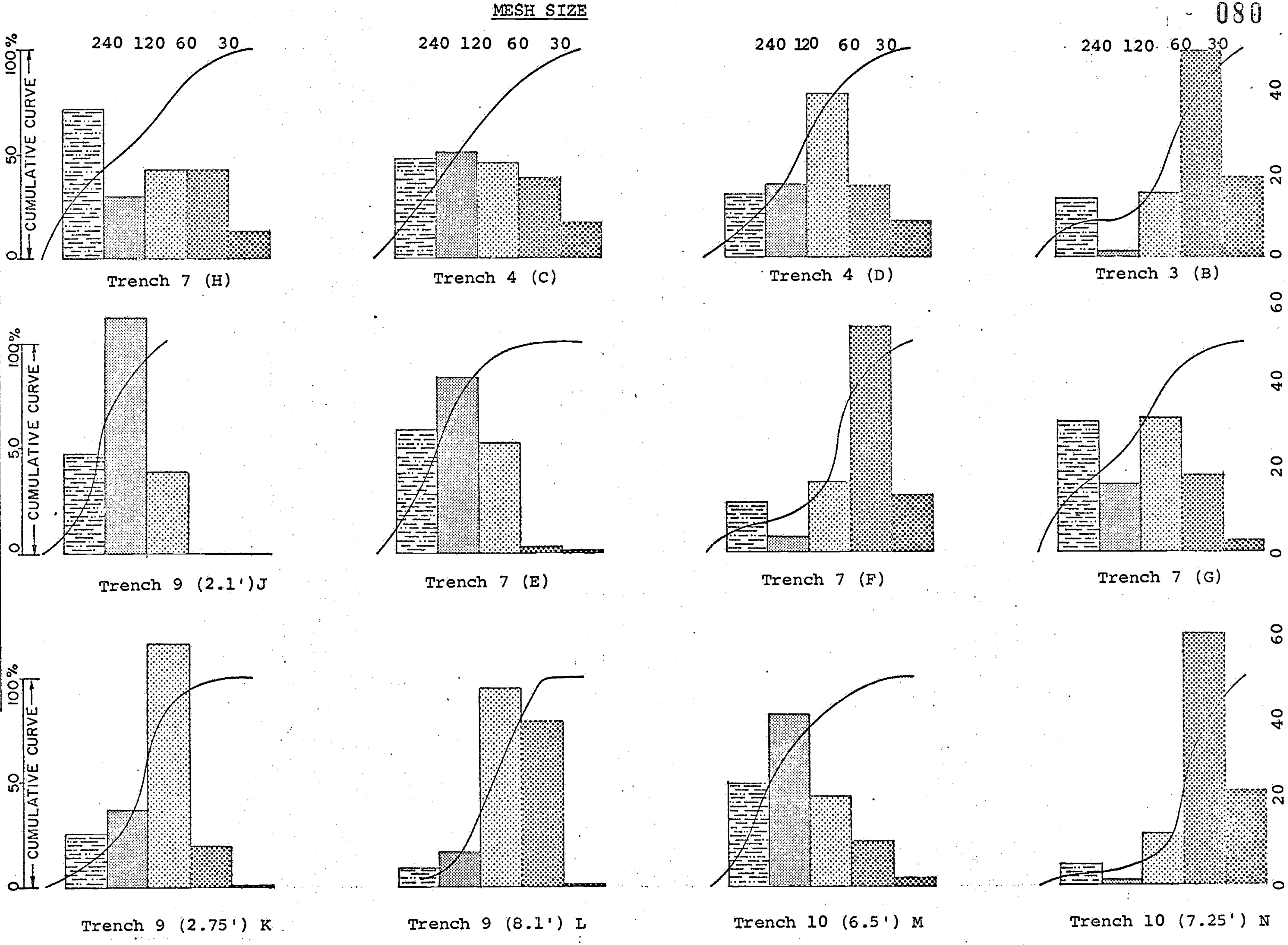


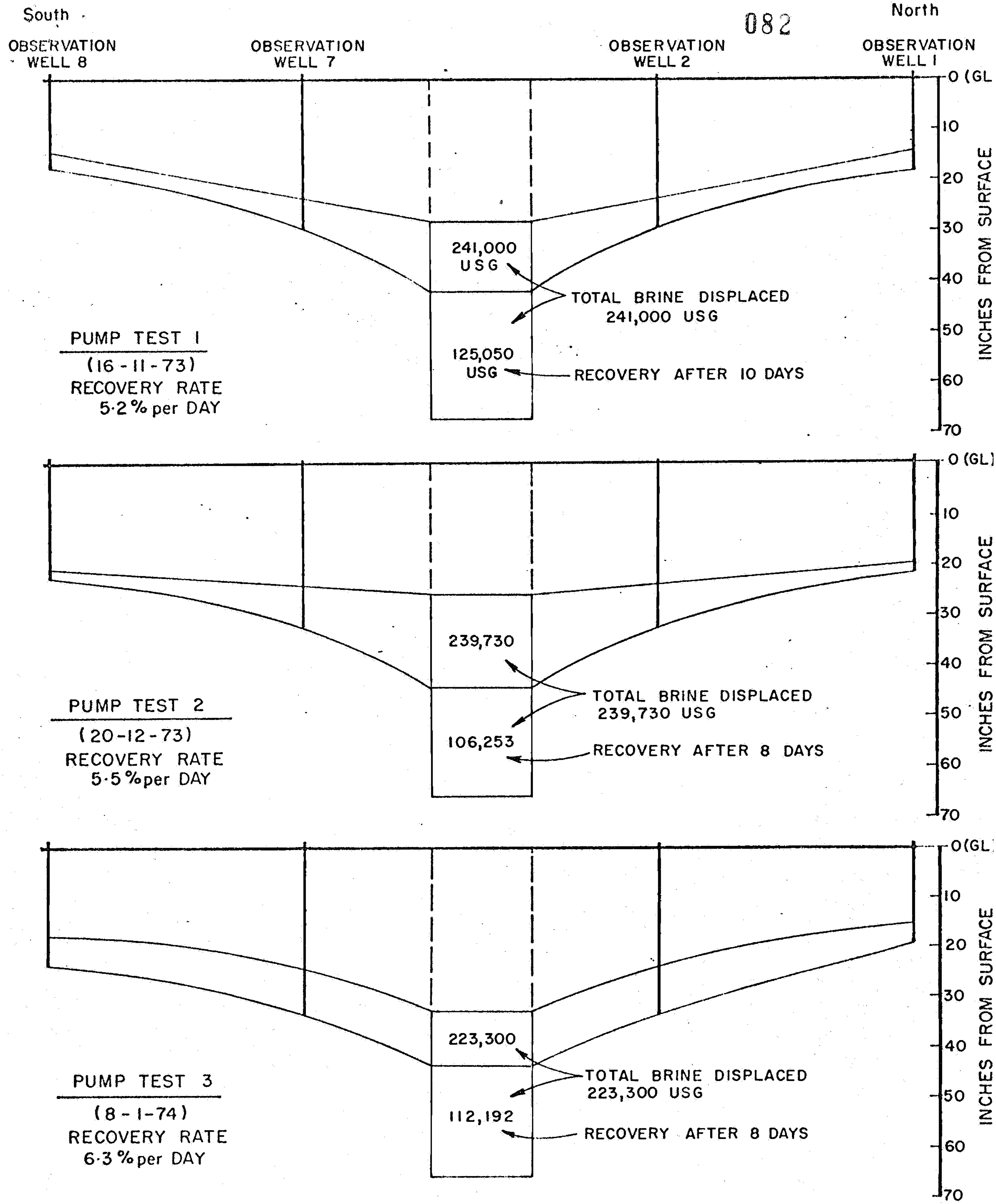
Figure 9.

Drawdown and Recharge

Observation wells (OW's) were augered and cased to a depth of 6 feet at 8 or 16 locations and up to a distance of 150 feet from each trench. Watertable levels were recorded prior to, during, and for at least one week after each trench was pumped. Watertable data recorded indicate a variety of time lag responses to trench pump tests. In the vicinity of Trench 9 and 10 the OW's showed rapid dewatering of the sediments for several days after pumping, followed by recharge and approximate stable recovery in less than 20 days. At a distance of 150 feet from Trench 9 the maximum depression of the watertable surface was 7.0 inches. Further north, in the vicinity of Trench 6, where the reservoir sands are somewhat thinner the maximum depression of the watertable is about 2 to 5 inches at a distance of 150 feet after 8 days (Figure 10). Full recovery requires approximately 30 days.

Brine recharge after pumping varies with the type and size of the reservoir sands. In the case of Foreset Area "A" the five pump tests

082



TRENCH 6

Location : 42N 5W

Figure 10

conducted on Trenches 9 and 10 have proven a rapid recovery of brine within a period of 12 to 20 days, (Figures 11 - 18). The amount and quality of recharge brine has not yet been proven to vary between tests to any substantial degree, except when rain causes flooding in the vicinity of the trenches. In such cases there is observed a very rapid recharge phase and a moderate decline in brine density. Such conditions normally stabilise after a few days and brine density recovers its former quality within about 10 to 14 days.

BRINE RECHARGE

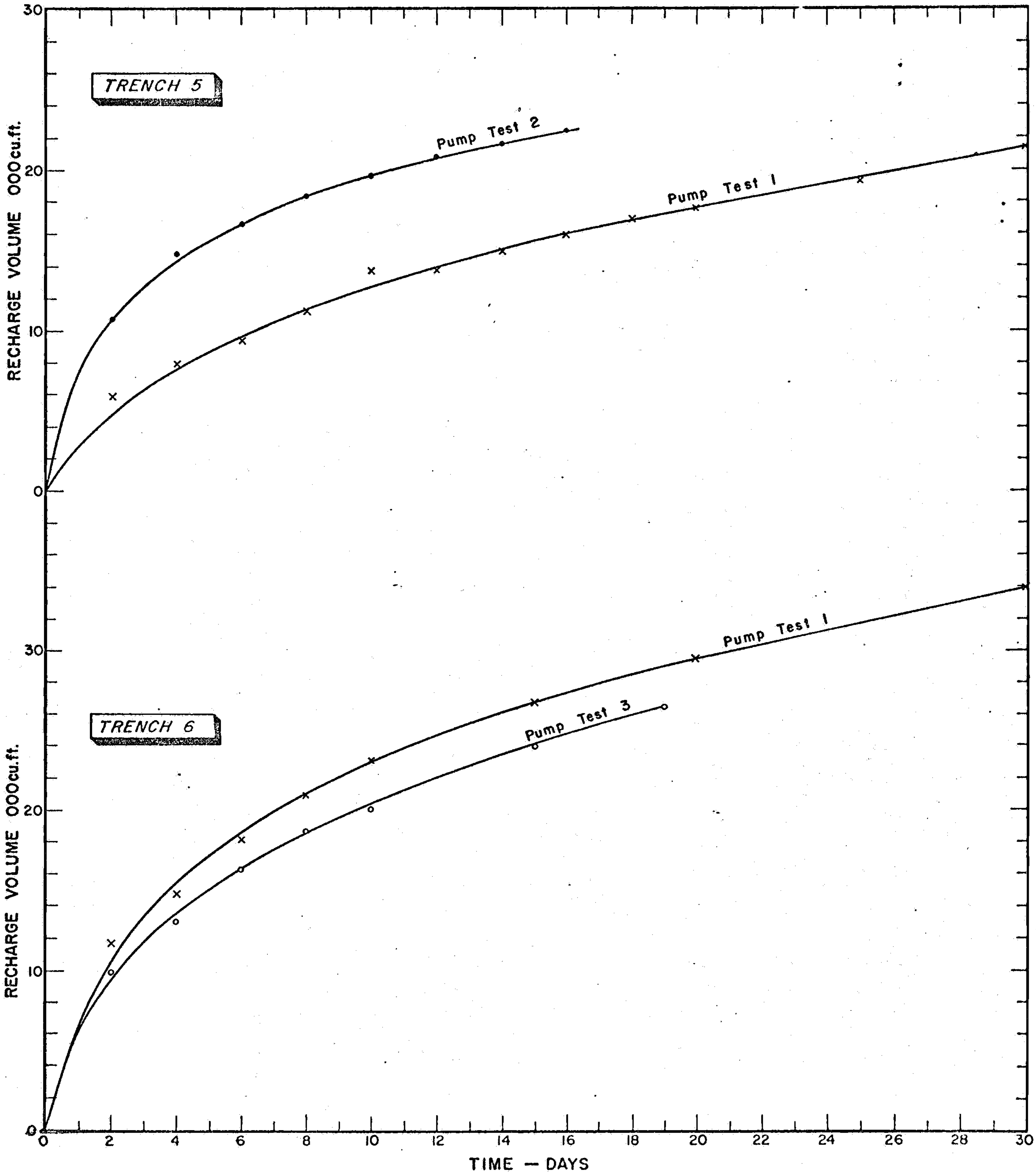


Figure 11

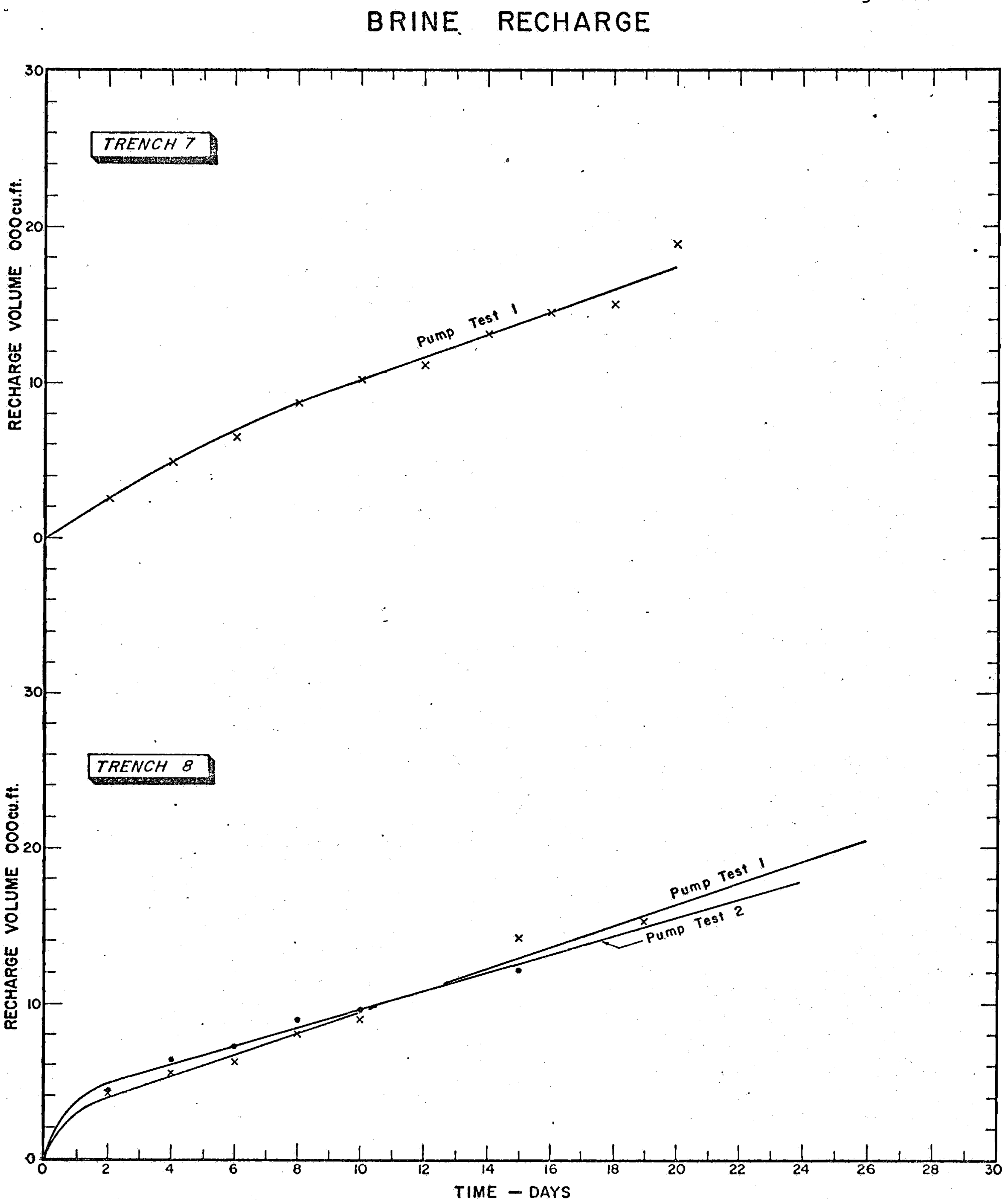

BRINE RECHARGE
TRENCH 7
RECHARGE VOLUME 000cu.ft.
Pump Test 1
TRENCH 8
RECHARGE VOLUME 000cu.ft.
Pump Test 1
Pump Test 2
TIME — DAYS
0
10
20
30
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

Figure 12

BRINE RECHARGE

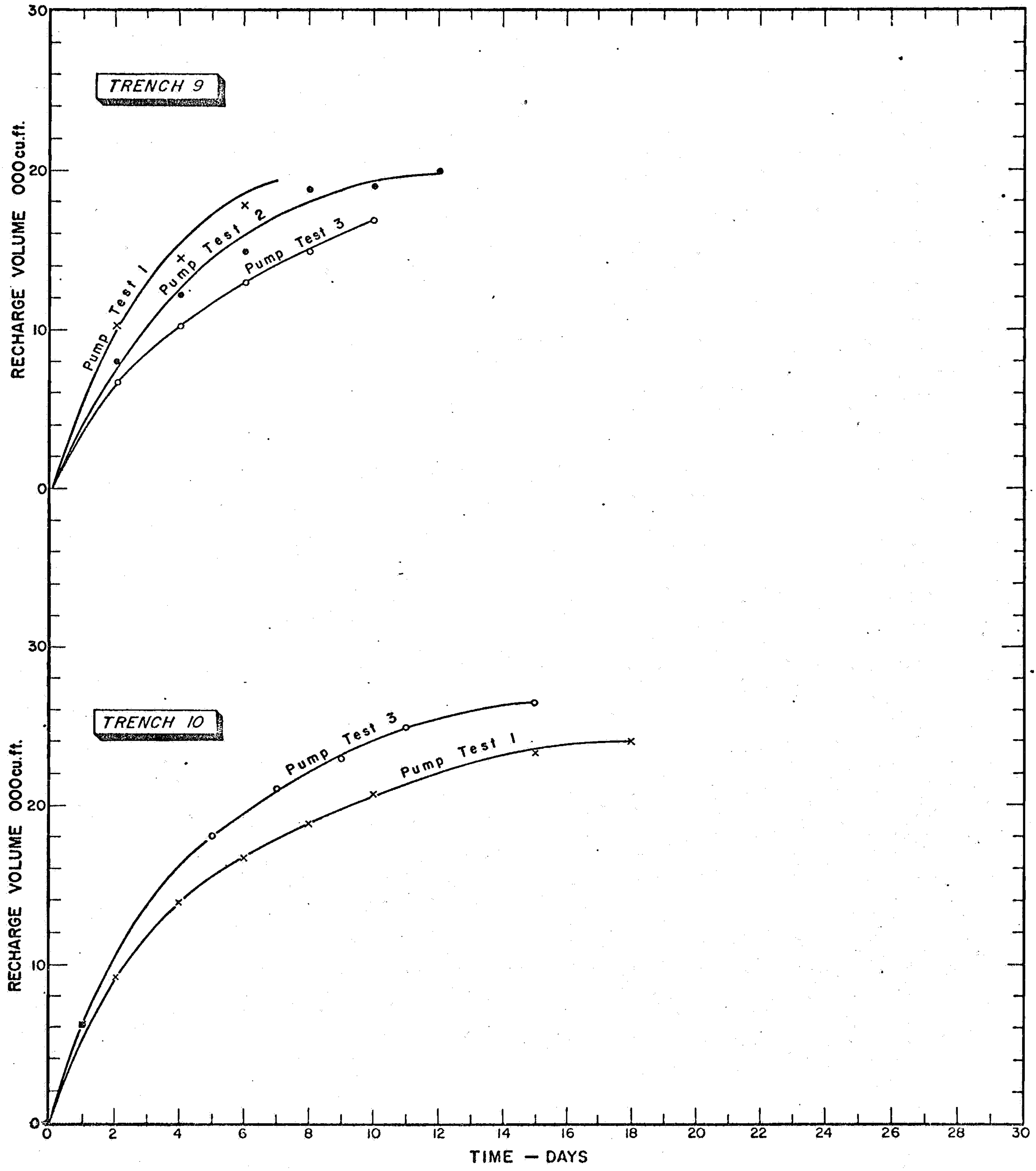


Figure 13

BRINE RECHARGE

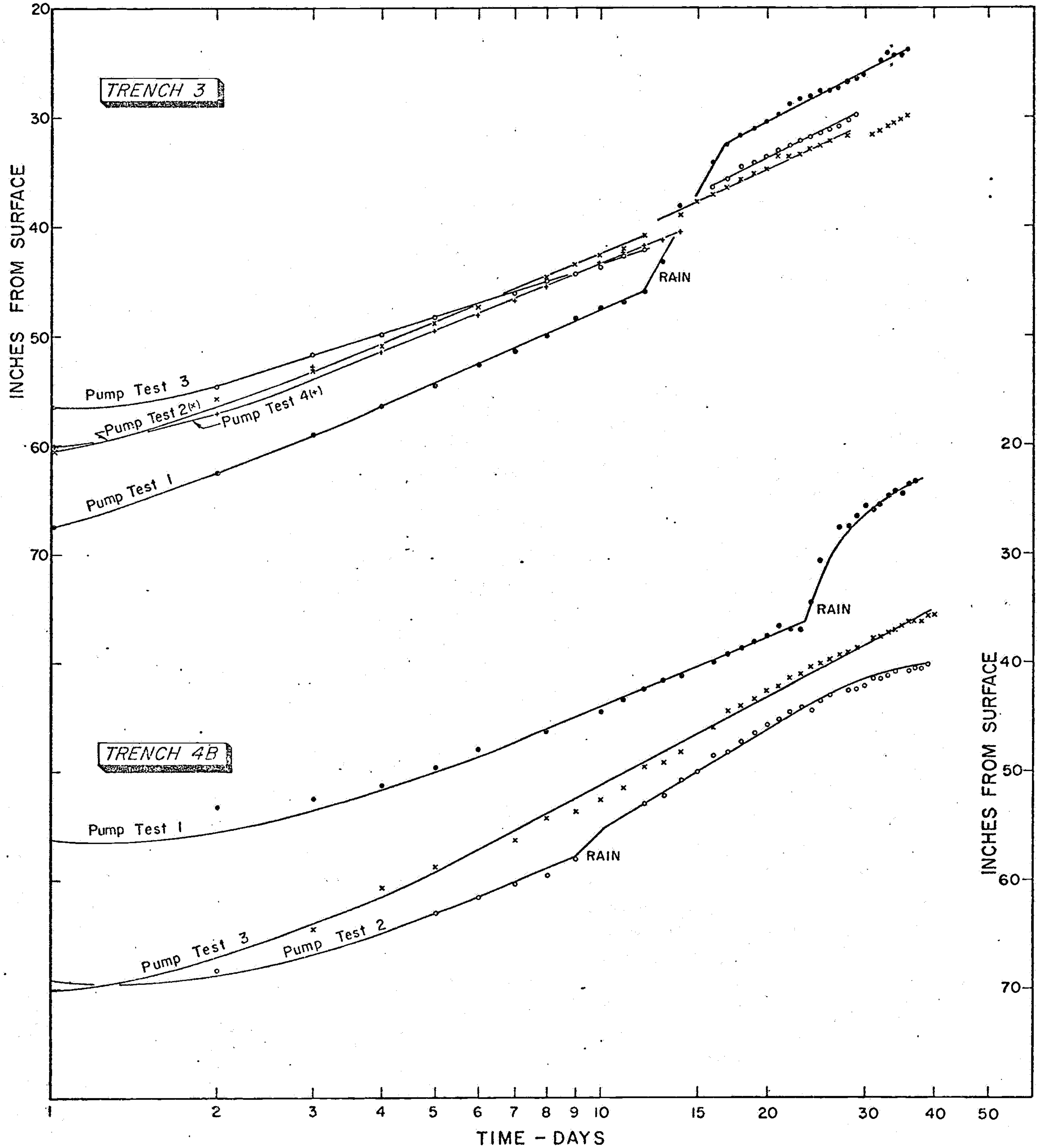


Figure 14

BRINE RECHARGE

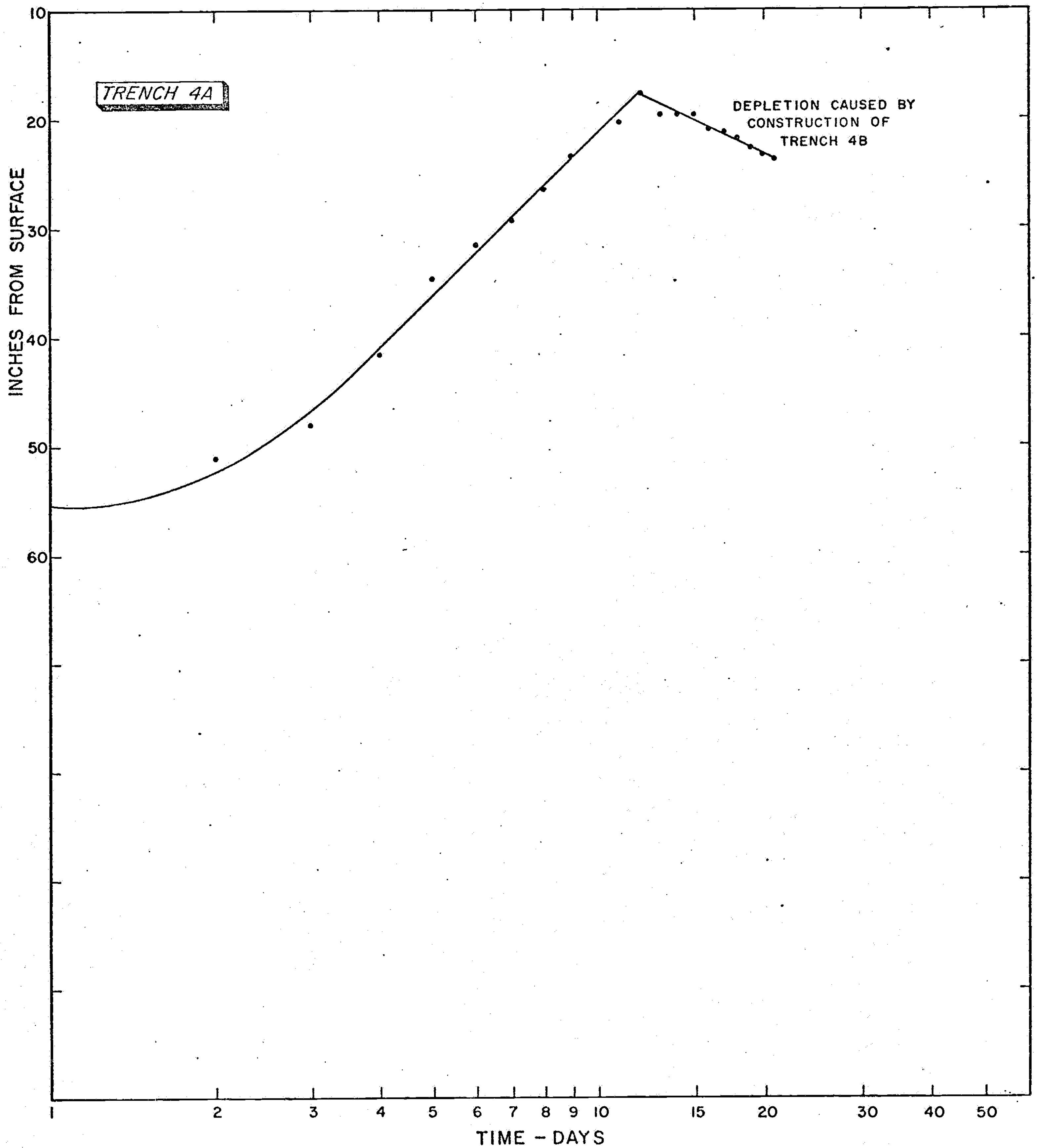


Figure 15.

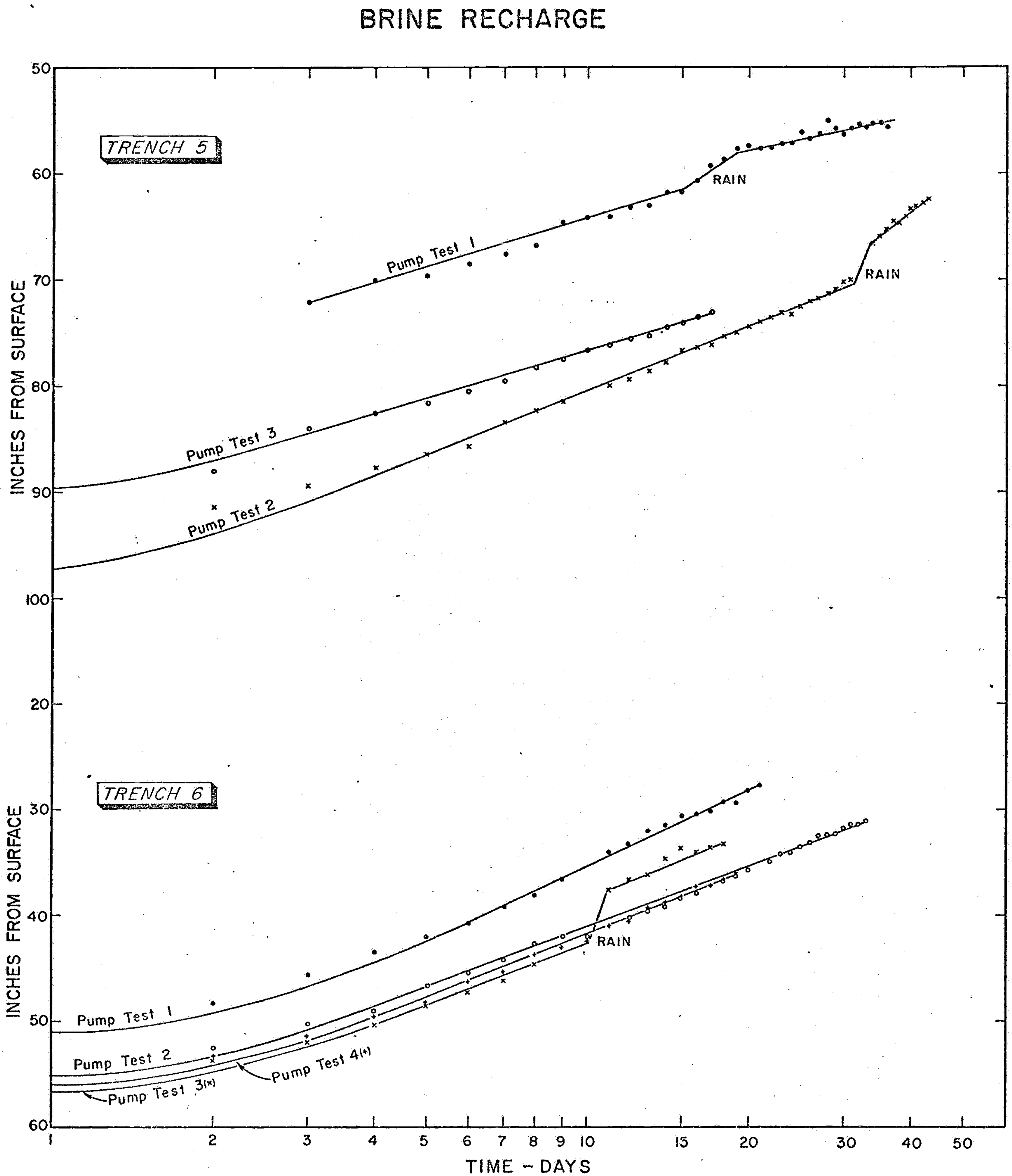

BRINE RECHARGE
TRENCH 5
Pump Test 1
RAIN
Pump Test 3
Pump Test 2
RAIN
INCHES FROM SURFACE
50
60
70
80
90
100
20
30
40
50
60
TRENCH 6
Pump Test 1
Pump Test 2
Pump Test 3(x)
Pump Test 4(+)
RAIN
INCHES FROM SURFACE
1
2
3
4
5
6
7
8
9
10
15
20
30
40
50
TIME - DAYS

Figure 16

BRINE RECHARGE

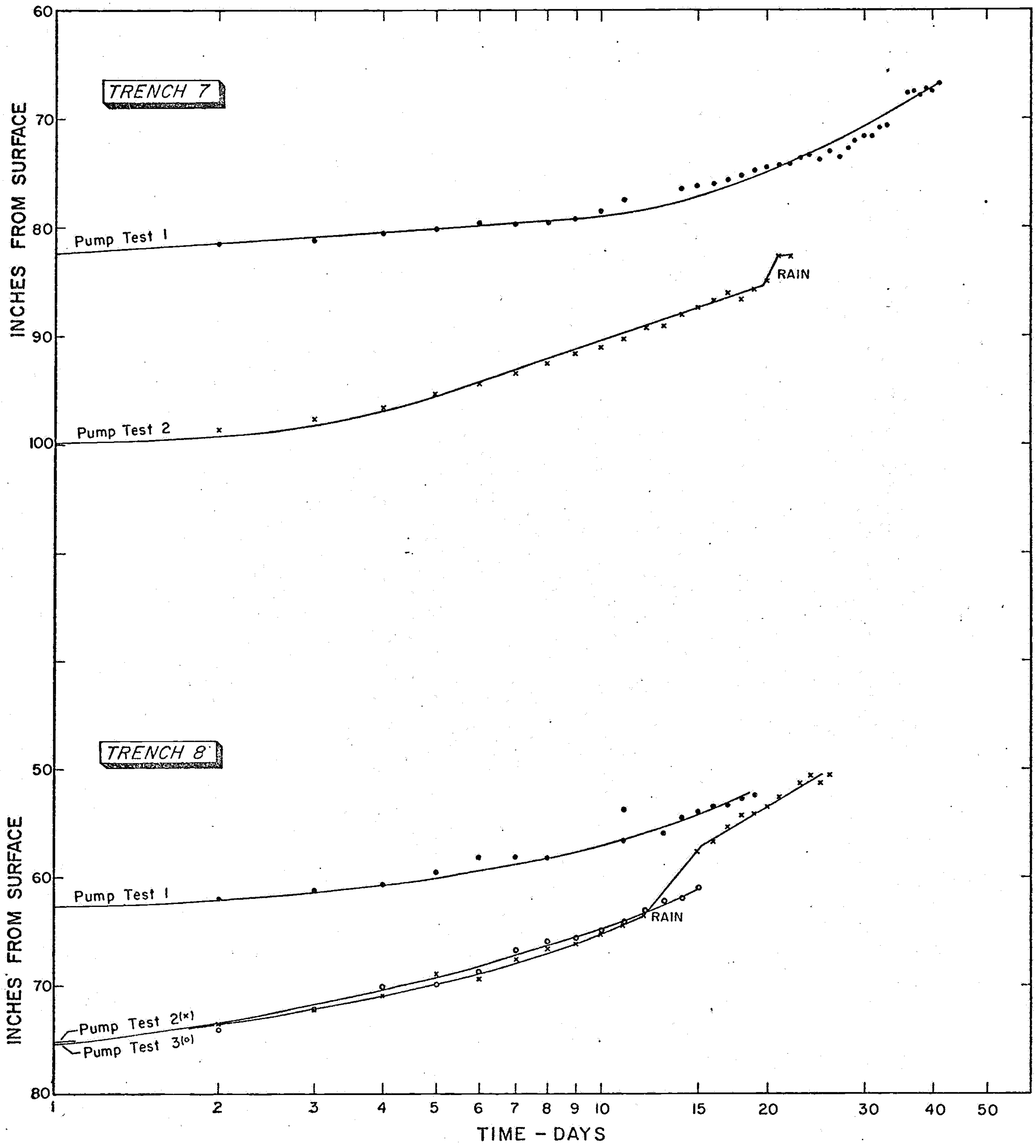


Figure 17

BRINE RECHARGE

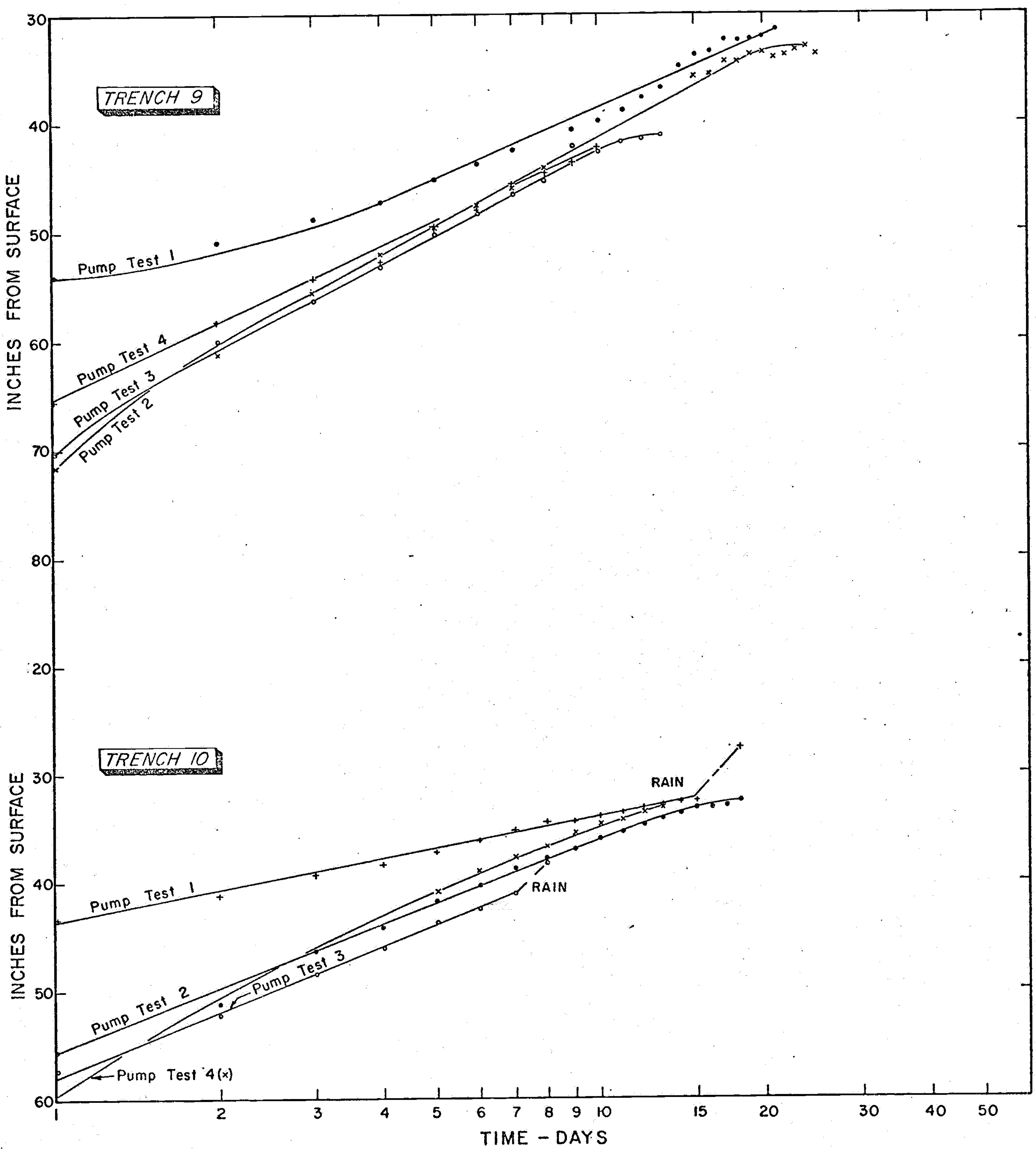


Figure 18

Expenditures

A large part of the proposed 2-year work programme for Exploration Licence 60 was condensed into 12 months.

Major factors affecting items or services with abnormal costs are as follows:

1. Necessity of purchasing specialised amphibious equipment.
2. Labour and standby-labour required for 20 hour/7day work schedule.
3. Extraordinary rainfall and lack of adequate road system.
4. Remoteness of site.
5. Excessive maintenance resulting from brine corrosion effects.

from Summary Report.

Lake Torrens Exploration Programme

Items	Expenditure May-Dec.1973		Expenditure May 1973-March 1974	
Sals, wages & assoc costs	38,807		48,724	
Travel & Accommodation	3,026		3,297	
Entertainment	165		165	
Consultants	19,045		19,045	
Operating Expenses:				
Dragline	31,086		32,561	
Pumps	685		996	
Camp	10,967		11,356	
Other Equipment	4,731		5,271	
Equipment Rental	2,620		3,520	
Assays	2,391		2,948	
Capital Equipment Purchase				
Dragline	30,894		39,150	
International Pick Up	6,760		6,760	
Toyota swb	4,142	17253	4,142	17253.
Toyota $1\frac{1}{2}$ ton flat bed	3,488	10% =	3,488	10% =
BUE Earth Cruiser	2,863	$1725	2,863	$1725
Honda ATC 90 bikes x 7	3,442		3,990	
ATV Vehicle	745		745	
Walkie Talkies x 4	257		257	
2 way Radio	899		899	
Generator-Petbowlister	2,406		2,406	
Pumps K & L Diesel	5,176		5,176	
Camp Equipment	1,244		1,244	
Survey Gear	700		700	
Power Auger	486	Remainder	486	Remainder
Miscellaneous	1,224	$47473	1,224	56277
	178,249	20% = $9495.	201,413	20% = $11255.

With allowable capital expenditure Total → $124743 $140863.

Future Programme

Rapid and "equilibrium" pump tests of Trenches 9 and 10 will be continued in an effort to further refine production rates and drawdown effects of sediments in the Foreset Area "A".

Deep (15 feet) observation wells will be drilled and cased in order to further define the extent of brine depletion and to record the rate of replenishment of the acquifers.

Samples of sediments and brine from Foreset Area "A" will be collected and analysed in order to develop more reliable data on recoverable and in situ reserves.

A second weather station will be established on Lake Torrens, in the vicinity of Trench 10, and on-site evaporation characteristics of dense brine will be documented and correlated with normal meteorological data.

Chemical analyses and experimental evaporation-crystallisation of dense brine will be conducted in the laboratory in order to determine the feasibility of producing NaCl to specification and to estimate the rate of recovery.

PETROCHEMICAL CONSORTIUM
OF
SOUTH AUSTRALIA

LAKE TORRENS BRINE EXTRACTION PROGRESS REPORT N°2.

C.Bleys & Associates

MARCH.'74

CHRIS BLEYS AND ASSOCIATES
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Kingswood, S.A. 5062
Telephone 71 9877

PETROCHEMICAL CONSORTIUM

OF

SOUTH AUSTRALIA

LAKE TORRENS BRINE EXTRACTION

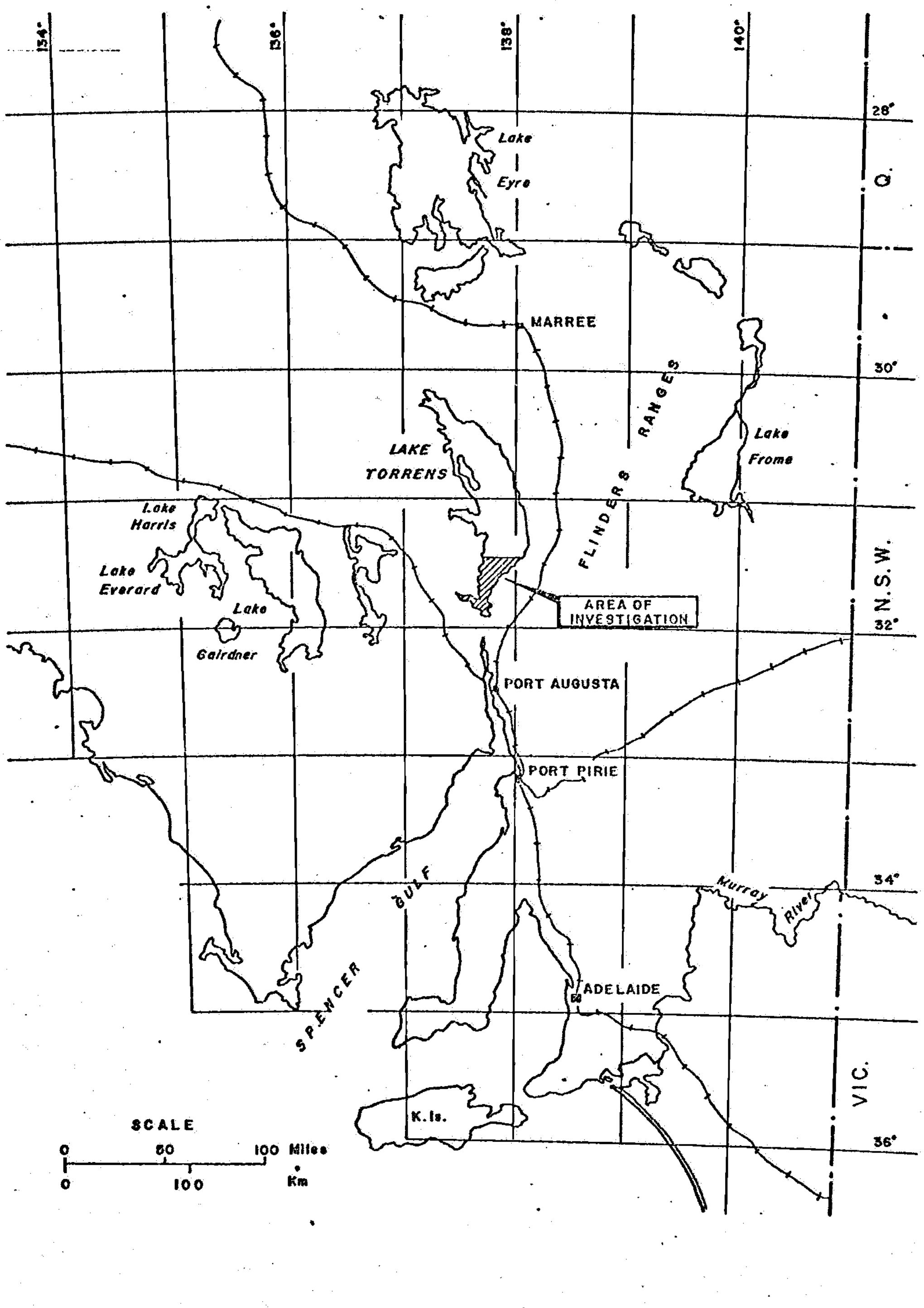
PROGRESS REPORT: No 2

CONTENTS

TABLES

FIGURES

C.BLEYS & ASSOCIATES



PETROCHEMICAL CONSORTIUM OF SOUTH AUSTRALIA

LAKE TORRENS BRINE EXTRACTION

LOCALITY PLAN

Fig I

CONCLUSIONS

The new data made available to the author have enabled calculations of storativity and transmissivity values to be made. These computed aquifer parameters suggest that:

- Without taking into account the recharge of brine either from the lower levels or laterally, sufficient brine is available for 8 years of production at a rate of 4 million m^3 per annum
- At a distance 1000 m away from Trenches 9 and 10, the cones of drawdown created after pumping them continuously for 1000 days is negligible
- After pumping two trenches, constructed 500 m apart, continuously and simultaneously for 1000 days, a mutual interference of 0.25 m would occur

The chemical analyses have made it possible to calculate the quantities of NaCl in solution per square km of surface area of sand. The estimates show that:

- In the vicinity of Trenches 3, 4, and 7, a volume of 24,000 to 30,000 Tonnes of NaCl per km^2
- More than 100,000 Tonnes of NaCl per km^2 is stored near the Trenches 9 and 10

In these estimates, the quantities of NaCl stored in the clays and silts have not been taken into account.

From the information at present available it has been calculated that 42 km long trenches would be required to produce 4 million m^3 of brine per annum.

RECOMMENDATIONS

Although the drilling of observation wells, the excavation of pits and trenches, and pumping tests have yielded valuable information, there are still certain aspects of the project for which insufficient documentation is available in order to be able to arrive at definite conclusions.

In order to overcome these problems and to obtain even better estimates on the potential brine production, it will be necessary to:

- Drill observation wells open to the lower Aquifers 2 and 3 Done
- Deepen the trenches so that Aquifer 3 can be fully penetrated ?
- Drill 2 or more exploration holes to a depth of 150 m in order that an assessment can be made of the brine content in the sediments occuring at a depth greater than 4.5 m Possible
- Conduct pumping tests at a considerably lower discharge rate so that the trenches are not emptied during a test conducted over several days Pumps purchased & on hand
- Take measurements of the drawdown levels during the pumping test and the sebsequent recovery period after the pumping has been stopped. ok

1. GENERAL

In the period from January 1st to March 1st 1974, a considerable amount of additional data relating to the Lake Torrens Brine Extraction Project was made available by Delhi International Corporation. This information includes:

- Rainfall and evaporation data
- Pumping test measurements
- Chemical and petrographic data
- Interpretation of Geological data

This additional data was discussed on various occasions with Mr. R.R. French of Delhi International Corporation who is in charge of the investigations.

2. REQUIREMENTS

Mr. French advised that production of NaCl from Lake Torrens will be reduced from the anticipated 800,000 Tonnes to 214,000 Tonnes in the first year of procudtion, and will thereafter be increased as follows:

- 2nd year: 330,000 Tonnes
- 3rd year: 400,000 Tonnes
- 4th year: 440,000 Tonnes

An additional 320,000 Tonnes of NaCl will be produced at the salt pans north of Red Cliff.

This proposition will allow ample time for a large scale investigation into the production of salts from the lake during these 4 years which will assist in estimating the total potential withdrawal rate of brines.

3. WORK COMPLETED

Work completed during the period falls within two categories; field work, and office duties.

3.1 Field Work

Arrangements were made to visit Lake Torrens on the 2nd and 3rd January, 1974. On these days, all trenches, observation holes and exploration pits constructed were inspected. This site investigation assisted in a better understanding of the problems related to the extraction of brine from the lake sediments. On this occasion, the writer was also shown the various methods used to obtain hydrological data.

On February 25th and 26th, a second field trip was made by the writer who was, on this occasion, accompanied by Mr. R. R. French. Heavy rainfalls during December, January and February had left surface waters of a density of 1% standing on some parts of the lake. Special attention was paid to these waters and their effect upon the brine level in Trenches 9 and 10, which contained no surface runoff. The delta of Willochra Creek (which contributed a considerable volume of water to the lake) was inspected and small pools of water of a density of 1% were observed.

3.2 Office Duties

These duties include attending meetings held at the offices of Delhi International Corporation.

The additional data supplied by Mr. French made it possible to:

- Prepare further estimates on the volumes of brine stored
- Correlate the recovery levels of various pumping tests
- Assess the effect of pumping on the aquifer levels
- Make further estimates of transmissivity
- Estimate the distance apart at which two trenches should be placed in order to ensure the absence of mutual interference while pumping them simultaneously

The above mentioned estimates made it possible to assess the shape of the cone of drawdown which will be created after 1000 days of continuous pumping.

4. RAINFALL

Precipitation and evaporation data are collected at a meteorological station established at the camp site, about 1.5 km south of Lake Torrens. The rainfall during September, October and the first half of December was as low as expected. However, during the last days of December and the months of January and February, unexpected high rainfalls were recorded. (Fig 2-1)

These high rainfalls have affected the investigations as, due to the wet surface, some trenches and observation holes could not be reached in order to record water levels. Other observation holes have collapsed as a result of the influx of surface waters.

The high rainfalls will probably increase the brine level in the sediments and the level is not likely to fall to its yearly autumn low level

A resume of the rainfall data is tabulated in Table 1. However, as during the first few days of February the camp site could not be reached, no daily rainfall data is available for this period.

It is reported that the rainfall on the lake was possibly higher than that recorded at the camp site as it appeared that some showers which fell on the lake did not reach the meteorological station. It may be possible to check this with the rainfall data from South Gap Station, which to date, has not been received.

4.1. Rise in Brine Level

Sudden rises in the brine level of the trenches have been reported. These can be almost wholly related to the precipitation as the catchment area formed by the surrounding walls of spill is at least twice the surface area of the brine. The slow recovery of the brine levels in the trenches suggests that the additional rainfall will filter into the aquifers only slowly.

On February 26th, the levels measured in Trenches 9 and 10 were approximately 0.43 m below the surface, the estimated static water level. (Figs 3 and 9 of the Feasibility Study) It has not as yet, however, been established whether the lake surface waters have actually percolated downwards to the body of brine and increased the total volume stored.

4.1.1. Brine Density

Brine densities have been affected by the high rainfalls. On February 7th, some three days after a total rainfall of 127.7 mm, the brine density in Trench 10 was reduced from 20% to 14%. No further rainfalls were recorded during February. On February 26th, the brine density in Trench 10 was found to have recovered to 19% - the normal level. It is therefore believed that evaporation has not affected the density to any great extent, and that the increase in the density is due to leaching of the spill surrounding the trench.

5. EVAPORATION

Evaporation data, which is obtained from an Australian pan installed near the camp site, is illustrated on Figure 2-1 and is tabulated in Table 2.

Evaporation for February was probably lowest during the first 4 rainy days when a total rainfall of 14.99 mm was recorded over a 5day

TABLE 1

RAINFALL DATA

Year	Month	Total (mm.)	Maximum Per Day (mm)	No of Days of Rain
1973	September	30.99	16	8
1973	October	40.64	14.22	10
1973	November	13.72	6.86	4
1973	December	38.35	30.48	6
1974	January	75.18	29.46	5
1974	February	68.83	53.09 (4 days)	4

TABLE 2

EVAPORATION DATA

Month	Total (mm)	Daily Average (mm)	Highest	Date	Lowest	Date
1973						
September	117.04	5.9	13.46	30th	2.79	7th
October	211.46	7.14	13.46	16th	0.76	17th
November	299.95	9.99	20.83	20th	2.29	3rd
December	396.20	12.8	26.92	22nd	0.51	14th
1974						
January	389.89	12.5	21.95	25th	3.30	28th
February (to 26th)	219.96	8.4	13.72	11th (during rainfall period)		

period. The evaporation figures above do not, however, reflect the actual evaporation from the lake surface or the evaporation of waters contained in the soils forming the lake bed. An attempt has been made to relate the evaporation data to the fall in water level in the observation holes, but to date these measurements do not reflect the effects of evaporation.

6. SAND PERCENTAGE

Delhi International Corporation has produced a map, based on the geological sequence observed in exploration auger holes and pits, showing the percentage of sands occuring in the 6.26 m of sediments excavated. (Fig 2-2) This map shows that in 31% of the area investigated more than half of the sediments penetrated consist of sands, while on 51% of the area, the sand content is between 25% and 50%. The area covered by these sand percentages are tabulated in Table 3.

The extent of these areas is important in relation to the volume of brine stored and the quantities of fluid which can be produced. It should be noted that Trenches 10, 9, 7, and 5, or part thereof, have been dug in Areas 1 and 2.

In order to assess the volume of brine stored in the various areas, it is necessary to know the storativity, "S", of the sands penetrated.

6.1 Storativity

The petrographic and chemical analyses of samples taken from Trenches 3, 4, 7, 9, and 10 have been used to assess the storativity of the aquifer penetrated. However, two different methods were used. Storativity values calculated on the basis of both methods have been used to assess the volumes of brine stored and the cones of drawdown to be expected under heavy pumping conditions and will be discussed later.

6.1.1. Filtration Method

Porosity values of the sand samples of the trenches were calculated by weighing a portion of the bulk samples, then drying and reweighing them. The remaining portions were filtered and the same procedure as above applied. The measured loss in weight is the value of the specific retention. By subtracting the specific retention from the porosity the value for storativity is obtained. These values are

TABLE 3

SAND PERCENTAGE

Area	Percentage	Coverage (km^2)
1	>50	17.
2	>50	5.7
3	$<50>25$	37.2
4	<25	13.

given in Table 4.

It will be noted that the storativity of the lower sand samples are generally the highest. However, on the whole, the estimates are low as storativity values for sands and silts usually range from 15% to 35%. It must be remembered however, that during transportation of the samples to Adelaide, a portion of the fluid may have drained off or evaporated resulting in the low storativity values recorded, which are almost equivalent to those of clays and silty clays. It is thus possible that the tabulated storativities do not present a true picture of the situation, and therefore another approach has been used to arrive at more probable and realistic values.

6.1.2. Sand Sieve Analyses

Sieve analyses were made of wet sand samples. The accumulated percentage of weight and volume of the various samples was then calculated. The results of these analyses are illustrated in Figures 2-3 to 2-5. A specific yield curve of average sand samples, which has been used to estimate the storativity of the samples, has also been shown on these figures.

It is interesting to note that up to 80% of the sands have a storativity of well above 20% and that less than 40% of the samples have a storativity between 10% and 20%. On the basis of these figures an estimated storativity value of 20% is reasonable particularly for those areas where the sand content is more than 25% of the total sediments penetrated (Areas 1, 2, and 3, Fig 2-2).

7. PUMPING TESTS

In the period from September 1973 to February 1974, some 15 pumping tests have been conducted to evaluate the volumes of brine stored. Due to the slow movement of the fluid through the aquifers, the static brine levels were not reached before any of the pumping tests were conducted.

The recharge mechanism is of great importance for the assessment of the potential volume of brine extraction but the recharge measurements can only be used for this purpose. Although a large number of observation holes have been drilled near the trenches to the top of Aquifer 1, most of these are no longer suitable for brine level measurement as they have collapsed due to the downwards movement of surface waters.

TABLE 5

DAILY RECHARGE RATE
PER METER LENGTH OF TRENCH

Days After Pumping Stopped	Trench 9 $m^3/d/m$	Trench 10 $m^3/d/m$
1	0.516	0.61
2	0.28	0.478
3	0.13	0.248
4	0.196	0.178
5	0.148	0.154

TABLE 4

STORATIVITY ESTIMATES

Trench No	Sampling Depth (m)	Porosity %	Specific Retention %	Storativity %
3	0.76	18.59	8.95	9.64
3	1.52	15.13	4.44	10.69
4	1.06	16.46	11.16	5.30
4	2.71	14.65	12.72	2.17
7	1.52	22.03	16.70	5.93
7	2.28	18.81	12.33	6.84
7	2.46	22.29	18.85	3.44
9	0.63	18.37	12.78	5.59
9	0.81	16.61	9.79	6.82
9	2.46	20.08	7.60	12.48
10	1.98	18.95	8.95	9.00

7.1 Recovery Curves

In order to evaluate the pumping tests, recovery data has been plotted on semi-logarithmic paper (Figs 2-6 to 2-9). These figures illustrate a similarity in the recharge patterns of the trenches and indicate that to date, the withdrawal of brine has not affected the recharge rate. They cannot, however, be used to assess a fall in the brine levels. However, such falls in levels is not expected to occur as yet as only small quantities of brine have been withdrawn from the very large body of fluid.

On the Figure 2-9 of Trenches 9 and 10 the amount of rain which fell during the recovery of the first and second pumping tests is shown. This rainfall did not affect the trend of the recovery after the first pumping test on both trenches, neither of which could be reached after the heavy rainstorms. As a result, no brine levels were taken until February 26th, at which time the highest levels ever were recorded.

The observation holes drilled are about 1.80 m deep and the brine levels measured in these reflect those of the upper Aquifer 1. The brine movements in the observation holes near Trenches 9 and 10 together with the recovery data of these trenches have been plotted on Figure 2-10. These curves indicate a much more rapid recovery in the trenches than in the observation wells. The change from a convex into a concave curve suggests that Aquifers 2 and 3 produce the largest volume of brine. This is also evident from the decrease in daily recharge rates which indicates that Aquifer 1 contributes only a small portion of the total brine. This general decrease in recharge rate is illustrated in Table 5.

In cases where pumping tests are conducted over a long period of time at a constant pumping rate, the drawdown and recovery curves can be used to calculate the transmissivity of the aquifer(s) and their values used to predict the cone of drawdown which will occur after an extended period of pumping. These extrapolated cones of drawdown can then be used to predict the distance apart at which two trenches should be placed to ensure the absence of mutual interference while both are being pumped continuously. However, another method has been used to obtain this information and will be discussed hereunder.

7.2 Transmissivity

When a pump test is conducted on a trench, the trench is emptied in a short period of time whereafter the brine level is allowed to recover in it. As a result, such a pump-tested trench can be compared to a surface stream in which the flow level decreases due to a reduction in the volume of runoff and which is recharged by groundwater.

Rorabauch (1964) estimated the total outflow of groundwater into water courses during periods of low surface flows and produced equations for semi-confined aquifers to obtain reliable estimates of "ST". His equation is as follows:

$$Q^2 = s^2 \frac{ST}{\pi t}$$

where: Q = groundwater flow rate per unit distance

s = the recovery rate per unit time

S = storativity

T = transmissivity

t = time unit

and can be used for this project.

Values of ST were computed for Trenches 4, 6, 7, 9 and 10 and various values for each trench obtained. The maximum and minimum values are tabulated in Table 6.

As the transmissivity is dependent on the thickness of the aquifer, the high values of Trenches 4 and 6 are therefore not unexpected inview of the relative thinness of the sand beds penetrated. In general the values for ST appear to be reasonable for these types of brine aquifer.

8. EXPECTED CONE OF DRAWDOWN

In order to design a well or trench field, the expected cone of drawdown created by pumping continuously over a long period of time should be known.

As the brine is to be extracted from trenches, the drain equations (Ferris et al. 1962) should be used to calculate the shape and extent of the cone of drawdown. These equations are:

$$s = \frac{Qr}{2T} D(u)q$$

$$u^2 = \frac{r^2 s}{4Tt}$$

Where: s = the drawdown

Q = the pumping rate per unit length (m)

r = distance from the trench

TABLE 6

STORATIVITY X TRANSMISSIVITY

Trench	ST Maximum $m^3/d/m$	ST Minimum $m^3/d/m$	ST Average $m^3/d/m$
4	8.1	4.7	6.5
6	15.	4.8	9.
7	2.5	1.9	2.4
9	12.	3.1	5.9
10	8.4	3.1	5.6

t = time unit (days)

S and T as previously defined

D(u)q is a function of u

Drawdown curves have been calculated for a period of 1000 days for Trenches 4, 6, 7, 9 and 10. The computed drawdowns are based on the:

- average "T" shown in Table 7
- various values of S
- average recharge rates, "Q", per meter length as determined for each trench

A semi-logarithmic graph of the calculated drawdowns at various distances away from the trenches has been used to draw the cones of draw down best suited to the points plotted. These are illustrated on the Figures 2-11 and 2-12, and are tabulated on Table 7.

It will be noted that no drawdowns have been calculated for the various trenches at distances of 100 m and 1000 m. This is due to the inaccuracies which arise if the value of D(u)q is greater than 10 or smaller than 0.05.

In the vicinity of these trenches turbulent flows will occur, resulting in drawdowns larger than those which would be expected to occur from extrapolation of the curves to these points. Therefore the curves have not been continued close to these points. This indicates that trenches should be constructed to a depth of at least 4.5 m in order to allow for turbulent flows.

To facilitate comparison between the cones of drawdown of all the trenches, drawdowns have been calculated on a common withdrawal rate of Q = 0.147 $m^3/d/m$, and a storativity of 20%, except for Trench 7 where the maximum "S" is probably not more than 17%. Figure 2-13 illustrates the computed cones of drawdown which shows that a negligible drawdown will occur 1000 m away from Trenches 9 and 10 by pumping continuously for 1000 days. It also illustrates a mutual interference of approximately 0.25 m resulting from 1000 days continuous and simultaneous pumping on two trenches constructed 1000 m apart. This additional drawdown due to mutual interference should be considered when constructing new trenches and where possible, should be accounted for by deepening them.

To date, Aquifer 3 has not been fully penetrated. If new trenches are constructed and the third aquifer penetrated completely, smaller drawdowns and greater recharge rates are expected during and after pumping, respectively. Pumping tests conducted on deeper trenches

TABLE 7

DRAWDOWN AFTER 1000 DAYS CONTINUOUS PUMPING

Trench	Q $m^3/d/m$	S %	Drawdown at Distances 100m	250m	500m	1000m
4	0.08	0.04	-	0.47	0.42	0.36
4	0.08	0.20	0.4	0.28	0.15	-
6	0.06	0.08	-	0.29	0.24	0.15
6	0.06	0.2	0.73	0.51	0.27	0.07
7	0.025	0.05	0.28	0.23	0.17	0.09
7	0.025	0.17	0.25	0.17	0.04	-
9	0.12	0.08	-	0.71	0.68	0.29
9	0.12	0.20	0.84	0.47	0.21	-
10	0.147	0.08	1.03	0.86	0.65	0.36
10	0.147	0.20	0.92	0.58	0.30	-

would result in smaller drawdowns in these and the observation wells and would indicate higher transmissivity values. These higher values substituted in the drain equations would illustrate less pronounced cones of drawdown than those calculated above.

9. BRINE STORED

The cones of drawdown constructed, and the expected upward movement of brine (described on P. 17 of the Feasibility Study) suggest that the quantities of brine obtainable from Lake Torrens are large. Without taking the recharge into account, a volume of 32.3 million m^3 of brine is stored in the area at present being investigated (Fig 2-2) This is illustrated in Table 8.

Without considering recharge, there is thus, sufficient brine stored for 8 years of production at an annual rate of 4 million m^3. If allowance is made for a lower withdrawal rate of 6.7 million m^3 of brine during the first four years, sufficient brine would be left for a further 6 years of production at the origionally proposed withdrawal rate of 4 million m^3 per annum.

10. NaCl STORED

An assessment can be made of the tonnage of NaCl contained in the sands occuring in the upper 4.5 m of Lake Torrens sediments by using the chemical analyses of McPhars Geophysics. These analyses yield data on the quantity of NaCl per acrefoot and are based on the total NaCl in situ and that occuring in the filtered fluid. The acre footage figures are somewhat misleading as they do not take into consideration the thickness of the sand beds. The data of the chemical analyses have been converted to Tonnes per km^2 for each sand bed penetrated and these are tabulated in Table 9.

This table illustrates that the best producing zones are those in which Trenches 7, 9 and 10 are located. It also shows that the sand beds in an area of one km^2 around the trenches will produce some 259,000 Tonnes of NaCl. Additional NaCl could also be obtained from the silt and clay beds as they would supply brine although in limited quantities.

11. AREA REQUIRED FOR PRODUCTION

The computed recharges of the trenches are best suited to the

TABLE 8

BRINE STORED BASED ON S = 20%

Area	Coverage km^2	Sand Thickness m	Silt Thickness m	Brine Stored $m^3 \times 10^6$
1	16.8	2.14	0.85	10.08
2	5.2	2.14	0.85	3.12
3	36.	1.10	1.06	15.5
4	11.9	0.45	1.06	3.6
			TOTAL	32.3

TABLE 9

QUANTITIES OF NaCl STORED

Trench No	Sand Thickness m	NaCl in Situ 1000 Tonnes Per km^2	NaCl In Fluid 1000 Tonnes Per km^2	
3	0.61	83.	24.2	32.6
3	0.45	63.5	8.4	
4	0.61	88.3	20.2	24.2
4	0.30	76.5	4.	
7	0.76	102.	21.4	
7	0.30	99.	8.7	31.4
7	1.21	70.3	17.3	
9	0.70	59.	12.3	
9	0.53	83.4	18.9	111.1
9	1.21	103.2	79.	
10	1.16	95.	51.9	107.6
10	1.22	112.6	55.7	

calculation of the length of discharge trench required for the production of 4 million m^3 ob brine per annum. Trenches 9 and 10 have a recharge rate of about 0.13 $m^3/d/m$ and on the basis of this flow, 42 km long trenches would be required. Twenty one km of these trenches could be constructed in Area 1 (Fig 2-2) if they are dug 1000 m apart. Another 9 km could be constructed in Area 2. The remaining 10km will have to be constructed in areas where the sand content is less than 50%, although they may thereby possibly yield smaller supplies of NaCl.

If the trenches are deepened and Aquifer 3 is penetrated completely, the flow of brine should be improved as this aquifer appears to contribute the largest quantity of fluid.

Although widening of the trenches and lowering of the gradient of the banks would not improve the flow of fluid, it would prevent collapses and would result in well exposed aquifers. Such potential improvements should certainly be investigated.

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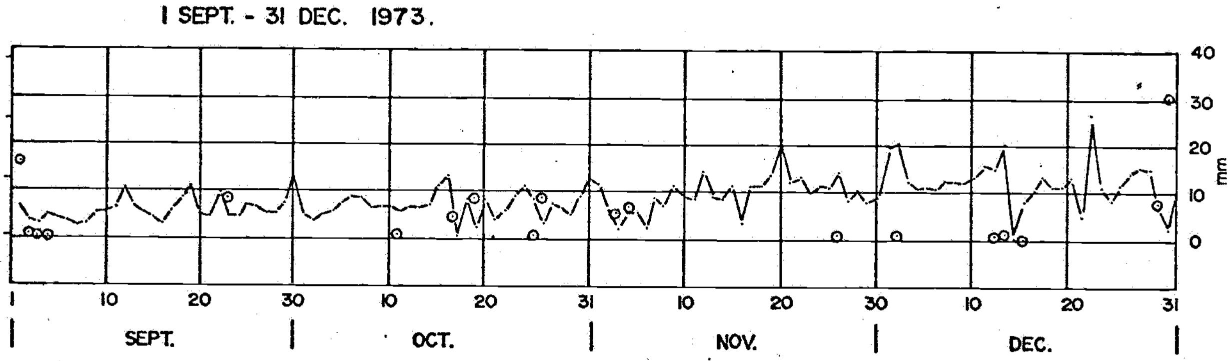
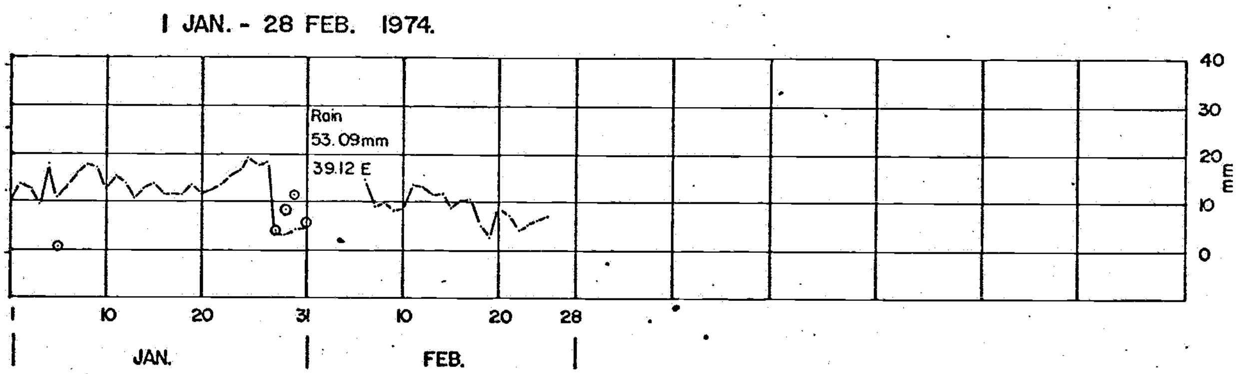




LEGEND

Precipitation ⊙
Evaporation ———

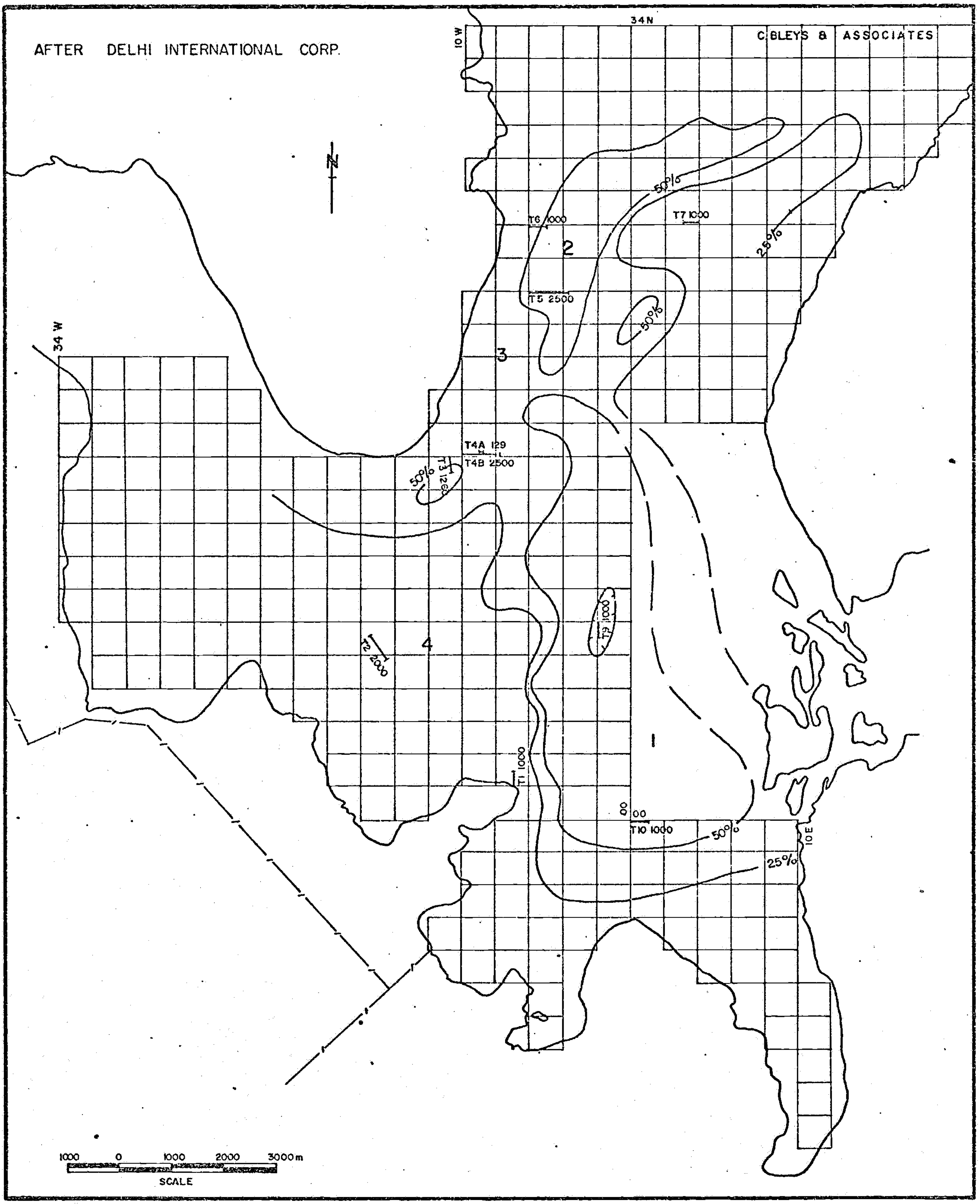
PETROCHEMICAL CONSORTIUM OF SOUTH AUSTRALIA

LAKE TORRENS BRINE EXTRACTION

RAINFALL & EVAPORATION AT CAMP SITE

Sept. 1973 - Feb. 1974

Fig 2 - 1

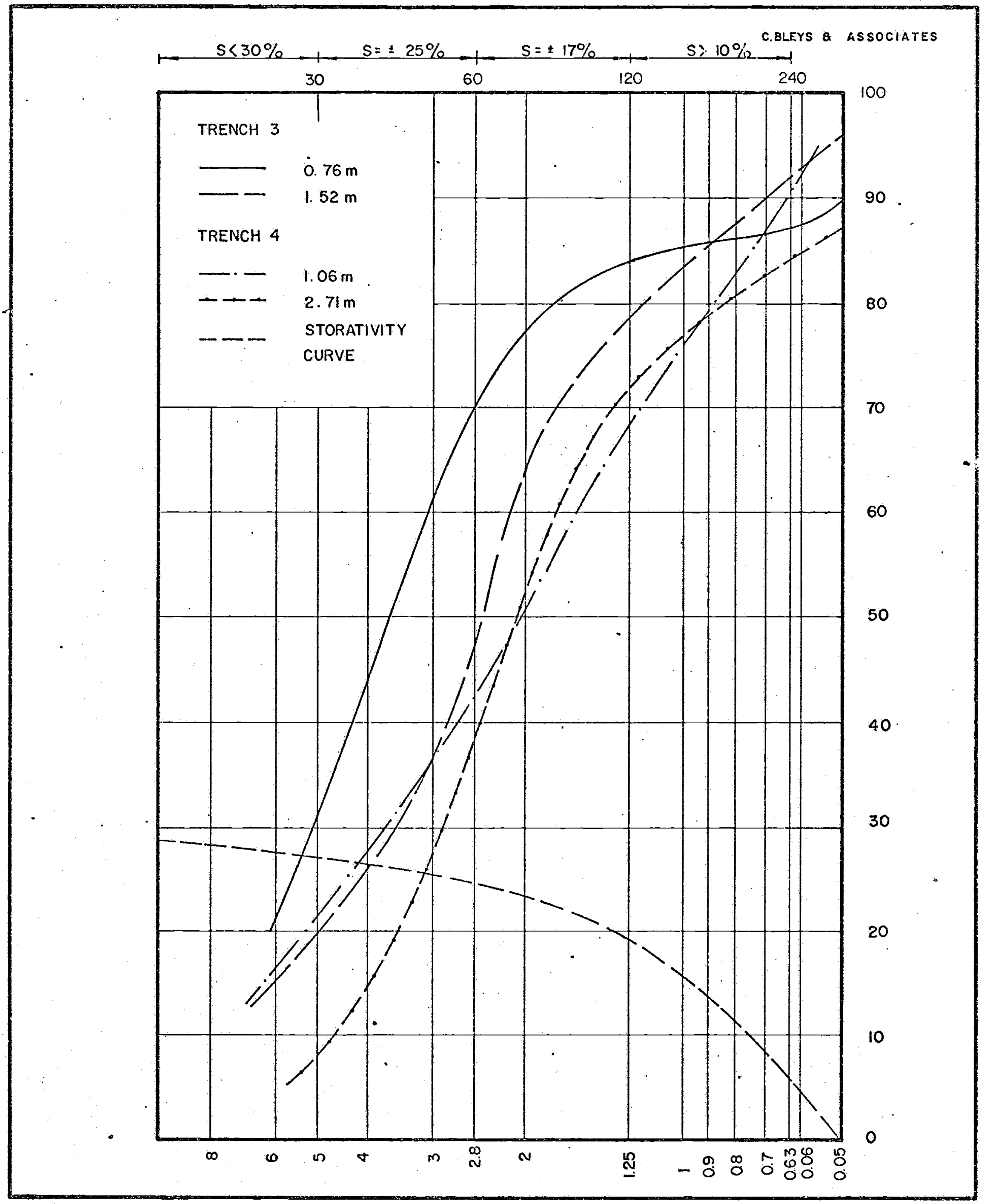


PETROCHEMICAL CONSORTIUM OF SOUTH AUSTRALIA

LAKE TORRENS BRINE EXTRACTION

SAND FACIES MAP

PERCENTAGE SAND IN UPPER 4.50m

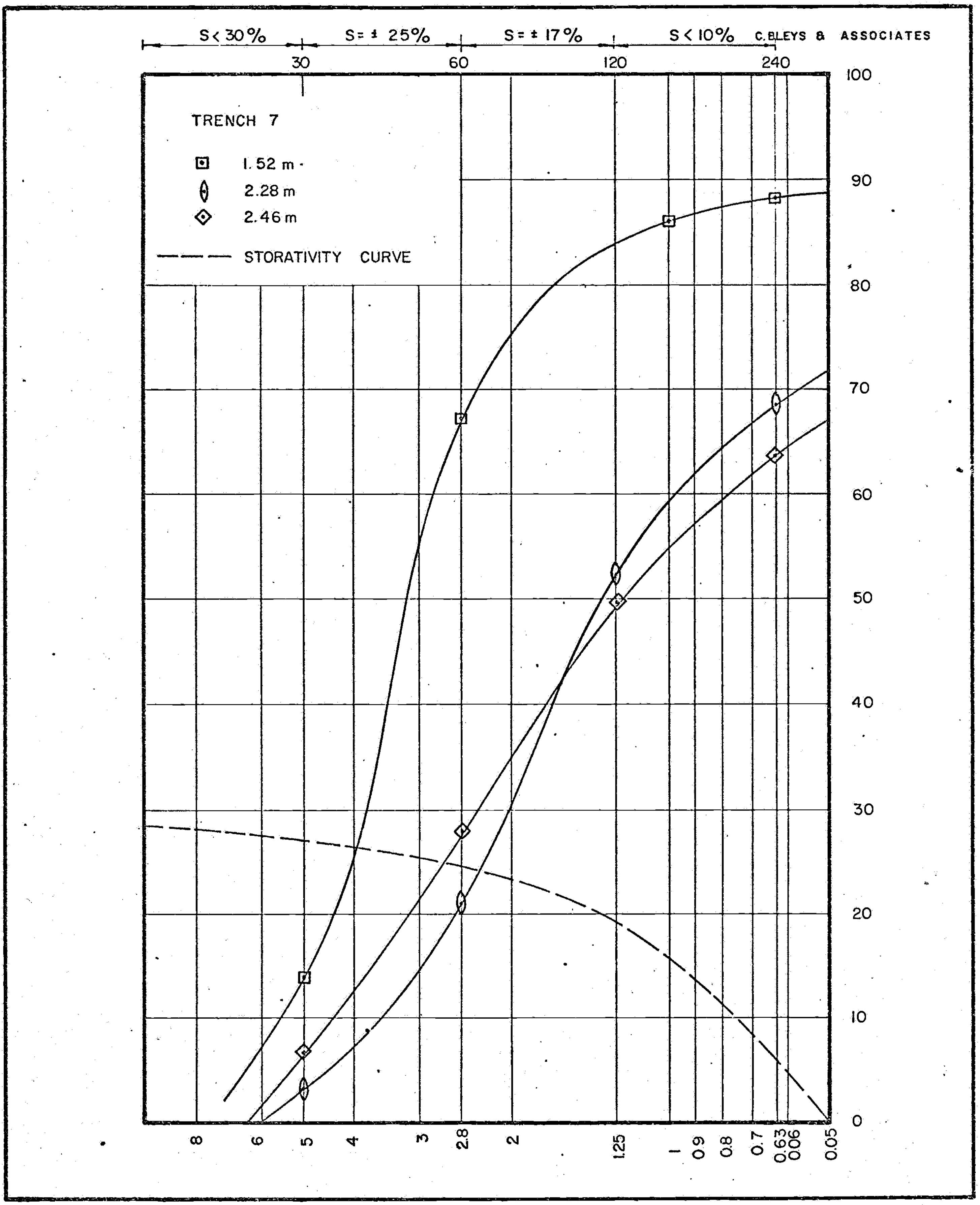


PETROCHEMICAL CONSORTIUM OF SOUTH AUSTRALIA
LAKE TORRENS BRINE EXTRACTION

SAND ANALYSES

TRENCHES 3 & 4

Fig 3.3

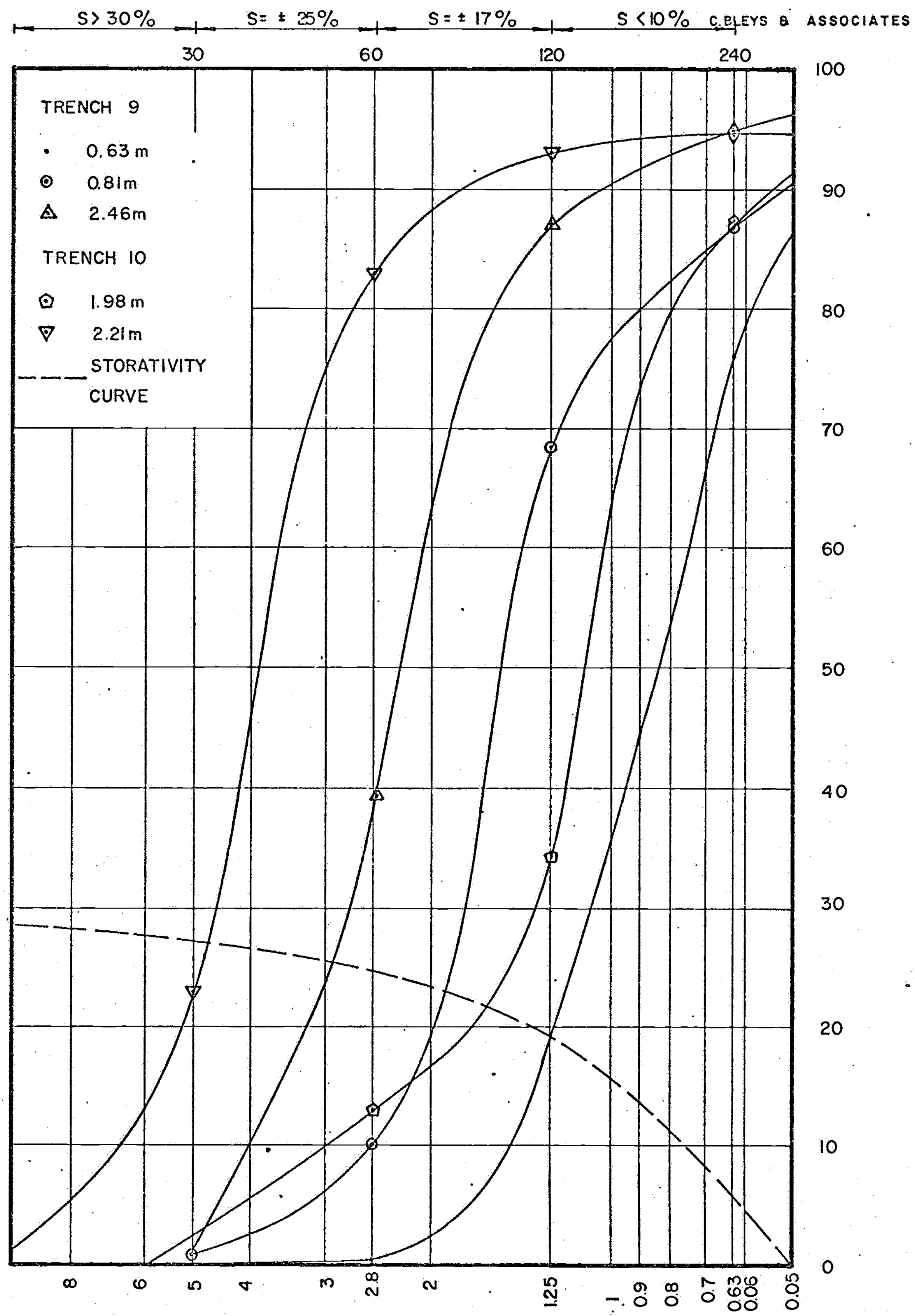


PETROCHEMICAL CONSORTIUM OF SOUTH AUSTRALIA
LAKE TORRENS BRINE EXTRACTION

SAND ANALYSES

TRENCH 7

Fig 2-4



PETROCHEMICAL CONSORTIUM OF SOUTH AUSTRALIA

LAKE TORRENS BRINE EXTRACTION

SAND ANALYSES

TRENCHES 9 & 10

Fig 2-5

RECOVERY CURVES

TRENCHES 3 & 4

PETROCHEMICAL CONSORTIUM OF SOUTH AUSTRALIA
LAKE TORRENS BRINE EXTRACTION

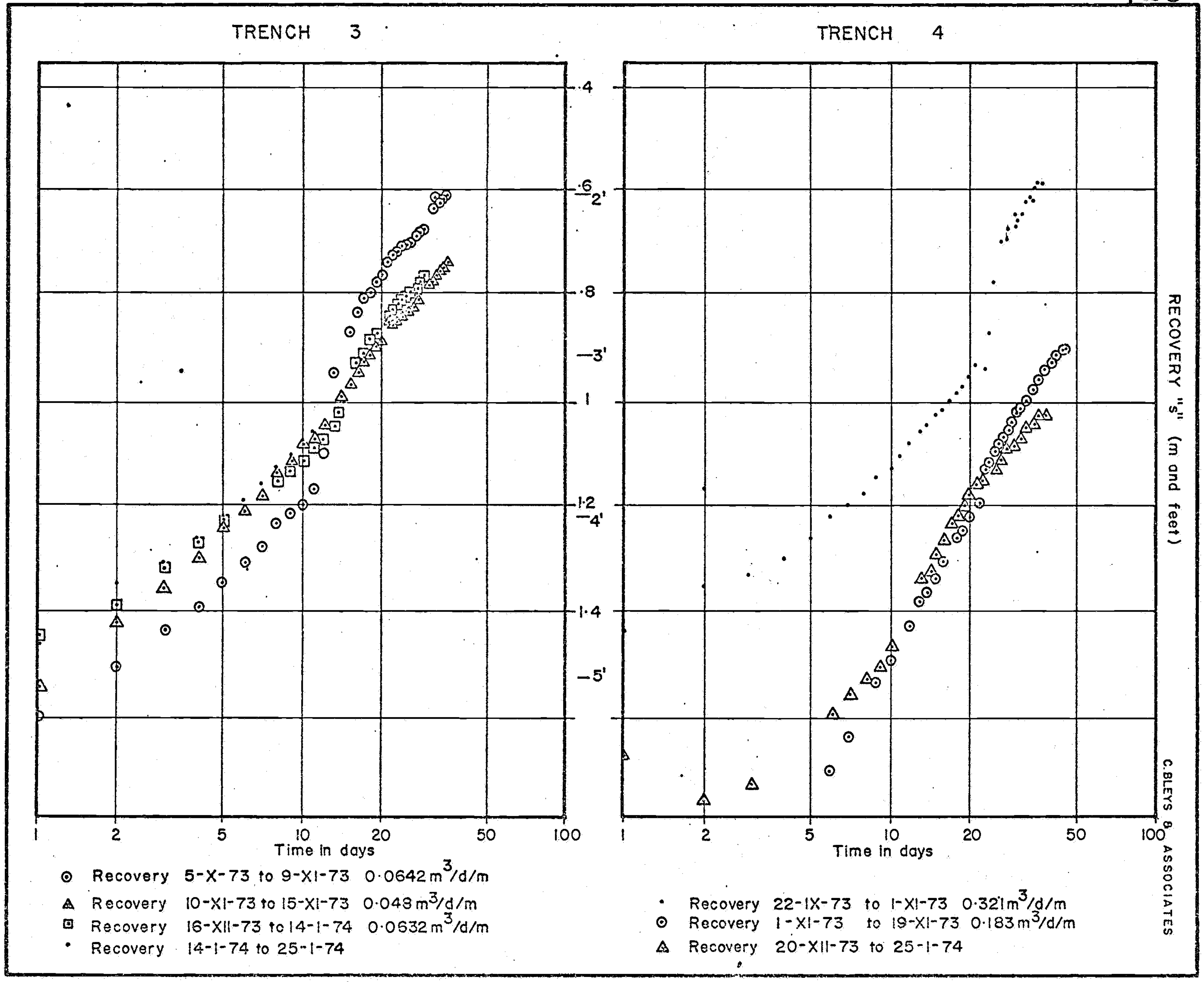
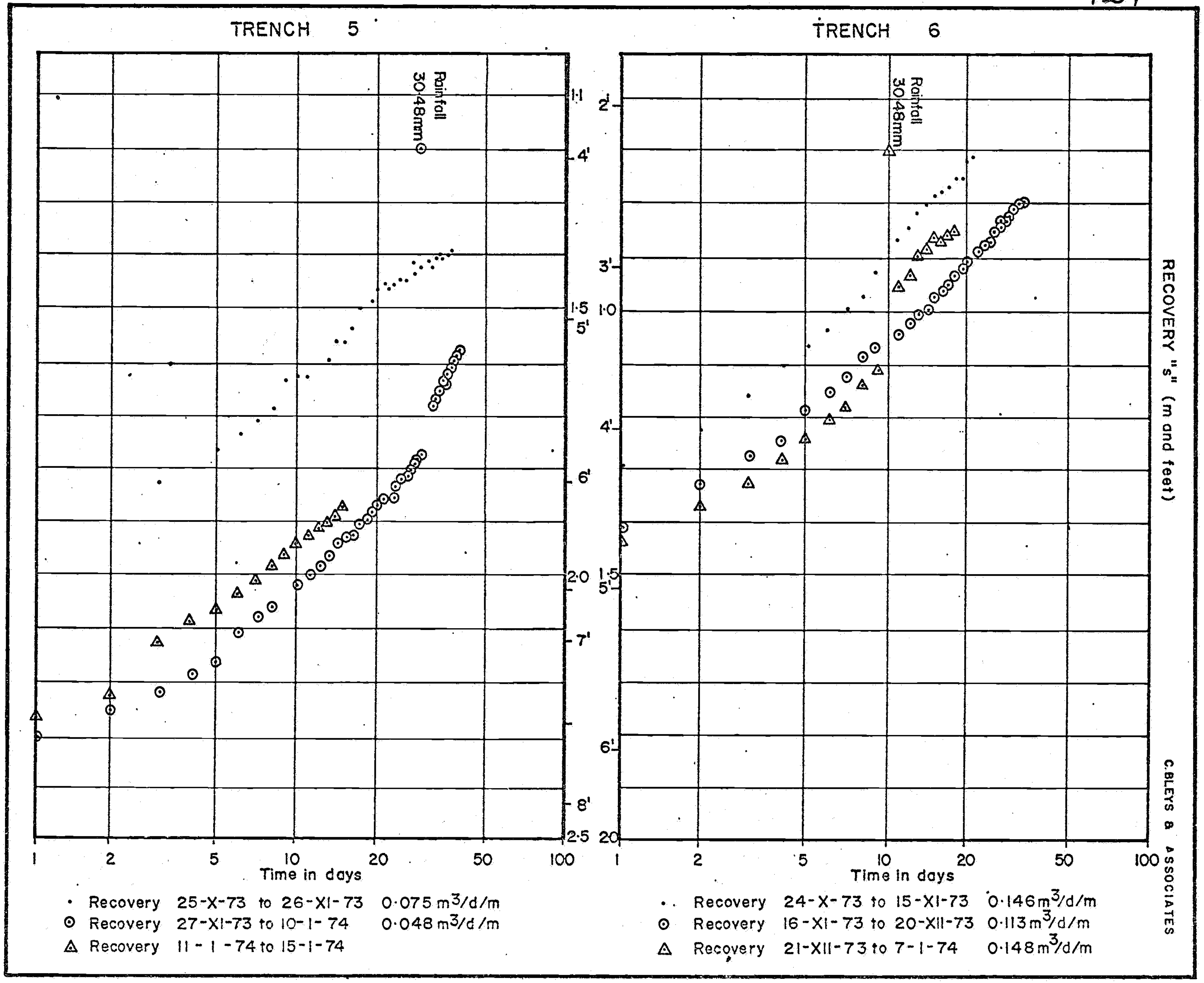


Fig. 2-6



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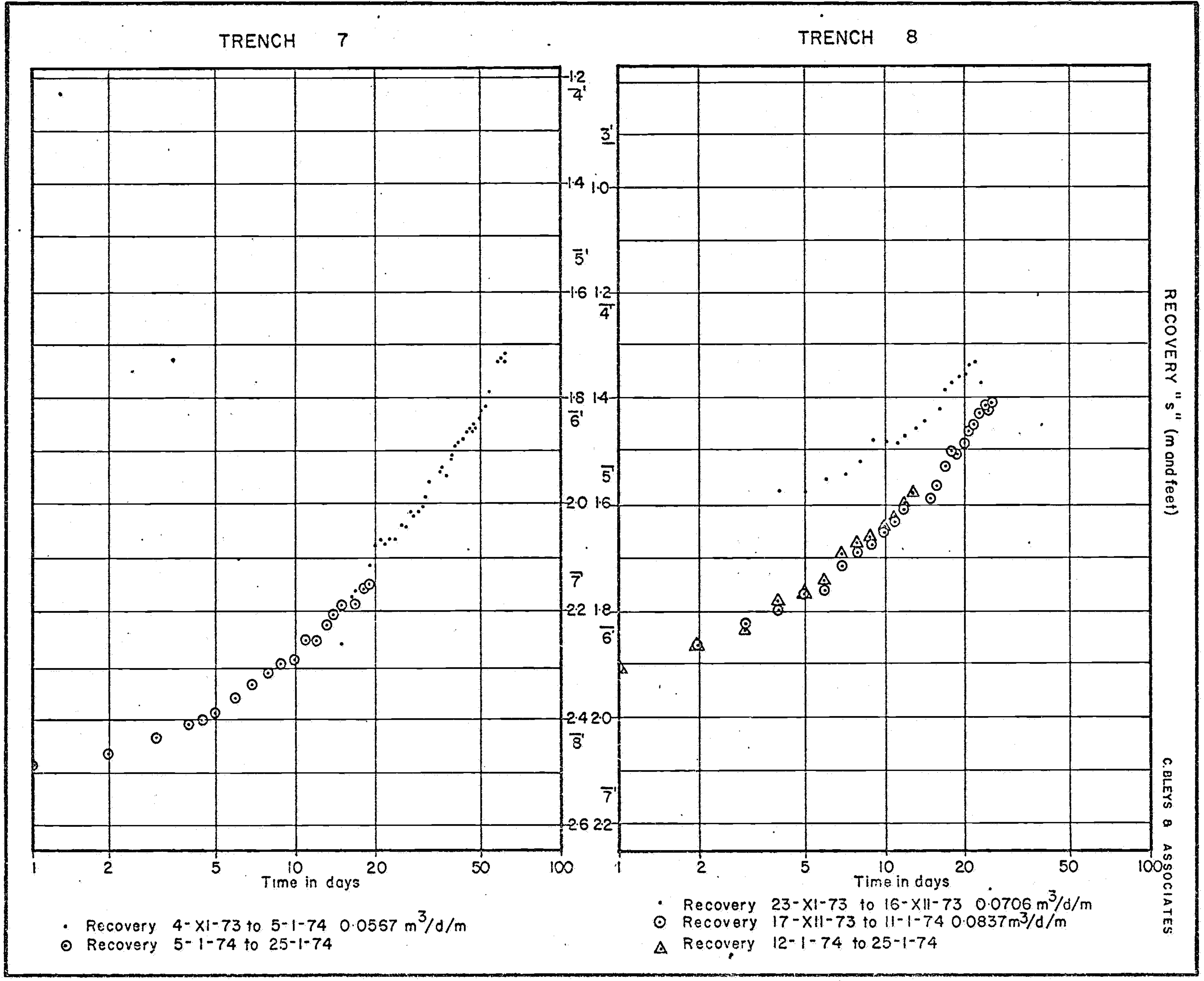
LAKE TORRENS BRINE EXTRACTION

RECOVERY CURVES

TRENCHES 5 & 6

Fig. 2-7



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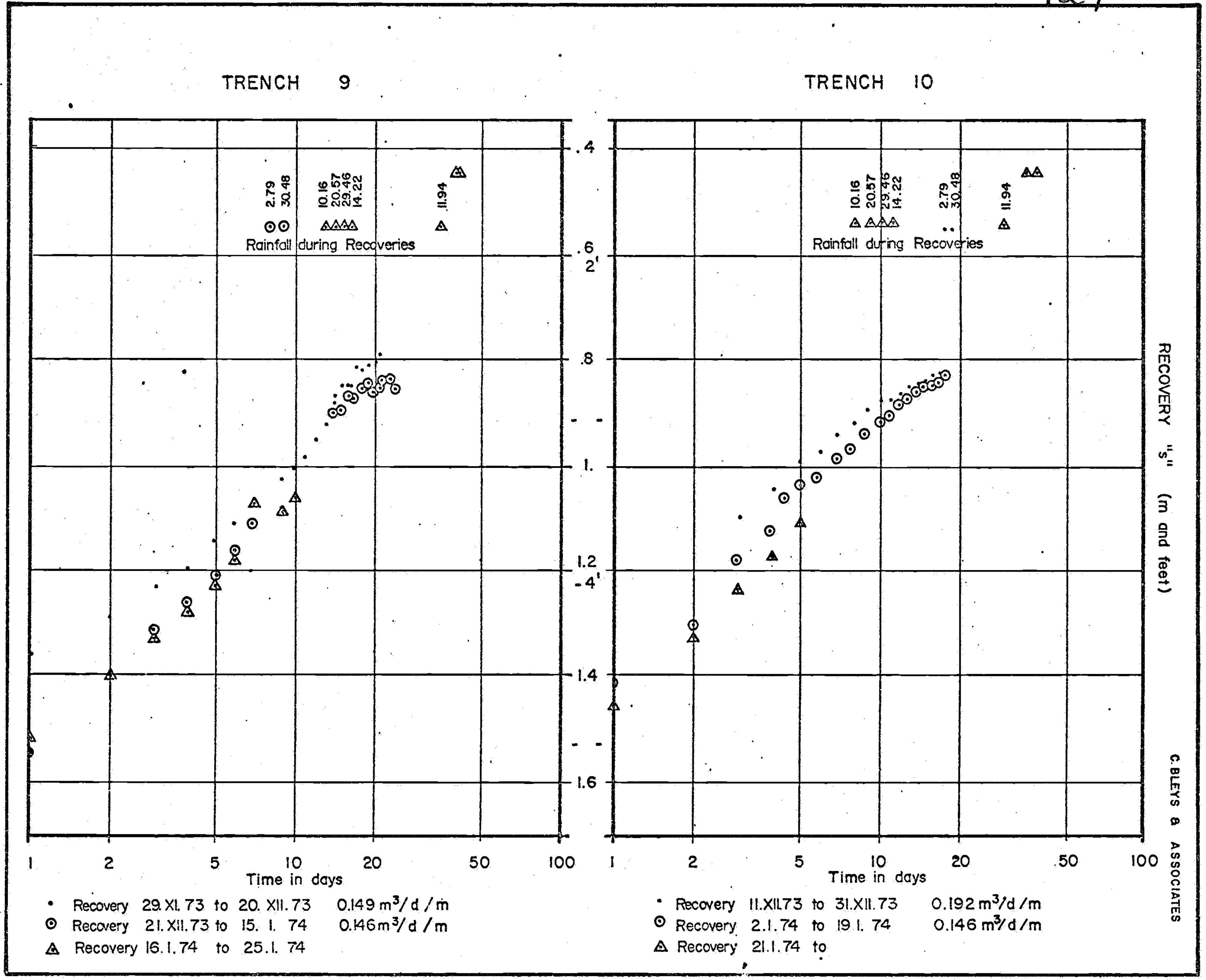
LAKE TORRENS BRINE EXTRACTION

RECOVERY CURVES
TRENCHES 7 & 8

Fig. 2-8



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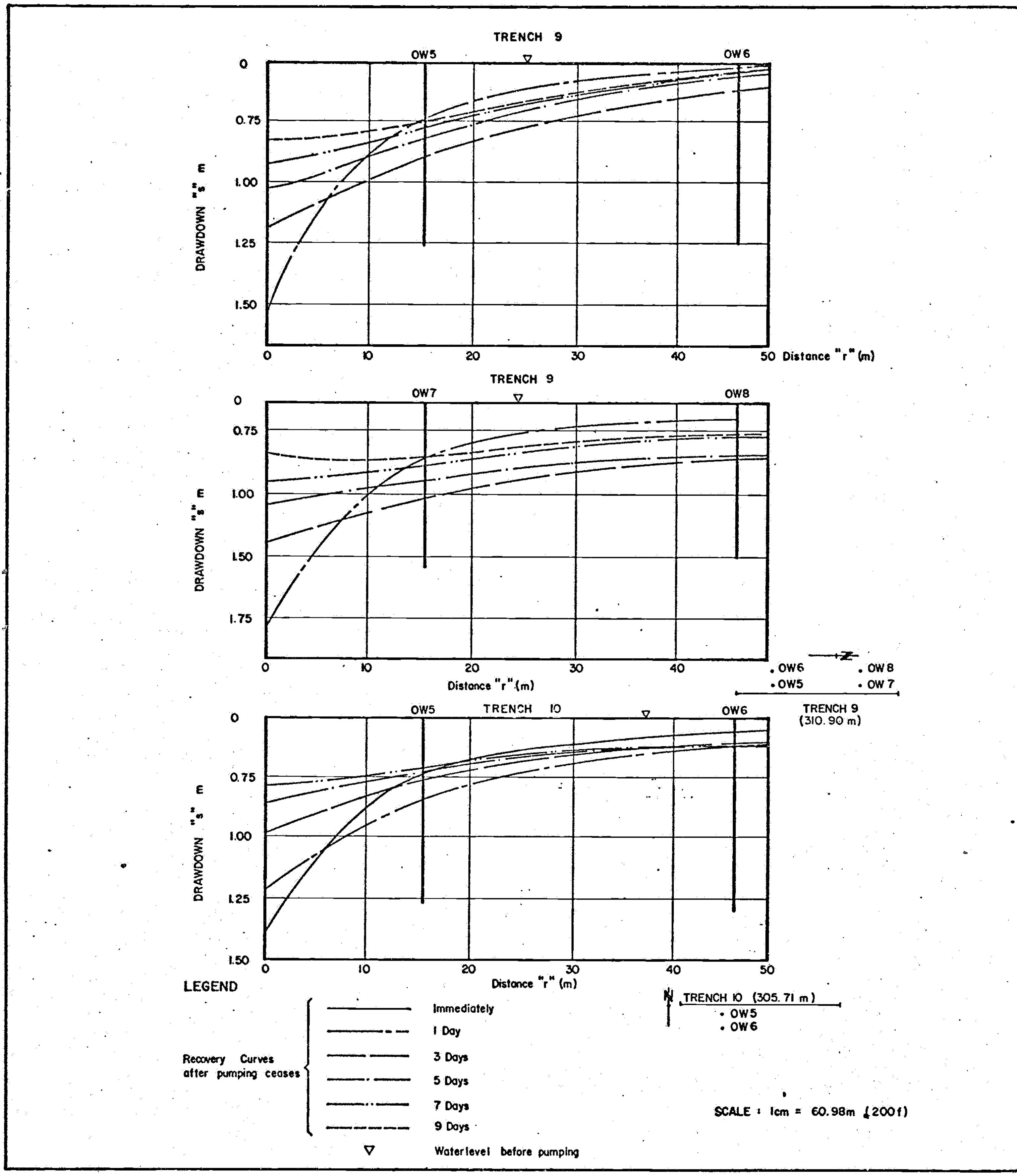
LAKE TORRENS BRINE EXTRACTION

RECOVERY CURVES

TRENCHES 9 & 10



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LAKE TORRENS BRINE EXTRACTION

RECOVERY CURVES

TRENCHES 9 & 10 AND THEIR OBSERVATION WELLS

Fig 2-10

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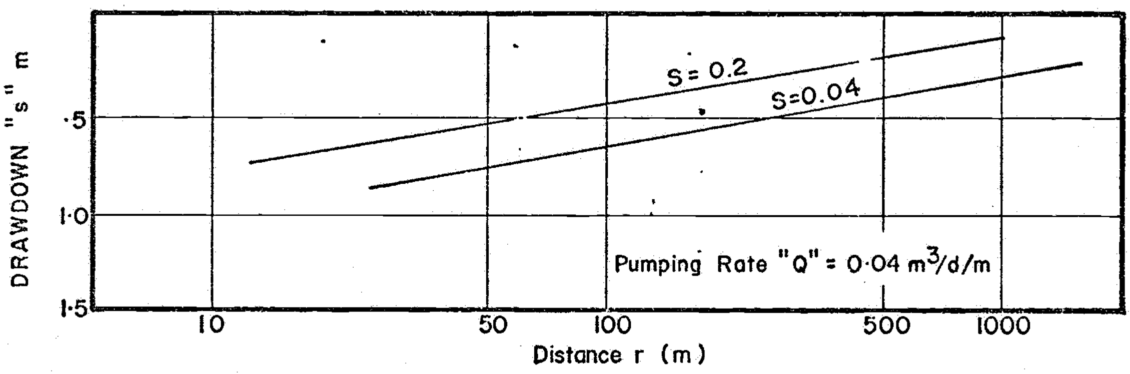
TRENCH 4



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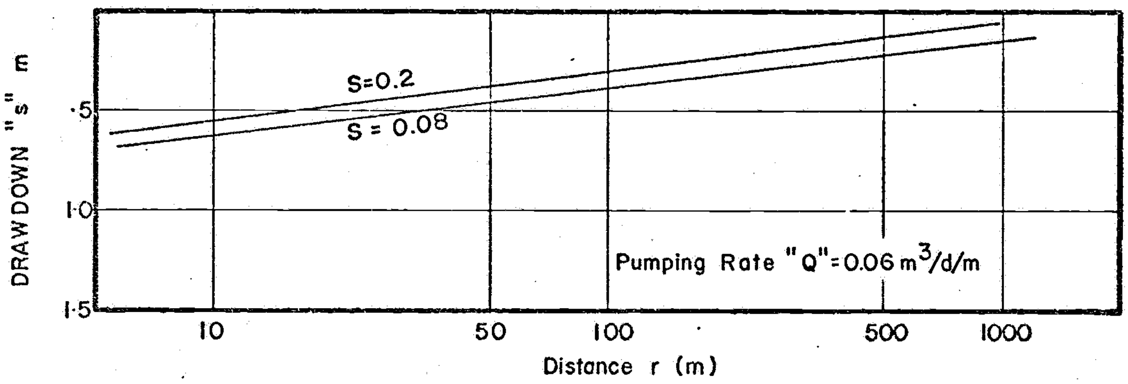
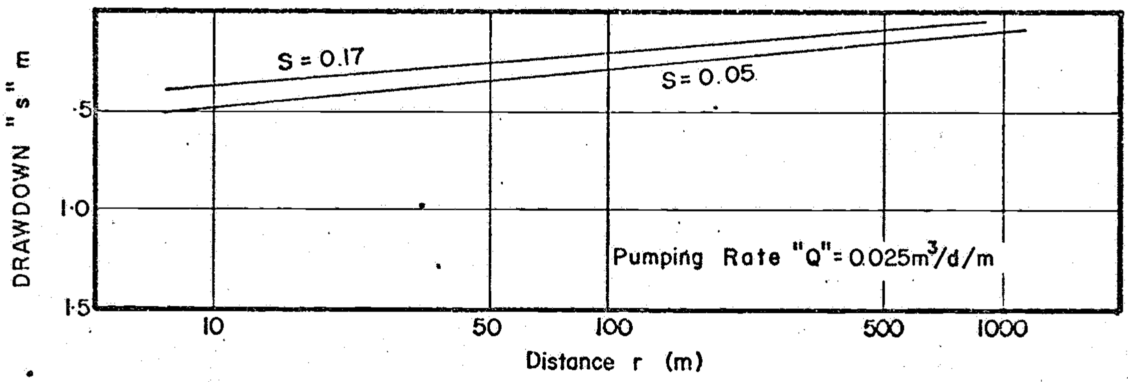


TRENCH 7



PETROCHEMICAL CONSORTIUM OF SOUTH AUSTRALIA

LAKE TORRENS BRINE EXTRACTION

DRAWDOWN CURVES

FOR

1000 DAYS CONTINUOUS PUMPING

Fig 2-11

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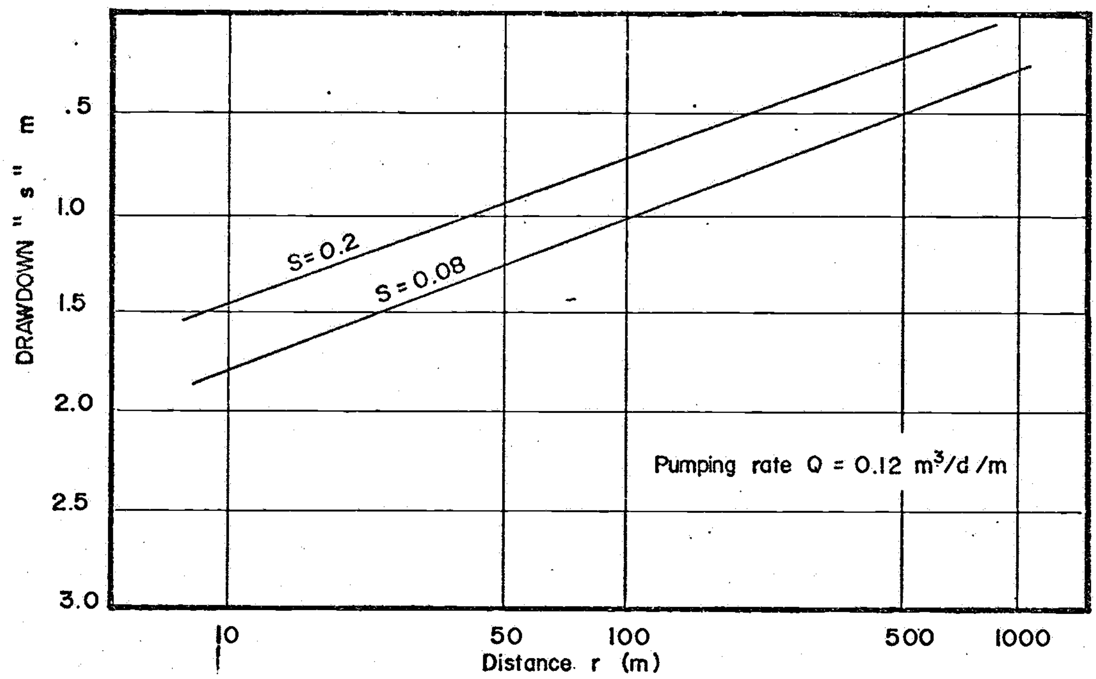
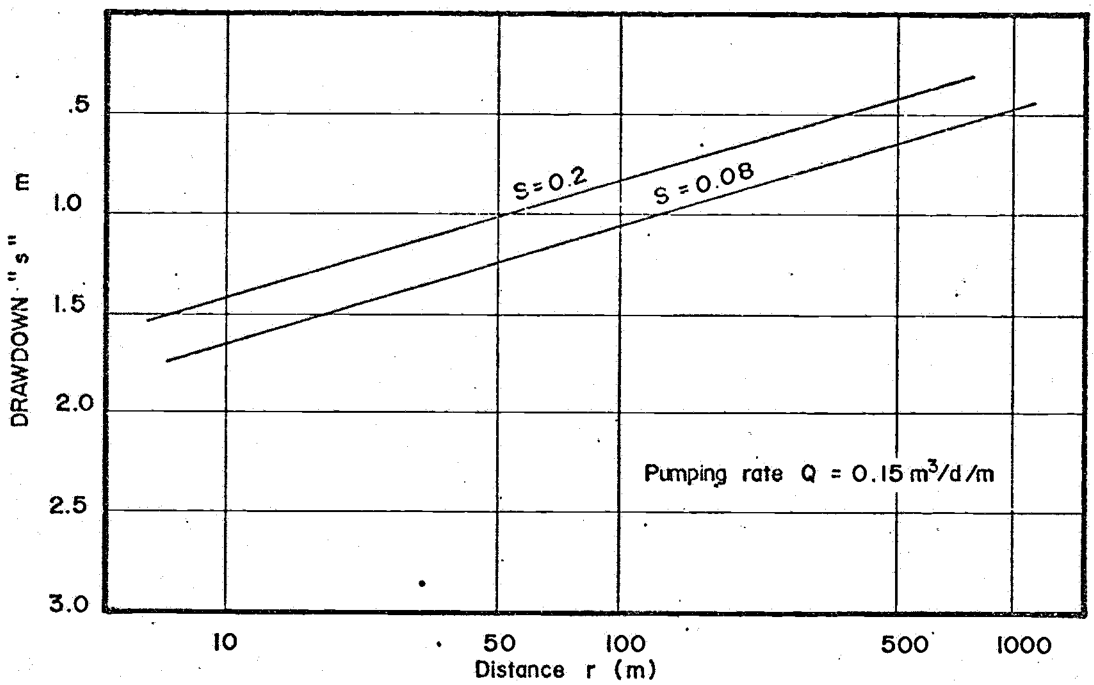
TRENCH 9



TRENCH 10



PETROCHEMICAL CONSORTIUM OF SOUTH AUSTRALIA
LAKE TORRENS BRINE EXTRACTION

DRAWDOWN CURVES

FOR

1000 DAYS CONTINUOUS PUMPING

Fig. 2-12

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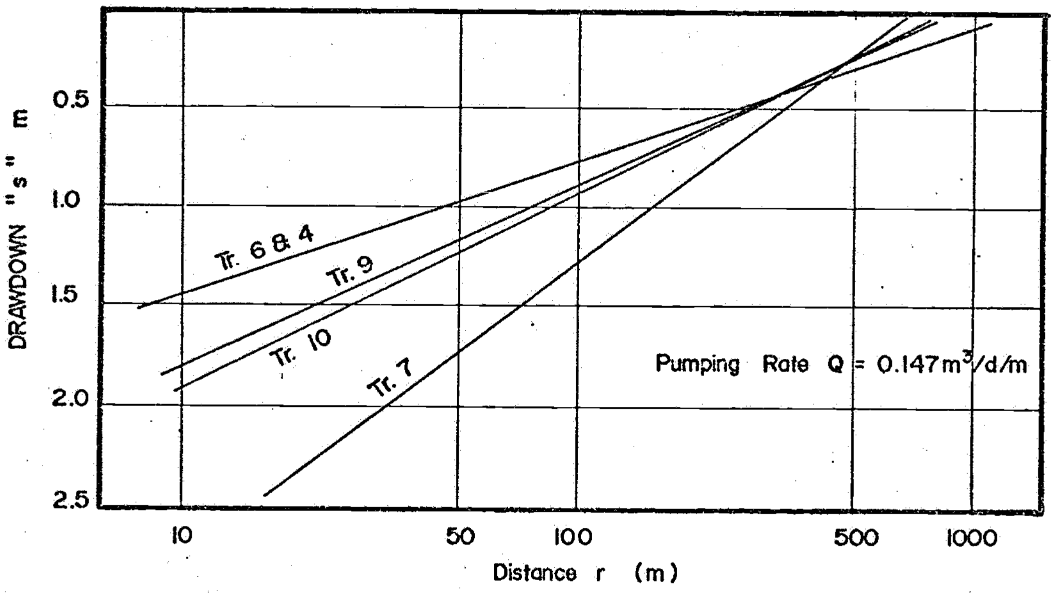

PETROCHEMICAL CONSORTIUM OF SOUTH AUSTRALIA

LAKE TORRENS BRINE EXTRACTION

DRAWDOWN CURVES

FOR

1000 DAYS CONTINUOUS PUMPING

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your reference

our reference A151/1
RAR/tjr

21 June, 1974

The Director,
Department of Mines,
PO Box 38 Rundle St.,
ADELAIDE. S.A. 5000.

Dear Sir,

Re: LAKE TORRENS BRINE EXTRACTION PROPOSALS
Your Ref. EL60 WRPB:JS 14 June, 1974

1.0 INTRODUCTION:

We have now completed our study of Delhi International Oil Co. proposals to extract brine from Lake Torrens and to transport it via pipeline to Yorkey's Crossing. Our firm has limited our examinations to the hydro-geological aspects of the proposal and these aspects are considered in the following. We have commissioned AMDEL to study the pipeline and transportation aspects of your request as these matters are outside the scope of our usual activities. Mr. W. Walker of AMDEL will report separately on these latter aspects.

The Delhi proposals are in a state of flux and this has created some difficulties in our study. Delhi's situation is entirely understandable for they are continuing to both gather data on the project and to negotiate sales. Our assessments have been based on an assumed production rate of 460,000 tonnes per year and that production will be limited to Foreset Areas A and B (Fig. 1)(total area = 22 square kilometers).

Our review has been based largely on data supplied in :

(a) "Lake Torrens Brine Extraction" Progress Report No. 2 by Chris Bleys and Associates

(b) Exploration Licence No. 60 - Summary of Activities - April 1973 to March 1974

(c) Filtration and NaCl content, etc. data supplied by Mc.Phar Geophysics Pty. Ltd.

(d) Particle Size distribution, Apparent Specific Gravity and mineralogical descriptions supplied by Ian R. Pontifex and Associates

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The Director,
Department of Mines,
Adelaide, S.A.

(e) Pump test and borehole log information supplied by Delhi International

The site has not been inspected. No soil samples have been examined.

The report is presented in three further sections -

Section 2 - Summary and Conclusions
Section 3 - Technical discussion and data interpretation
Section 4 - Further investigation

In the summary and conclusions section the investigation and results are briefly presented and this is followed by a discussion and questioning of the estimated reserves.

In Section 3, the specific yield data is examined and interpreted. This is followed by a discussion and interpretation of the results of a well instrumented test in Trench 10.

In Section 4, areas where further information is required is discussed, and an outline is given of the extent and nature of the desired further investigation.

2.0 SUMMARY & CONCLUSIONS

The investigations to date have comprised the development of two of the usual three broad components of a groundwater extraction investigation:

(a) geological model
(b) aquifer testing

No water balance study has been attempted though rainfall and evaporation stations have been installed.

2.1 The geological model

The model has been based on shallow excavations at 2000 feet intervals. The present extent of the investigation is shown in Figure 2 and cross sections are shown in Figures 3 and 4.

The surface deposit appears to comprise a lenticular sequence of medium to fine sands, silts and clays. Delhi have estimated that 40-50% of soils in the profiles investigated have comprised materials classified as water (brine) yielding sands (Fig. 1). This estimate seems to be reasonable. The pump tests have shown that there is satisfactory interconnection between lenses. A high density brine (approx. 20 percent NaCl) occurs throughout the sediments and rises to within 200-500 mm of the ground surface. Almost all the salt in the soil is in solution. Mudcracks, carbonaceous root tubes and old erosion surfaces have been observed.

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Estimates of the specific yield of the various sediments have been attempted by laboratory filtration tests where suctions have been applied to undisturbed samples and from published (though controversial) relationships between particle size distributions and specific yield. Delhi appears to have arrived at the following values of specific yield for their reserve estimates:

Sands = 20%
Silts = 7.5%
Clays = 2.5%

Our view is that these values are optimistic, though possible. The matter is further discussed in Section 3.1. The specific yield of the sediments determine the available reserves.

2.2 Aquifer testing

Delhi have carried out in excess of 20 pump tests over the Lake Torrens area. Unfortunately only the latest tests on Trenches 9 and 10 within Foreset Area A have been adequately instrumented. In general the tests have involved the digging of a 300 metre trench, the pump out of the trench at a high discharge rate, and the observation of the recovery of brine in the trench and observation wells.

Our analysis has been limited to an examination of the results of pump test 5 in Trench 10 (discussed in Section 3.2).

It is difficult to make reliable assessments of aquifer parameters from the data available and time has prevented any detailed assessment of parameters on our part. However the tests have provided considerable information, as they simulate the production operation on a small scale.

We have not seen the trenches in operation, but we understand from Delhi that they function satisfactorily and there are no serious problems with stability. It would appear from the tests that the pumping of brine from the trenches is a feasible proposition. The tests are inadequate to predict long term extraction rates and reserves.

2.3 Water balance

The estimates of production rates and reserves have been based on a static situation assuming the available brine between the ground surface and 4.25 metre depth will be recoverable and is the only brine recoverable. It has been noted that yields have increased following rain. The water balance involves a very dynamic situation involving rainfall, evaporation, runoff, recharge and production rates.

We have not and could not carry out a water balance study. The following are obvious factors affecting the water balance of the production areas:

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(a) Rainfall or diverted waters (flooding from Willochra Creek) which percolate slowly through the soils above the water table will contribute to the total salt production

(b) Prolonged dry periods without rain could reduce the amount of available brine. It is possible that the water levels are high at the moment due to exceptional rains

(c) Recharge from porous zones below the production levels. There is no information on the stratigraphy below the base of the trenches. The existance of permeable gravels below the trenches could make available very large reserves of brine. Considerable further deep drilling is required

Our overall impression is that a detailed water balance study is more likely to have increased estimated yields than to have reduced them.

2.4 Production and reserves

Delhi have estimated that the total recoverable NaCl reserves in the 22 square kilometers and upper 4.25 metres of Foreset Areas A and B are 2,810,000 tonnes and that these reserves can be recovered at the rate of 460,000 tonnes of NaCl per annum from 30 km of trench at approximately 1 km spacings.

We believe that the present data does not justify such large recoverable reserves or that the proposed drawoff rate can be achieved for an extended period of time.

Their estimate of 2,810,000 tonnes of NaCl is based upon the above specific yield data (which is thought to be optimistic) and the assumption that the full 4.25 metres of drawdown is recoverable (i.e. the piezometric surface between adjacent trenches will be horizontal and level with the base of the trenches at the end of the operation).

From the present data it is impossible to affirm that drawoff rates of 460,000 tonnes per annum can or cannot be achieved. However the value does not appear to be unreasonable in the short term (first 2 years), though in the long term there must be strong doubts as the interaction of cones of depression (which is assumed in the calculation of reserves) will surely significantly reduce recovery rates of the trenches.

Our estimate of economically extractable brine in Foreset Areas A and B is in the rate of 1.3-1.7 million tonnes and this has been based on the following assumptions:

S sand = 10 to 15% where S = specific yield
S silt = 5 to 7.5%
S clay = 0 to 2.5%

and that only 75 percent of the total volume of brine will be economically recoverable. No recharge has been considered.

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Here it should be realised that both Delhi and ourselves are using doubtful specific yield values. However even accepting Delhi's total reserves of 2,810,000 tonnes of NaCl it is very doubtful if more than 75 percent of the reserves (2,100,000 tonnes) could be extracted at close to the proposed production rate.

2.5 General

There is nothing in the data examined which suggests that the overall concept of the scheme is impractical. Delhi's experience with the trenches is that they work well and that with their present trench configuration they have had little problems with instability. Increasing trench depths and drawdowns will tend to increase instability. In general trenches which encounter no stability problems are almost certainly more costly in the long term than the cost of maintenance and construction of narrower, steeper trenches with some minor slope instability.

Our overall view is that the investigations to date have been sound but there seems to be a continual tendency in the interpretation of data to lean to the more optimistic assessment. Their assessments of yields and reserves are not viewed as unrealistic but rather as being optimistic.

3.0 DISCUSSION:

3.1 Specific yield

Delhi's estimates of extractable brine have been based on laboratory filtration tests. The procedure adopted in these tests has been to place the undisturbed soils in a Buckner funnel and subject it to a suction (through a water pump) until flow ceases. This appears to be a sound procedure provided the suctions applied in the laboratory are in the same order as suctions (depressions in the free water surface) in the field.

The maximum water surface drawdown in the field will be in the vicinity of the trenches and will be in the order of 3 to 4 metres of brine. The average drawdown for say a situation of 1 metre interference at the midpoint between trenches is likely to be in the order of 2-3 metres. However while the water surface is depressed an average of 2 metres, the average increased suction for a soil is only 1 metre (half the total drawdown). Hence to reliably simulate the field conditions, suctions should be limited to 1-1.5 metres of water.

We do not know what suctions were applied in the laboratory tests. We understand though that the suctions were not controlled. We have checked the suction obtained in our laboratory water pump and found that well over 7 metres of water suction was easily achieved. We believe that it is probable that the laboratory suctions could have considerably exceeded the field situations and hence the estimates of extractable brine are over-estimated.

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The Director,
Department of Mines,
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In general (though with considerable reservation), most fine to coarse sands will drain under suctions of 1 to 3 metres, and, suctions in excess of 3 metres will not produce large increases in extractable brine. Hence it is likely that the volumes of filtrate available in the sands will be of the same order (though lower) than the laboratory calculated values. On the other hand the laboratory extractable brine from the silts and clays could grossly exceed the amount available in the field.

Estimates of specific yield can be made from the laboratory tests by the simple calculation of the volume of extractable brine per unit volume of soil. The average specific yield calculated in this manner (for sands alone) is approximately 18 percent and in our view this value represents the most optimistic assessment of specific yield for sands that can be drawn from the present data. The specific yield for the sands and clay soils is likely to be considerably less than the average value of 10% calculated from the test results, owing to the large suctions applied in the laboratory.

It is interesting that this procedure was rejected in the report of Chris Bleys and Associates. Their calculated values (Table 4 of their report) were low, but we suspect that they erred in using moisture contents (weights) where they should have been comparing volumes (porosities).

The analysis of pump test 5, Trench 10, gave specific yield values of only 4 percent. It is believed that there are a number of reasons why this low value is atypical.

From the data available, our own experience and consideration of the relatively low drawdowns and the high viscosity of the brine, we suggest that the following values of specific yield are appropriate at this feasibility level.

	Upper bound	Lower bound
Sand	15%	10%
Silt	7.5%	5%
Clay	2.5%	0

3.2 Pump test

We have examined the results of Pump Test 5 on Trench 10. This was a well instrumented test using a total of 14 observation wells at distances ranging from 50-300 ft. from the trench.

The trench was pumped for 34 hours 32 minutes and 55,600 cubic feet of 17.8^{o} Baume grade brine (average temperature 79.4^{o}F) was discharged. The water level in the trench was drawn down from 15 inches (below ground level) to 71 inches.

Figures 5A, B and C show the plots of water levels in the trench and observation wells at:-

Fig. 5A Completion of test
Fig. 5B 2 days after the completion of test
Fig. 5C 9 days after the completion of test

......7

The Director,
Department of Mines,
Adelaide, S.A.

From a qualitative point of view the relatively large scatter of water levels for the same distance at the completion of tests shows that there is less than perfect interconnection between aquifers. However the water level readings for the 1st of May show a considerable stabilization of the water surface and hence it would seem in the long term that there is sufficient interconnection between lenses.

From the results we have attempted to produce a water balance and an assessment of specific yield.

eg. (25/4/74)
Total water removed during pump test = 55,600 cubic ft.
Vol. of water removed from trench during pump test = 44,400 cubic ft.
Vol. of water removed from storage in soil to end of pump test = 55,600 − 44,400 = 11,200 ft.^{3}

On 25/4/74 water level in trench had recovered from 71.1" drawdown to 44.8" drawdown.

Vol. of water taken up by trench from completion of test to 25/4/74 = 14,100 + 11,200 = 25,300 ft.^{3}

The area of cone of depression (1 side only) from Fig. 5B = 298 ft.^{2}
Length of trench = 1000 ft. (+10%)
Total volume of cone of depression = 2 x 1100 x 298
= 655,000 ft.^{2}

$$\text{Specific yield} = \frac{25,300}{655,000} = 3.9\%$$

A similar calculation for a water balance at the end of the test yielded a value of 3.6 percent.

There are probably a number of reasons for this low result.

(a) The test was not a full scale test. The average drawdown was only in the range of 0.2 to 0.3 metres and this is probably inadequate to fully drain the sand lenses

(b) The surface horizons tend to contain a higher clay content than the lower horizons and hence the value probably underestimates the average values

......8

The Director,
Department of Mines,
Adelaide, S.A.

While the test result remains the most substantial indication of specific yield it is considered that it would underestimate long term full scale test values.

Production estimates have been based upon an assumed annual requirement of 460,000 tonnes of NaCl and it has been assumed by Delhi that this can be achieved from approximately 30 km of trench.

To achieve this production it would be necessary to maintain a long term average inflow of 0.182 metre^3/day/metre (m^3/d/m) of trench. This value is comparable though higher than the short term inflow rates achieved in the present series of tests. The average inflow achieved in Trench 10 (Jan. 1 - May 5) was approximately 0.13 m^3/d/m. It is suspected that the inflows to Trench 10 were assisted by unseasonal heavy rains. However deepening of the trenches and experience in the most efficient means of extracting the brine would possibly make the assumed values possible, for the period before there is much interaction between the adjoining cones of depression.

4.0 FURTHER INVESTIGATION:

The geological model is presently seriously lacking in deep borehole information. A series of boreholes of 10-20 metres depth should be drilled throughout the exploration areas. The frequency of drilling will depend upon the variability encountered. At the feasibility level 4 holes should be drilled in Foreset Area A and 2 holes in Area B. The design phase could possibly require a higher frequency of drilling, say 1 hole/square kilometer. The drilling should include insitu permeability tests or alternatively representative bores should be pump tested.

A study of specific yields of representative materials should be undertaken in the laboratory simulating field drawdowns by the use of tension plates. This is a relatively small item of investigation and would supplement the results of the pump tests.

A production test should be carried out using:

(a) Trenches deepened to production level
(b) Monitoring, as in Test 5, Trench 10, but with piezometers up to 200 metres from the trench. It may also be wise to place piezometers in the same location at different depths
(c) Full drawdown of the water level in the trench and a long term pumping rate (1-2 months) sufficient to keep the drawdown level stable
(d) Complete record of drawdown and time, particularly in the first few hours and days of the commencement of pumping

An attempt should be made to come up with a water balance for the proposed extraction.

Yours faithfully,

R.A. Rallings
COFFEY & HOLLINGSWORTH PTY. LIMITED.

Encls. 7
Figs 1, 2, 5A, 5B, 5C, 3, 4

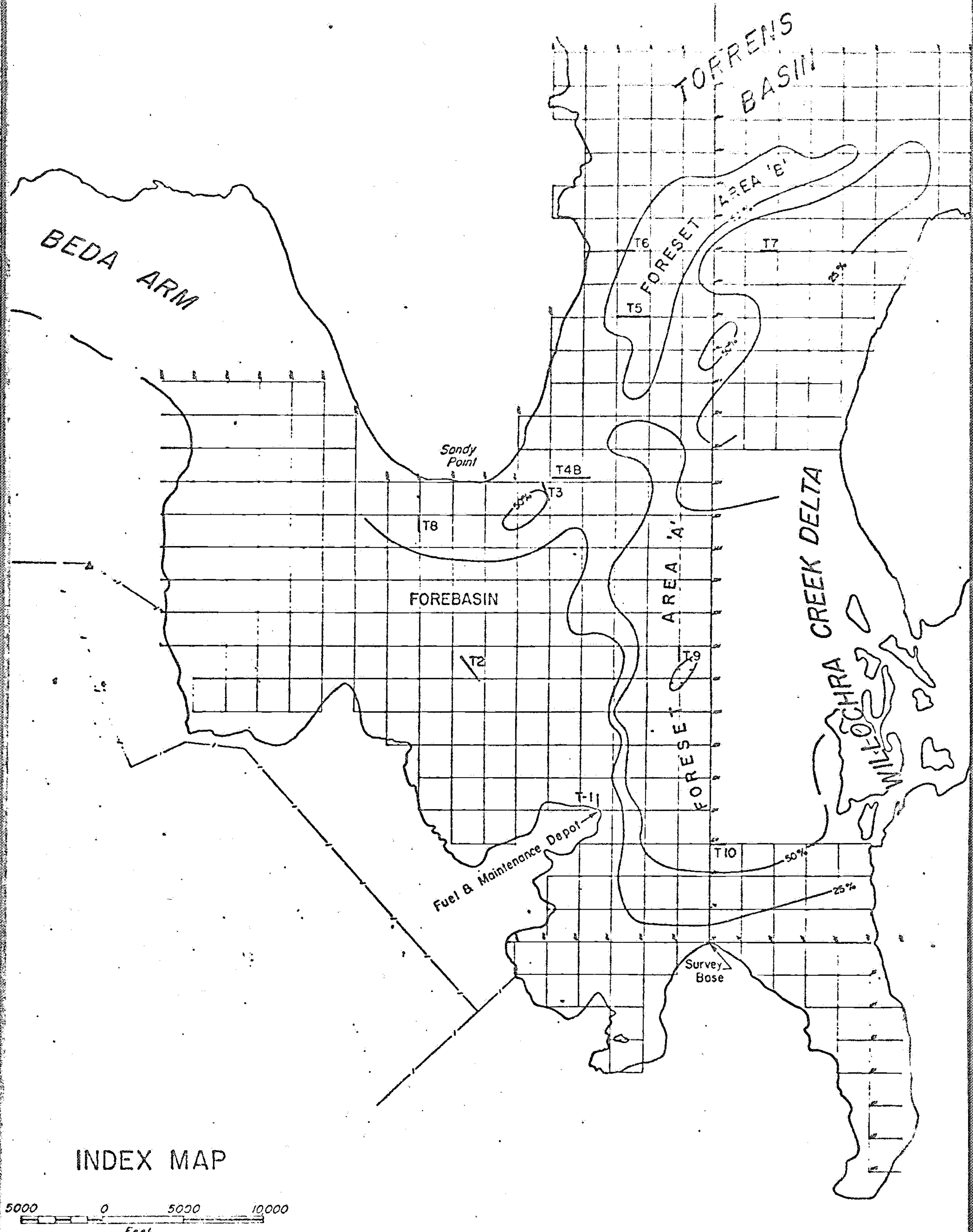


FIG 1

NOTE: Contours (Lithofacies) show estimated percentage of sand horizons in upper 14 feet.

client: DEPARTMENT OF MINES

project: LAKE TORRENS BRINE EXTRACTION

PRODUCTION AREAS

Pty. Limited Consulting Engineers in the geotechnical sciences

drawn: DELHI | approved: | date: 21 JUNE 74 | scale: AS SHOWN | job no: A151/1/1

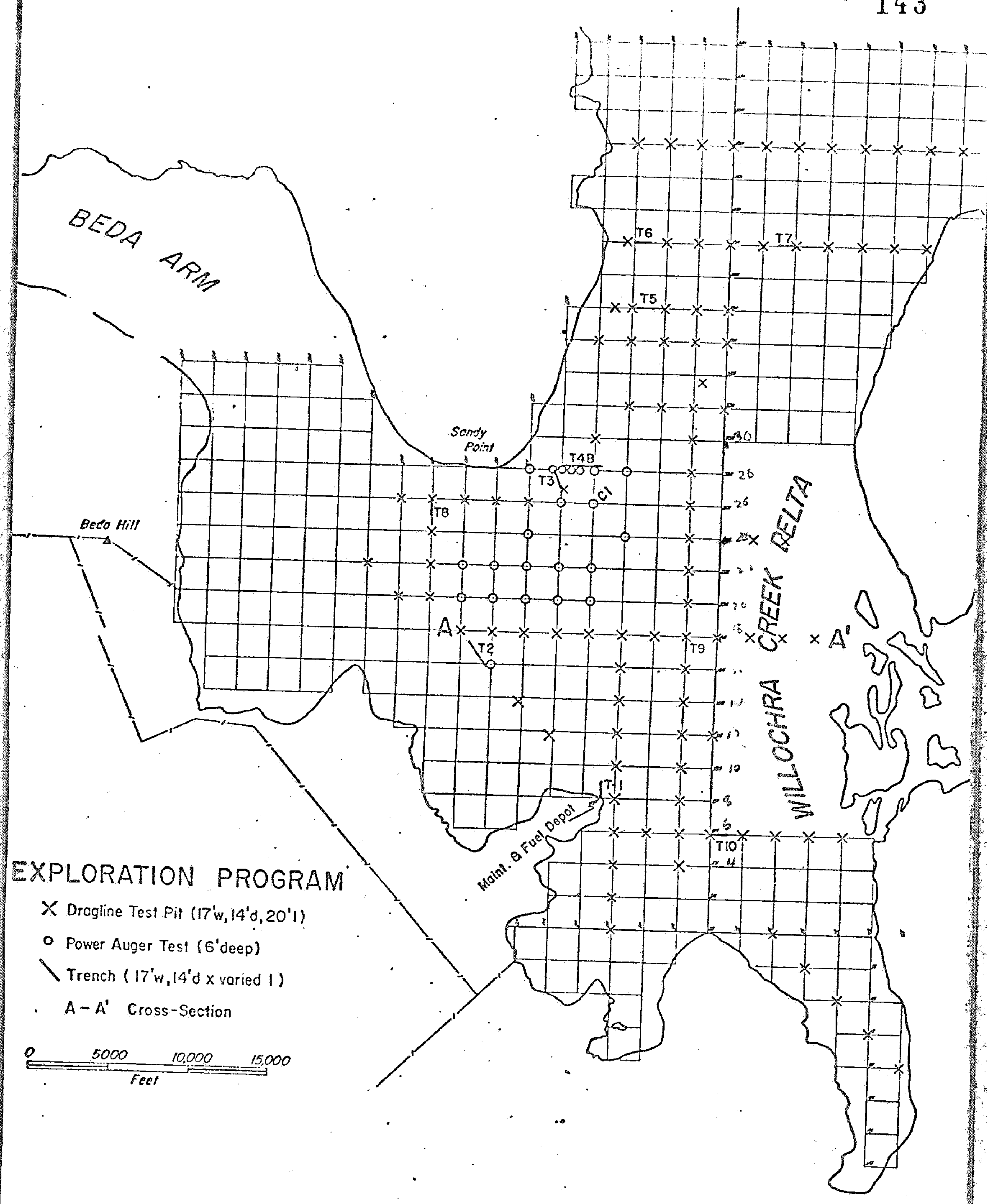
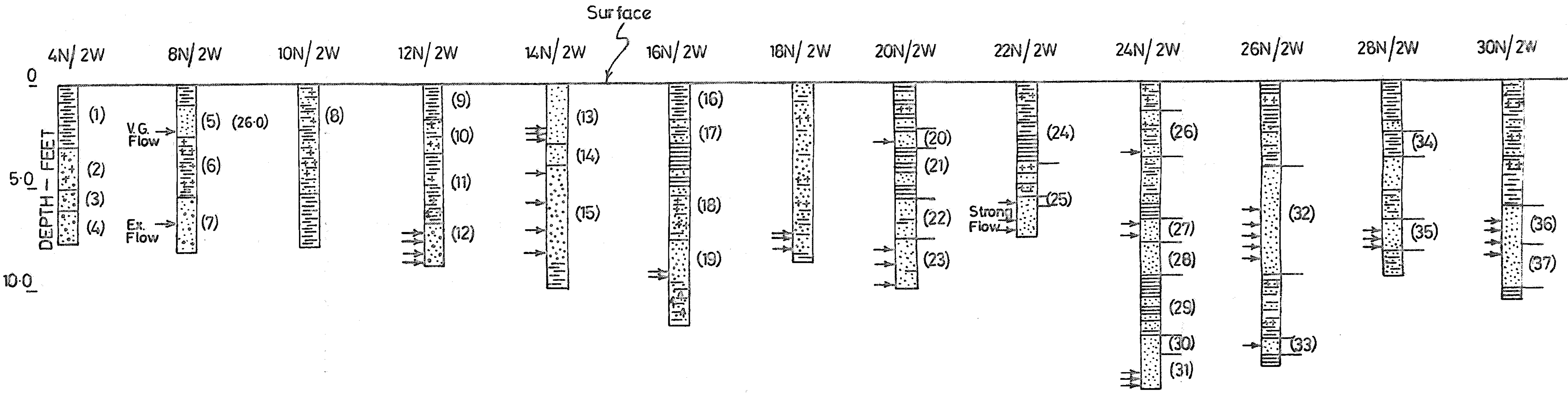


FIG 2

client: DEPARTMENT OF MINES	
project: LAKE TORRENS BRINE EXTRACTION	Pty. Limited Consulting Engineers in the geotechnical sciences
EXPLORATION PROGRAM	
drawn: DELHI / approved: / date: 21 JUNE 74 / scale: AS SHOWN	job no: A151/1/2



LEGEND

CLAY

SILT

SAND

GYPSUM

GRAVEL

→ BRINE FLOW
increasing arrows indicates increasing flow.

(19) Refer to McPhar Geophysics test numbers.

NOTE :- Pits are spaced at 2000 feet intervals.

FIG 3

DEPARTMENT OF MINES			
LAKE TORRENS BRINE EXTRACTION			
CROSS SECTION 2W			
drawn RAR	approved	date 21 JUNE 74	scale

Pty Limited
Consulting Engineers
in the geotechnical sciences

drg no A151/1/6

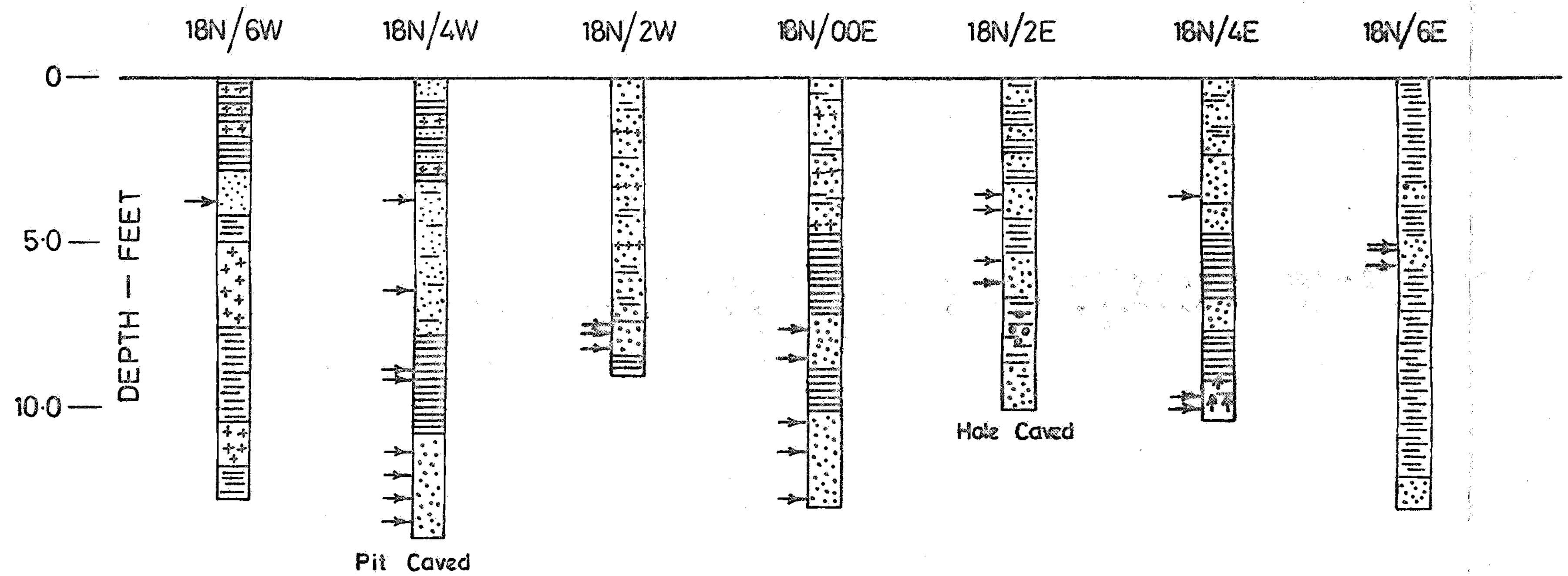


FIG 4

For explanation of symbols see A151/1/6
Pits are spaced at 2000 feet intervals.

DEPARTMENT OF MINES

LAKE TORRENS BRINE EXTRACTION

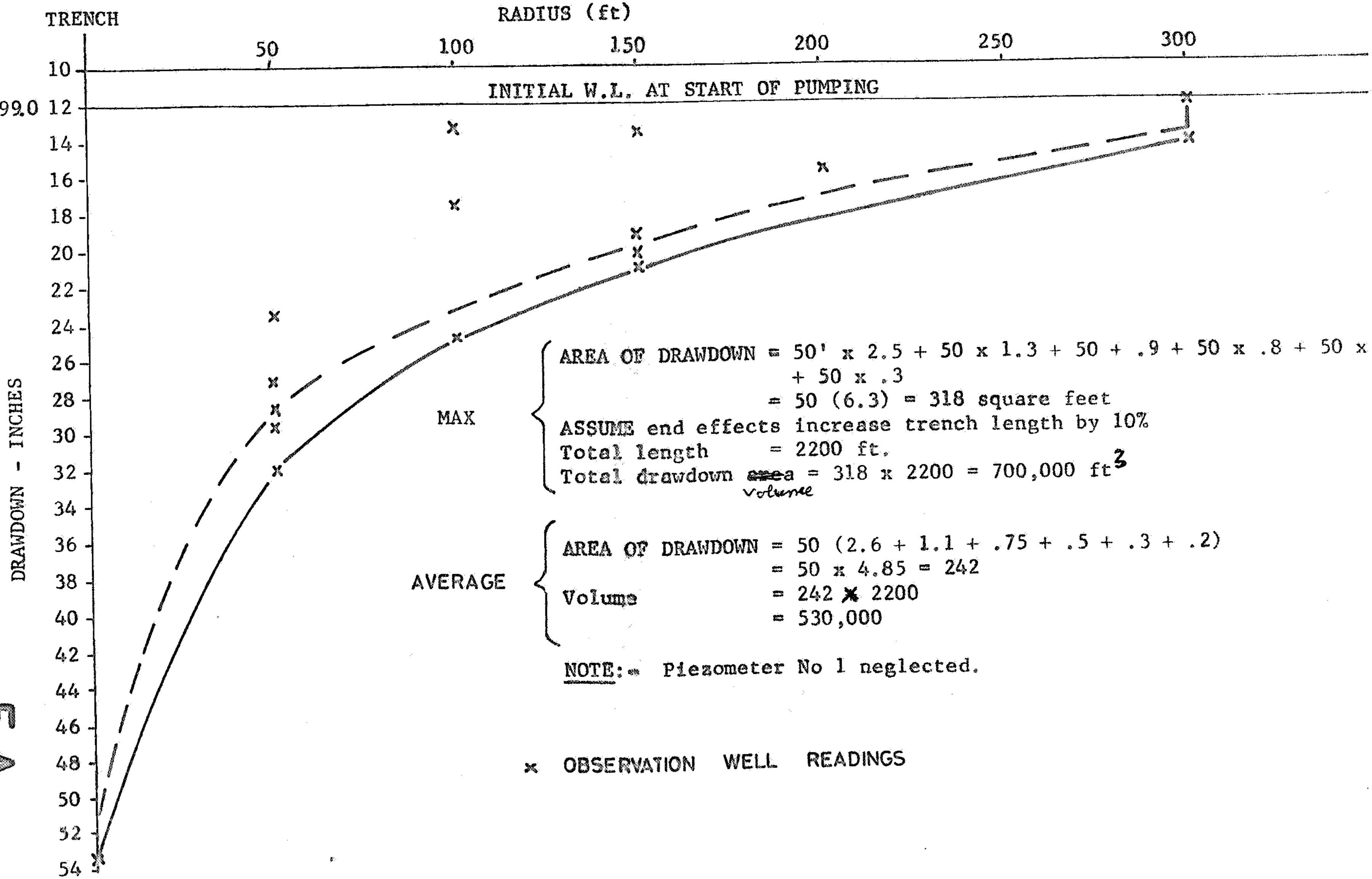
CROSS SECTION 18N

Consulting Engineers

drawn RAR | approved | date 21 JUNE 74 | scale | A151/1/7

TRENCH 10 (TEST 5)

WATER SURFACE — 23 APRIL 74 (ON COMPLETION OF PUMPING)



MAX

AREA OF DRAWDOWN = 50' x 2.5 + 50 x 1.3 + 50 + .9 + 50 x .8 + 50 x .5 + 50 x .3
= 50 (6.3) = 318 square feet

ASSUME end effects increase trench length by 10%

Total length = 2200 ft.

Total drawdown ~~area~~ volume = 318 x 2200 = 700,000 ft^3

AVERAGE

AREA OF DRAWDOWN = 50 (2.6 + 1.1 + .75 + .5 + .3 + .2)
= 50 x 4.85 = 242

Volume = 242 x 2200
= 530,000

NOTE:- Piezometer No 1 neglected.

5A

client: DEPARTMENT OF MINES

project: LAKE TORRENS BRINE EXTRACTION

WATER SURFACE OBSERVATIONS

drawn: RAR

approved: [illegible]

date: 21 JUNE '74

scale:

job no: A15 1/3

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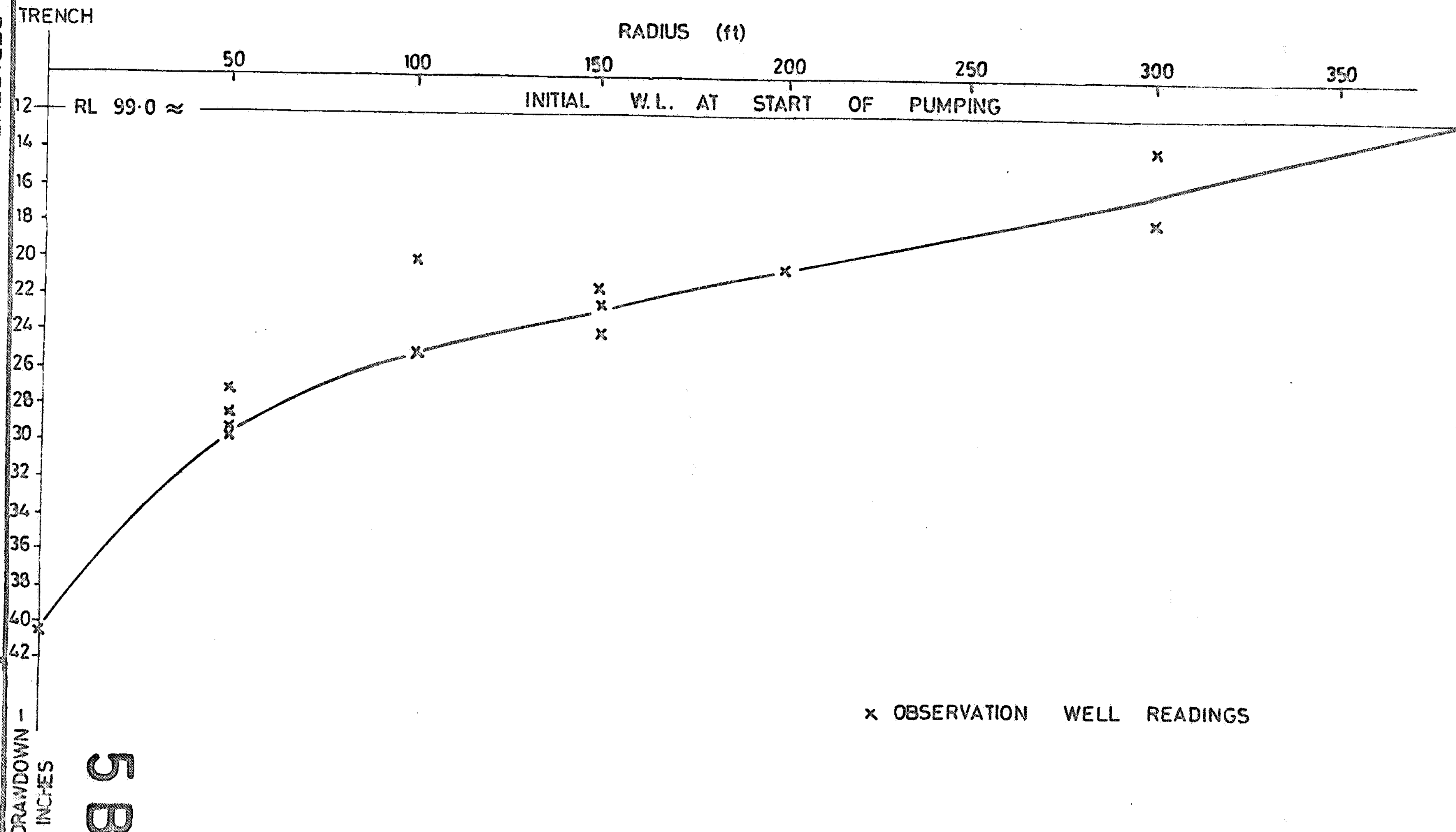
Consulting Engineers
in the geotechnical sciences

TRENCH 10 (TEST 5)

WATER SURFACE — 25 APRIL '74



5B

client: DEPARTMENT OF MINES

project: LAKE TORRENS BRINE EXTRACTION

WATER SURFACE OBSERVATIONS

drawn RAR

approved

date 21 JUNE '74

scale

job no A151/·/4

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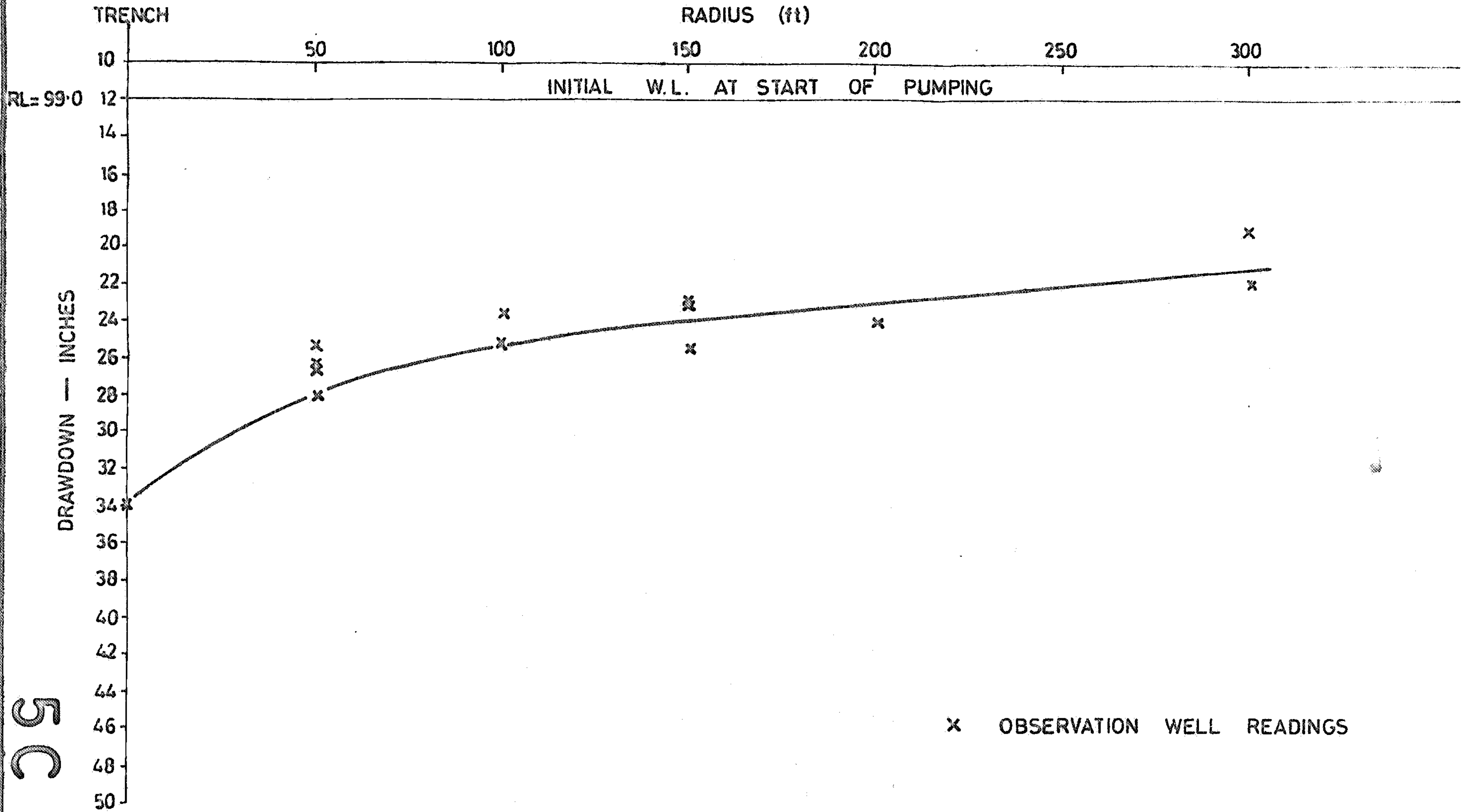
Consulting Engineers
in the geotechnical sciences

TRENCH 10 (TEST 5)

WATER SURFACE — 1 MAY '74

READINGS



client: DEPARTMENT OF MINES

project: LAKE TORRENS BRINE EXTRACTION

WATER SURFACE OBSERVATIONS

drawn: RAR

approved:

date: 21 JUNE 74

scale:

Pty. Limited
Consulting Engineers
in the geotechnical sciences

job no. A151/1/5

5C

amdel
The Australian Mineral Development Laboratories

Flemington Street, Frewville, South Australia 5063
Phone 79 1662, telex AA82520

Please address all correspondence to the Director
In reply quote: CM 1/31/0

27 June 1974

Mr W. Boucaut,
Department of Mines,
Box 38 Rundle Street PO,
ADELAIDE. S.A. 5000

REPORT CM 4746/74

YOUR REFERENCE:	Letter dated 12 June 1974 from Coffey and Hollingsworth.
WORK REQUIRED:	Assessment of feasibility of pumping brine from Lake Torrens as part of the Redcliffs Petrochemical Project.

Investigation and Report by:	W.M. Walker
Officer in Charge, Chemical Metallurgy Section:	J.E.A. Gooden

J.E.A. Gooden

for F.R. Hartley
Director.

cc Mr Ralph Rallings,
Coffey and Hollingsworth,
PO Box 2463,
ADELAIDE. S.A. 5001

CONTENTS

1. INTRODUCTION

The Department of Mines has requested Coffey and Hollingsworth to review the proposal by Delhi International Corporation to extract brine from Lake Torrens and to transport the brine by pipeline to the proposed Redcliff petrochemical plant. Coffey and Hollingsworth in turn requested Amdel to review the feasibility of the pipeline.

The NaCl requirement at Redcliff is for 780 000 t/a at a purity 99.2-99.8% NaCl depending on the type of cell used. Alternatives which have been considered for the supply of this amount include:

(1) Supply of part by sea water evaporation at Point Paterson. This area is estimated to be capable of supplying some 300 000 t/a NaCl.

(2) Supply of all or part by extraction of brine from Lake Torrens, crystallisation local to Lake Torrens and transport to Redcliff by truck and rail. The cost of transport, mainly by South Australian Railways, has been estimated as $2.35/t.

(3) Supply of all or part by extraction of brine from Lake Torrens, pumping to the natural clay pans at Yorkey Crossing, crystallisation followed by re-dissolving in sea water (possibly treated for the removal of magnesium) for pumping to Redcliff.

It is this third alternative that Amdel has been requested to review. The minimum quantity to be supplied by pipeline would be 500 000 t/a NaCl and Delhi has considered quantities in excess of 10^6 t/a NaCl, with the excess for possible expansion at Redcliff or for direct sale.

Coffey and Hollingsworth suggested Amdel should consider both 500 000 and 10^6 t/a NaCl.

2. BRINE COMPOSITION AND SCALING PROBLEMS

In a report "Exploration Licence 60, Summary of Activities April 13 1973 to March 31 1974", supplied by Coffey and Hollingsworth, a summary of the chemical analysis of the brine is presented.

Typically the brine to be pumped would have the following composition:

Specific Gravity 1.15

	%
$CaSO_4$	0.55
$MgSO_4$	0.09
KCl	0.04
$MgCl_2$	0.6
NaCl	20.0
T.D.S.	21.3

The brine is therefore lower in magnesium than concentrated sea water. The brine can be taken as being saturated with $CaSO_4$, and this is the main cause for concern with possible scaling in the pipeline.

Published data are available for $CaSO_4$ solubility in water, sea water both normal and concentrated, and in NaCl solutions. However data for concentrated brines having less $MgSO_4$ than concentrated sea water are not available. From the available data it is, therefore, not possible to predict exactly whether scaling will occur in a pipeline with possible temperature changes. Over the likely temperature range of interest (which could be as high as 50°C in an above-ground pipeline) indications are that the solubility of gypsum, $CaSO_4 . 2H_2O$, is relatively independent of temperature and if anything, slightly increases with increasing temperature. Over the same range, the solubility of anhydrite, $CaSO_4$, decreases rapidly with increasing temperature. For normal sea water concentrated to ∿14% NaCl, anhydrite is the stable solid phase at 30°C. With NaCl solutions, the point of intersection of the gypsum and anhydrite solubility curves is displaced towards lower temperatures as the NaCl content increases. The temperature effect in NaCl solutions with added SO_4 has not been experimentally investigated.

However, whether the scale will be gypsum or anhydrite depends not only on solubilities but on nucleation energies. Gypsum has a lower nucleation energy requirement than anhydrite and in numerous reported experiments where solubility data would suggest the anhydrite as the stable solid phase, gypsum has invariably been produced initially followed by anhydrite deposition in and on the gypsum. Only at temperatures well above the transition temperature can primary anhydrite be formed.

It appears probable therefore that scaling will depend on gypsum and not anhydrite solubility, and that over the temperature range of interest, the solubility will only vary slightly with change in temperature. A below-ground pipeline is recommended to minimise temperature (and solubility) changes.

Without data from a test pump-loop, preferable on-site, it is not possible to guarantee freedom from scaling and methods of controlling scaling must be considered. For example it has been suggested that some of the Ca should be precipitated prior to pumping by adding Na_2CO_3. This would not be totally effective since post-precipitation of $CaCO_3$ could itself cause scaling. The preferred method would be to add scale inhibitors such as those based on tripolyphosphate or on acrylic acid and its copolymers. It has been shown (P. Flesher et al, Proc. of 3rd Int. Symp. on Fresh Water from the Sea, 1970, Vol. 1, p. 493) that polymeric additives and particularly low molecular weight polymers based on acrylic acid and its copolymers, inhibit the precipitation of calcium sulphate at temperatures up to 100°C and with calcium sulphate concentrations of up to twice saturation.

The required addition levels are of the order 5 mg/l and, depending on which type used, the cost of the inhibitor would amount to 5 to 10 cents/tonne NaCl.

3. PIPELINE DESIGN AND COST ESTIMATES

The required pipeline from Lake Torrens to Yorkeys Crossing is 50 km (31 miles), and from Yorkeys Crossing to Redcliff is 35 km (22 miles).

The Lake Torrens pipeline was sized on the basis of a maximum capacity of 10^6 t/a NaCl although initially the throughput would be only 500 000 t/a NaCl.

For 10^6 t/a NaCl, allowing for a 65% recovery from the crystallisers at Yorkeys Crossing (the remainder lost as bitterns and leakage), the pipeline capacity is 1.54×10^6 t/a NaCl. Assuming 20% NaCl in the brine and allowing for harvesting over 8 months of the year i.e. pumping to the crystallisers over 8 months only, the required pipeline capacity is 0.348 m^3/s (4600 gpm).

A range of pipe diameters was considered for the Lake Torrens pipeline and an economic optimum selected based on power costs (at 0.8¢/kWh) and on annual capital charges (taken as 15%/a made up as 8%/a depreciation, 6%/a maintenance charges, 1%/a insurance). No allowances were made for interest charges or for operating labour. Since the brine to be pumped from Yorkeys Crossing to Redcliff will also be as a 20% NaCl solution, this pipeline will be of similar size and the cost was therefore determined proportional to the lengths.

Lake Torrens was taken as 30 m higher than Yorkeys Crossing.

The data are given in Table 1 for a 10^6 t/a NaCl pipeline and in Table 2 for a 500 000 t/a NaCl pipeline.

From the tables, a pipeline diameter of 0.53 m is optimum giving a total salt transport cost of \$1.10/t at 10^6 t/a and a cost of \$1.74/t at 500 000 t/a. Initially only one pumping station would be required from Lake Torrens to Yorkeys Crossing, and a second station could be added as required to meet increased capacity.

The costs are based on concrete-lined steel pipes, rated at about 3000 kPa pressure, protective-wrapped and buried. An above-ground pipeline would cost about 10% less.

4. CONCLUSIONS AND RECOMMENDATIONS

The main conclusions and recommendations reached in this review are as follows:

(1) It cannot be guaranteed that the proposed pipeline would be free from gypsum scaling.

(2) Scaling can be minimised by using a below-ground pipeline to minimise temperature changes, by making provision for insertion of a cleaning 'pig', and by providing for the addition of scaling inhibitors such as low molecular weight polymers based on acrylic acid.

(3) The cost of scaling inhibitors will be of the order of \$0.10/t NaCl product.

(4) The optimum pipeline diameter is 0.53 m (21 inches). Initially only one pumping station will be required, a second station being added to meet increased capacity.

(5) The pipeline transport cost (assuming a total capital charge of 15%/a) is estimated as \$1.10/t NaCl at 10^6 t/a and \$1.74/t NaCl at 500 000 t/a.

(6) The estimated capital cost of a 0.53 m diameter concrete-lined, protective-wrapped and buried steel pipeline with pumping stations suitable for a throughput of 10^6 t/a is \$4.0 × 10^6.

(7) If the required capital must be raised by loan at 10%/a, the pipeline transport costs become \$2.84/t at 500 000 t/a and \$1.79/t at 10^6 t/a plus the cost of scale inhibitors.

(8) If interest charges are included, the break-even capacity for the pipeline is of the order of 750 000 t/a.

(9) Before committment to a pipeline, scaling should be examined by operating a test loop at Lake Torrens.

(10) Scale inhibitors should be tested and selected by beaker-tests before testing in the loop.

TABLE 1: 10^6 t/a NaCl PIPELINE
$0.348\ m^3/s$ (4600 gpm)

Dia.	m	0.69	0.61	0.53	0.46
	inches	27	24	21	18
Vel.	m/s	0.97	1.19	1.59	2.14
	ft/s	3.2	3.9	5.2	7
Δp	kPa	480	980	2100	4500
	psi	70	142	320	660
Power, kW		200	400	860	1840
Pipeline Cost, $\$10^6$		4.3	3.7	3.1	2.7
Pumping Station cost, $\$10^6$		0.2	0.4	0.8	1.6
Total Cost, $\$10^6$		4.5	4.1	4.0	4.3
Capital Cost/a, $\$10^6$		0.67	0.62	0.60	0.65
Power Cost/a, $\$10^6$		0.01	0.02	0.04	0.09
Total Lake Torrens pumping cost, $\$10^6$		0.68	0.64	0.64	0.74
Total Yorkeys Crossing pumping cost, $\$10^6$		0.48	0.46	0.46	0.53
Total pumping cost, $\$10^6$		1.16	1.10	1.10	1.27
\$/t NaCl		1.16	1.10	1.10	1.27

TABLE 2: 500 000 t/a NaCl PIPELINE
($0.174\ m^3/s$ (2300 gpm)

Dia.	m	0.61	0.53	0.46	0.41
	inches	24	21	18	16
Vel.	m/s	0.61	0.79	1.07	1.37
	ft/s	2	2.6	3.5	4.5
Δp	kPa	87	480	1100	2200
	psi	13	70	162	320
Power, kW		18	100	230	450
Pipeline Cost, $\$10^6$		3.7	3.1	2.7	2.45
Pumping Station Cost, $\$10^6$		0.1	0.1	0.2	0.35
Total Cost, $\$10^6$		3.8	3.2	2.9	2.8
Capital Cost/a, $\$10^6$		0.57	0.50	0.43	0.42
Power Cost/a, $\$10^6$		0.01	0.01	0.01	0.02
Total Lake Torrens Pumping Cost, $\$10^6$		0.58	0.51	0.44	0.44
Total Yorkeys Crossing Pumping Cost, $\$10^6$		0.41	0.36	0.31	0.31
Total Pumping Cost, $\$10^6$		0.99	0.87	0.75	0.75
$/t NaCl		1.98	1.74	1.50	1.50

amdel
The Australian Mineral Development Laboratories

Flemington Street, Frewville, South Australia 5063
Phone Adelaide 79 1662, telex AA82520

Please address all correspondence to Frewville,
In reply quote: CM 1/31/0

5 August 1974

RECEIVED
22 AUG 1974
DEPT. OF MINES
SECURITY
2299

Mr W. Boucaut,
Department of Mines,
Box 38,
Rundle Street PO,
Adelaide. S.A. 5000

Dear Sir,

Pumping Lake Torrens Brine
Amdel Report CM 4746/74

We have considered the comments made in the letter dated 15 July 1974 from Mr R.R. French, General Manager of Delhi International Oil Corporation.

As regards the pipeline materials of construction, in our report we recommended a concrete-lined steel pipe. This should be more serviceable corrosion wise and information from The E & W.S. Department indicates that such a pipeline, if laid underground, would only be slightly more expensive than the steel pipe recommended by K.C. Dodd & Associates. Our suggested design allows for a pipeline velocity of 0.53 m/s at a capacity of 10^6 tpa NaCl and this should be more than adequate for 'pigging'.

In comparing pipeline transport costs against those of truck and rail we would make the following comments in answer to those of Mr French:

(a) The cost of truck and rail transport given in our report, viz \$2.35/t was not estimated by Amdel. This value was given by Mr Rallings of Coffey & Hollingsworth as the combined cost for trucking and railing. While, as Mr French points out, additional capital costs will be incurred for road, loading equipment etc. at Lake Torrens if rail transport is to be used, we would add that loading equipment, trucks, storage facilities and re-dissolving equipment will also be required for the scheme where salt is crystallised at Yorkeys Crossing. A detailed costing would be required to establish which site offered most advantages.

(b) We agree that inflation of rail charges were not considered. Inflation will be less likely to affect pipelining costs.

(c) From values of rainfall and water evaporation extrapolated from charts in 'Review of Australia's Water Resources' published by The Bureau of Meteorology, Melbourne 1968, and assuming the pipeline to be designed to cater for the 90 percentile rainfall data, little or no evaporation can be expected from May to August inclusive (particularly from brine solutions when the net evaporation will be only of the order of 70% of that for water). We therefore feel justified in considering pumping for 8 months only.

...2/

(d) We agree that the required pipeline from Yorkeys to Red Cliff is smaller than the Torrens - Yorkeys pipeline, the required capacity being of the order of 45%. If an annual capacity of 10^6 t is considered, the Yorkeys-Red Cliff line can be approximately estimated from the data calculated for 500,000 tpa from Torrens-Yorkeys. By reducing the pipeline size from 0.53 m diameter to 0.41 m diameter (21" to 16") a saving of $\$0.4 \times 10^6$ capital can be made. This is equivalent to about 12 cents/t NaCl. There are however additional costs which should be made when considering the Yorkeys scheme, such as delivery of water (treated sea water has been suggested) to Yorkeys Crossing. This will require an additional pipeline from the Gulf. By assuming the Yorkeys-Red Cliff pipeline to be the same size as the Torrens-Yorkeys line we have included a contingency for these additional, but unestimated, costs. Again a detailed costing for both schemes would be required.

(e) The Tables given in the Report assumed capital charges of 8% pa depreciation, 6% pa maintenance and 1% pa insurance i.e., a total of 15% pa. No allowance was made for interest charges or operating labour.

If a contract life of 20 years is assumed these charges will be 12% pa. Allowing an interest charge of 10% pa, the transport costs can be calculated as:

	Capacity	10^6 tpa	0.5×10^6 tpa
	Size	0.53 m dia.	0.53 m dia.
	Cost	$\$4.0 \times 10^6$	$\$3.2 \times 10^6$
	Capital Charges	$\$0.88 \times 10^6$	$\$0.70 \times 10^6$
	Power	$\$0.02 \times 10^6$	$\$0.01 \times 10^6$
	Total Torrens	$\$0.90 \times 10^6$	$\$0.71 \times 10^6$
	Total Yorkeys (by proportion)	$\$0.65 \times 10^6$	$\$0.51 \times 10^6$
	Total Pumping Cost	$\$1.55 \times 10^6$	$\$1.22 \times 10^6$
	Total Cost/Tonne NaCl	$1.55	$2.44
c.f.	Previously quoted cost	$1.79	$2.84

From these costs a breakeven capacity of about 0.55×10^6 tpa can be calculated, compared with the previously quoted 0.75×10^6 tpa when assuming a 12.5 year contract life.

We would agree with Mr French that a meeting of the various parties would help to clarify the situation and Amdel would be happy to be represented at such a meeting.

Yours faithfully,
The Australian Mineral Development Laboratories

R.P. Wilmshurst

for F.R. Hartley
Director.

Director of Mines

WMW:cah

EXPLORATION LICENCE 60

Summary of Activities April 1, 1974 to June 30, 1974

During the quarter ending June 30, 1974 Delhi International Oil Corporation continued to explore and evaluate the southern part of Lake Torrens, specifically Foreset Area A, as a source of NaCl brine for the Red Cliff Point petrochemical project.

The program included further exploration with the amphibious dragline, geochemical and petrographic analyses of samples obtained from the stratigraphic section, the compilation of meteorological data, detailed surveying of the Point Paterson seawall and the initiation of two environmental studies. Crystallisation, beneficiation and chemical analysis of solid NaCl obtained from Lake Torrens brine was and is being continued through McPhar Laboratories.

Exploration

Exploration of Lake Torrens continued with a detailed program of excavation and sampling on the main sands of Foreset Area 'A'.

Sixteen pits were excavated along a North-South line on 2 West, and West-East on 24 North and 12 North (See Figure 1).

Forty-seven samples of sand, silt and clay were taken from the dragline pits and were chemically analysed for NaCl content. Twelve of the above were subjected to detailed petrographic and sieve analysis.

Measured sections and sampling of the new sections indicate that Foreset Area A continues further eastward than was at first anticipated. The effect being that the main area of interest, (ie. thick, permeable sands) is now expected to be in the order of 5700 acres or 36% larger than the first interpretation (see Figure 2).

It now appears that Foreset Area A actually merges eastward with the Willochra Creek sediments and receives direct recharge of fluids from the Willochra's distributory streams.

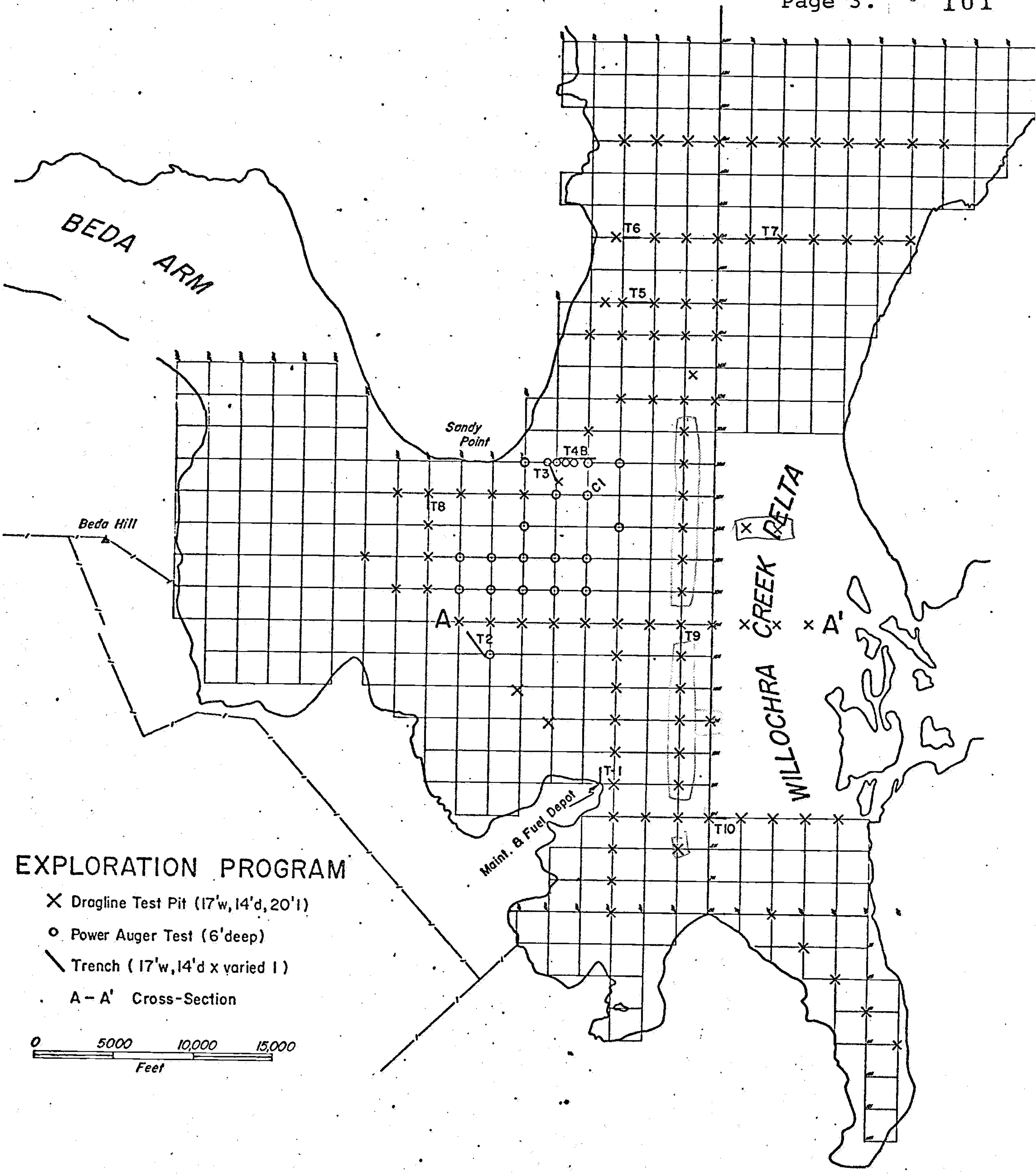

BEDA ARM
Sandy Point
Beda Hill
T6
T7
T5
T4B
T3
C1
T8
A
A'
T2
T9
T-1
T10
Maint. & Fuel Depot
WILLOCHRA CREEK DELTA
EXPLORATION PROGRAM
Dragline Test Pit (17'w, 14'd, 20'l)
Power Auger Test (6'deep)
Trench (17'w, 14'd x varied l)
A – A' Cross-Section
0
5000
10,000
15,000
Feet

Figure 1.

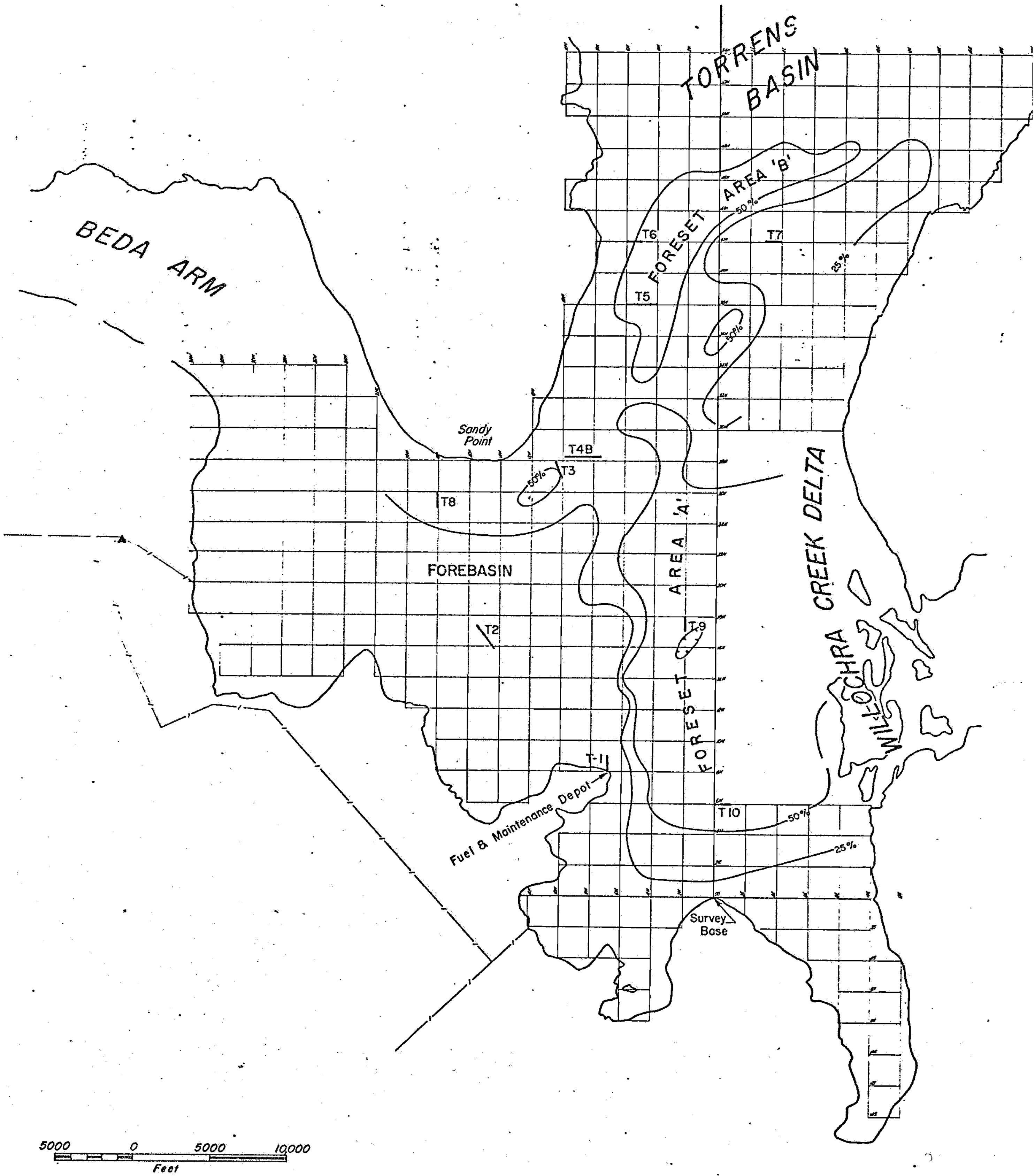


Figure 2 Distribution of Major Sands

Geochemistry

Forty-seven samples of saturated sand, silt and clay were obtained from various depths in the dragline pits located in Foreset Area 'A'.

Geochemical analyses showed the contained brine to be identical to that recovered from previous sampling and further confirmed the quantity and availability of NaCl from the various sedimentary types.

Table A summarises the analytical detail and illustrates that an average of 107 tonnes NaCl per acre/foot is present in the sand section and 114 tonnes per acre/foot is present in the clay and silt-clay mixtures.

Brine densities appear to be slightly less in areas where significant distributory streams carry flood-water from the Willochra Creek. However, the general pattern continues to indicate the availability of 18% - 22% brine, Figure 3.

Table A Foreset Area "A"

Geochemical and Petrographic Analyses

of Clastic Sediments

Sample Number	Litho Class	Weight (long tons/acre/foot) Total	Insolubles	Brine	Filtrate	NaCl Reserves (long tons/acre/foot) In Situ	Filtrate
1	cl/s	2124	1502	1378	-	109.6	-
2	cl/s	2293	1700	593	-	107.3	-
3	sd	2232	1645	587	234.7	109.6	45.1
4	m.sd	2281	1662	619	264.4	115.4	48.8
5	sd	2244	1677	567	201.0	116.0	42.5
6	cl/s	2293	1698	595	155.4	116.5	29.7
7	m.sd	2427	1849	578	422.4	114.6	84.1
8	cl/s	2390	1767	623	169.4	126.2	34.3
9	cl/s	2281	1557	724	-	146.7	-
10	cl/v.f.sd	2499	1826	673	264.2	140.2	53.7
11	cl/s	2450	1824	626	-	118.8	-
12	v.f.sd	2450	1736	714	334.9	137.0	63.8
13	sd	2524	1973	551	86.2	107.8	16.6
14	f.sd	2415	1749	666	347.0	129.7	67.9
15	sd	2221	1629	592	412.6	120.2	83.7
16	cl/s	2293	1673	620	-	108.5	-
17	cl/s	2378	1724	654	286.6	112.2	33.6
18	cl/s	2341	1692	649	193.2	118.0	31.0
19	sd	2499	1883	616	302.7	110.7	51.4
20	sd	2427	1817	610	264.8	104.6	45.4
21	cl/s	2330	1843	487	84.9	110.0	15.1
22	sd	2439	2065	374	166.3	100.0	29.6
23	m/f.g.sd	2415	1839	576	229.1	104.8	39.9
24	cl/s	2342	1722	620	187.0	86.7	24.0
25	cl/s	2355	1896	459	61.8	96.6	11.0
26	sd	2221	1490	731	311.2	121.9	37.1
27	f/m.sd	2427	1814	613	427.1	109.2	73.4
28	sd	2439	1861	578	224.2	97.1	44.4
29	cl/s	2367	1872	495	70.4	107.5	22.5
30	sd	2596	2212	384	-	43.6	-
31	m.sd	2547	2058	489	244.7	84.1	41.1
32	f.sd	2536	2094	442	53.2	70.5	9.0
33	m.sd	2464	1988	476	197.7	73.9	28.4
34	cl/s	2087	1527	560	50.9	106.2	13.2
35	m.sd	2378	1873	505	375.2	96.1	71.7
36	sd	2439	1890	549	231.9	110.5	67.5
37	cl/s	2450	1997	453	96.6	93.3	25.5
38	cl/s	2464	1943	521	80.8	100.3	18.1
39	sd	2487	2075	412	209.0	111.7	71.2
40	cl/s	2355	1871	484	-	116.6	-
41	sd	2476	1899	577	302.3	117.4	61.3
42	cl/s	2584	2126	458	-	94.6	-
43	sd	2547	2167	380	235.0	108.2	80.7
44	sd	2427	1880	547	374.0	100.2	61.6
45	cl/s	2438	2049	389	13.2	119.5	3.9
46	sd	2464	2091	373	149.4	114.3	50.2
47	sd	2439	2020	419	133.6	86.1	25.0
9 - 1	v.f.sd	2378	1866	512	179.0	70.9	21.3
9 - 2	f/m.sd	2378	1866	512	241.2	100.4	42.6
9 - 3	f/m.sd	2426	1807	619	418.2	124.2	78.7
10- 1	m/c.sd	2390	1840	550	299.9	113.3	54.0
10- 2	v.f/f.sd	2355	1670	685	295.0	135.6	54.9

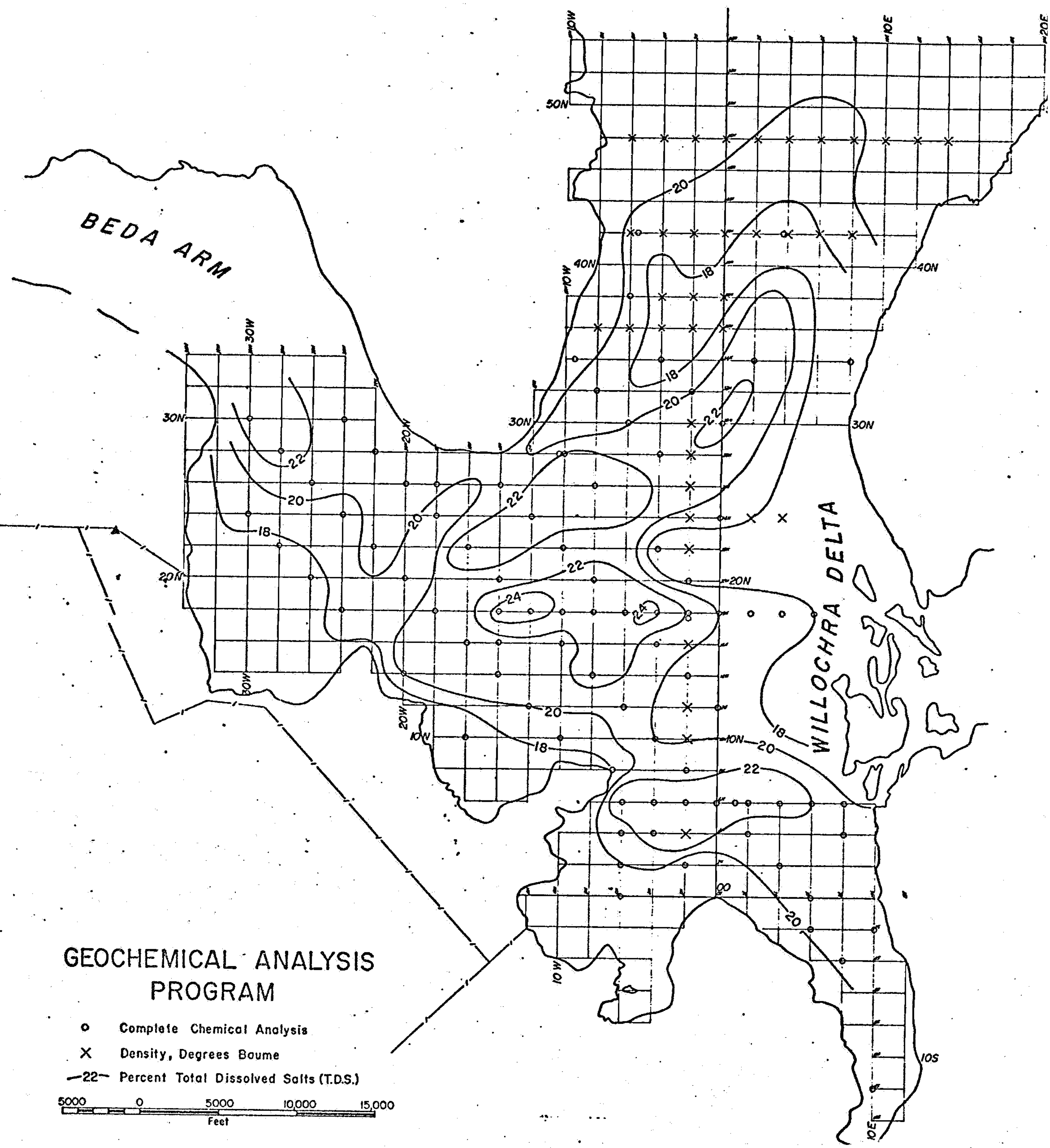

BEDA ARM
WILLOCHRA DELTA
GEOCHEMICAL ANALYSIS PROGRAM
o Complete Chemical Analysis
X Density, Degrees Baume
—22— Percent Total Dissolved Salts (T.D.S.)
5000 0 5000 10,000 15,000
Feet

Figure 3.

Petrographic Analyses

Twelve samples of sand and silt-sand mixtures were subjected to mineralogical analysis. The laboratory report is attached hereto and the sieve analyses of the "clean" sand samples are summarised in Table B.

Table B Foreset Area "A" Sands

Sample	Mesh Size, Percent Volume				
	+30	30-60	60-120	120-240	-240
4	9.95	48.39	13.71	7.52	20.43
7	3.68	58.90	19.33	5.52	12.58
12	0.0	0.33	16.03	56.76	26.71
14	0.09	0.67	56.57	22.00	20.65
23	1.71	33.22	32.53	7.19	25.34
27	1.30	41.21	43.38	6.25	7.86
31	7.78	53.89	22.01	8.35	7.97
32	6.87	25.72	37.69	15.96	13.74
33	12.62	39.32	25.24	12.13	10.68
35	15.29	53.25	24.61	2.62	4.23

Reserves

Reserves in place have been estimated from the geochemical analyses of fluids recovered from lithologic samples.

Table 5 of the Annual Report dated March 1974 has been revised on the basis of the new data and is as follows:

NaCl Reserves in Place

Area	Acres	Lithology	Thickness (upper 14')	NaCl tonnes/ acre/ft	NaCl Reserves x million
A	5700+	Sand	7.0	107*	4.3
		Silt & Clay	7.0	114	4.5
B	1400	Sand	7.0	107	1.0
		Silt & Clay	7.0	114	1.1
C	9200+	Sand	3.5	104	3.3
		Silt	3.5	72	2.3
		Clay	7.0	154	9.9
D	3200+	Sand	1.75	118	0.7
		Silt	3.5	72	0.8
		Clay	8.75	154	4.3
				Total million tonnes	32.2

* Shows decrease of 10%.

Pump Tests

A total of 10 pump tests have now been conducted on Trenches 9 and 10. The tests were conducted after recharge periods of 16 to 27 days and produced 6.83 to 20.32 tonnes NaCl per day per 1,000 feet trench.

Rainfall and evaporation affected the recovery data to a considerable degree. Rain appears to percolate quickly into the sediments and serves to increase brine recovery. Regression analysis of NaCl recovery v's rainfall indicates the following approximate relationship:

Tonnes NaCl/day/1,000 feet trench = 11.22 + 1.35 x inches Rain

Therefore, assuming 8" rain per year or 0.47 inches per recharge period, the average productivity of trenches in Foreset Area A should be in the order of:

11.22 + 1.35 (0.47) = 11.85 tonnes/day/1,000 feet.

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23	1.71	33.22	32.53	7.19	25.34
27	1.30	41.21	43.38	6.25	7.86
31	7.78	53.89	22.01	8.35	7.97
32	6.87	25.72	37.69	15.96	13.74
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Therefore, assuming 8" rain per year or 0.47 inches per recharge period, the average productivity of trenches in Foreset Area A should be in the order of:

11.22 + 1.35 (0.47) = 11.85 tonnes/day/1,000 feet.

Table C Recovery of brine and NaCl from Trenches 9 and 10

Test	Time in Days	Recovery U.S. Gallons	Specific Gravity	T.D.S. % w:w	Tonnes Brine	Tonnes NaCl	Tonnes NaCl/ day/1000 ft	Rainfall (inches)	Evaporation (inches)
Trench 9 (1,020 feet long)									
1	21 22	267,930	1.165	22.0	1,176.70 ~~1,010.53~~	[illegible] ~~223.25~~	[illegible] ~~10.42~~	1.34	8.52
2	26 29	286,000	1.181	24.1	1,273.93	307.95	11.61	0.02	9.83
3	22	365,220	1.164	21.9	1,603.38	326.56	14.55	5.03	7.51
4	27	207,260	1.166	22.2	911.47	188.18	6.83	1.08	8.47
5	16	360,100	1.132	17.8	1,537.44	254.51	15.60	2.12	2.68
Trench 10 (1,003 feet long)									
1	19 20	307,120	1.156	20.9	1,339.05	280.79	14.73	0.20	10.60
2	19 18	265,100	1.176	23.5	1,175.84	256.98	13.48	1.33	13.32
3	18	399,990	1.161	21.5	1,751.50	350.21	19.40	5.03	9.82
4	24	271,500	1.176	23.5	1,204.22	263.18	10.93	0.02	8.17
5	16	416,400	1.145	19.5	1,798.23	326.11	20.32	2.99	1.95

As given in annual report 73/74

Table C.

BRINE RECHARGE

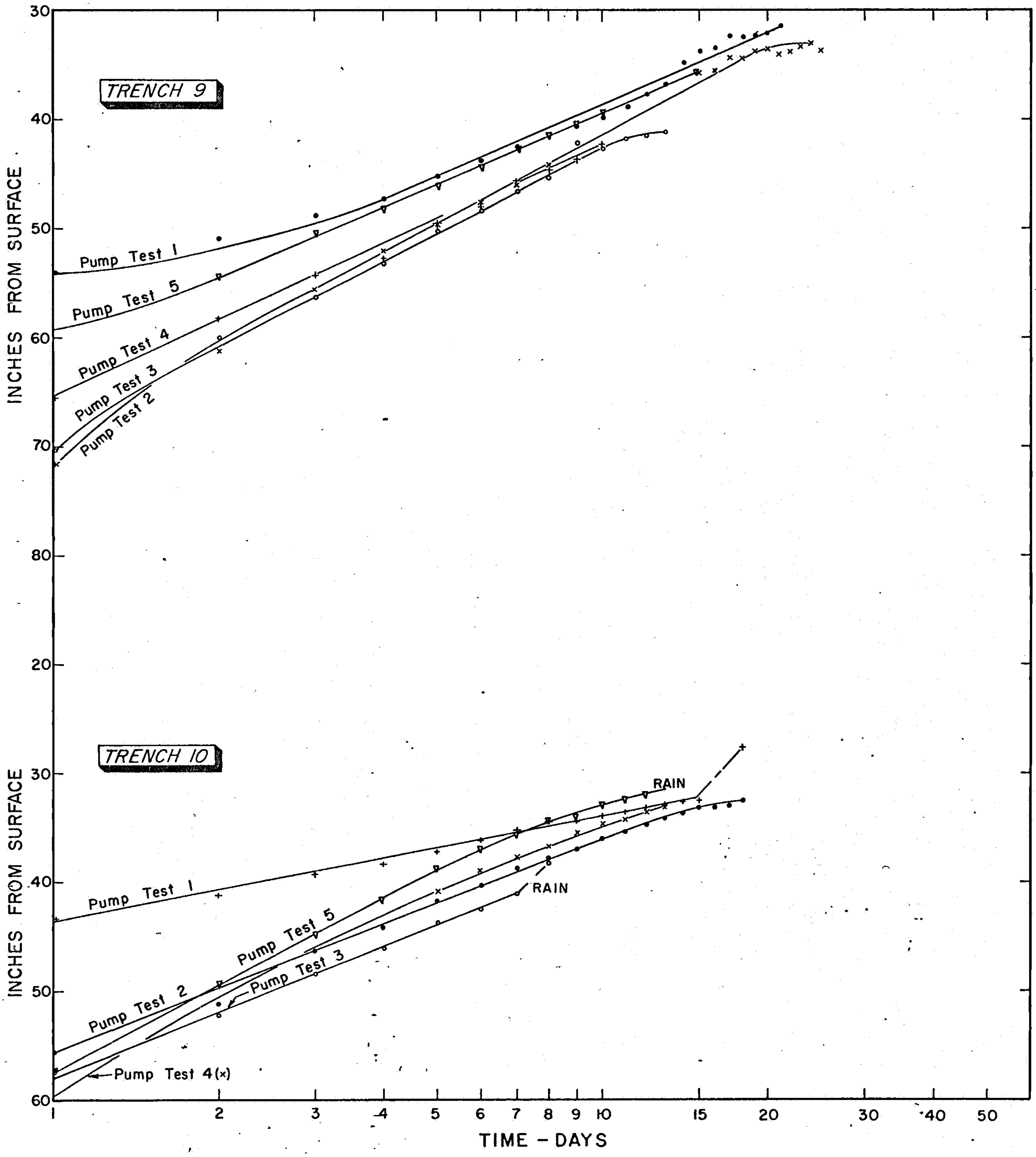


Figure 4.

BRINE RECHARGE

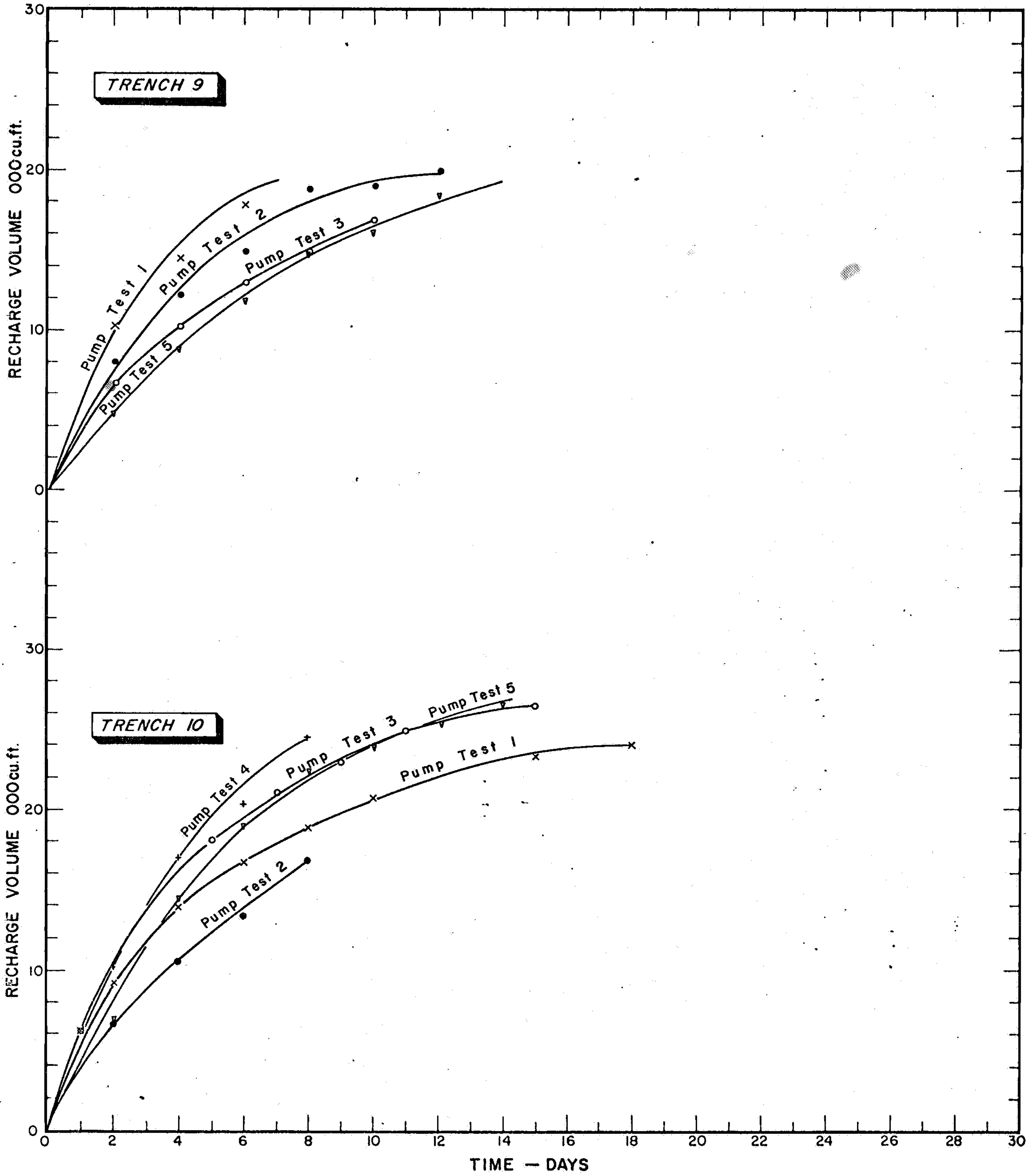


Figure 5.

Weather

Meteorological observations were continued at the base camp and a separate evaporimeter and anemometer were established near Trench 10.

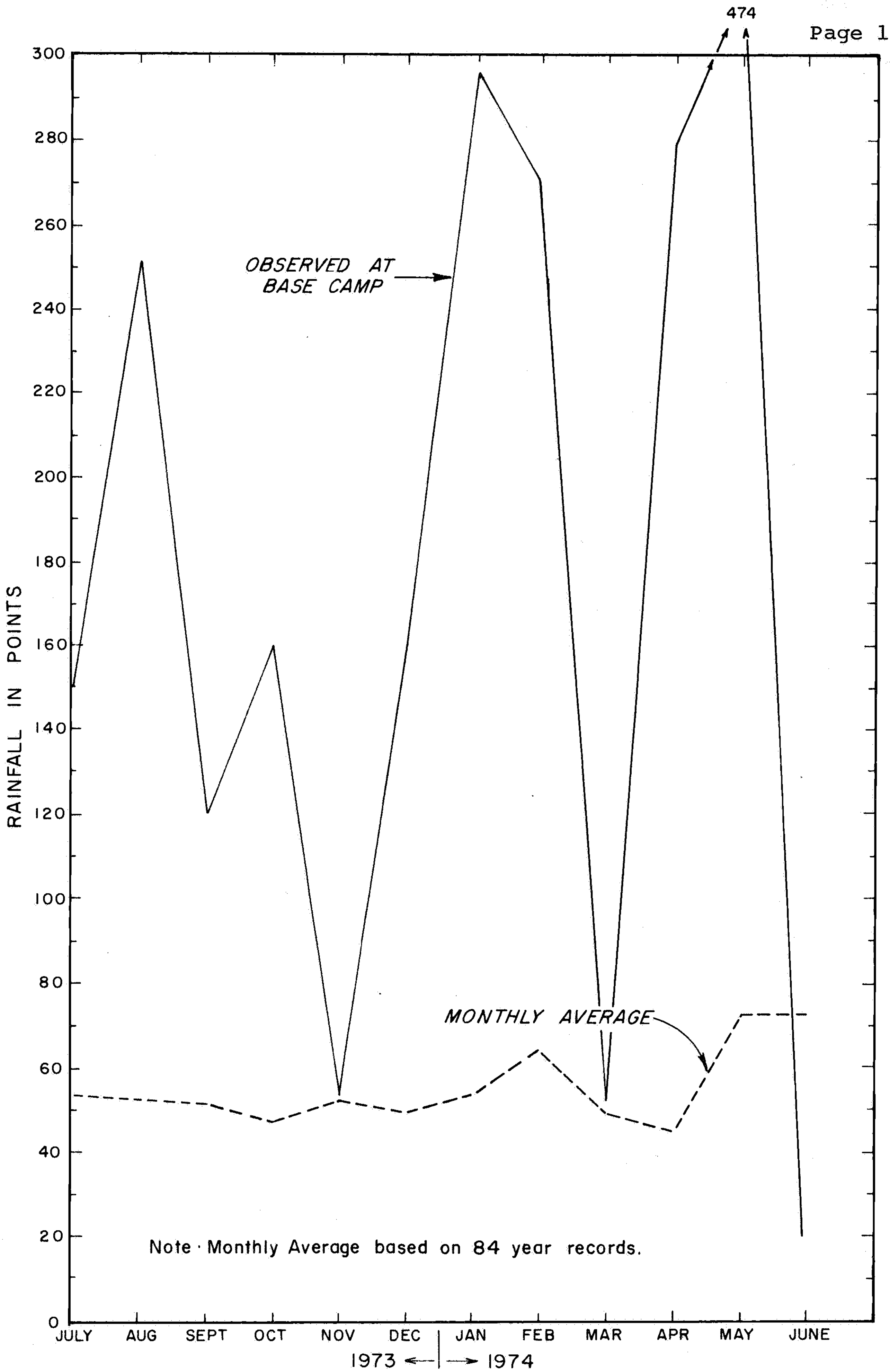
April and May continued the trend of abnormally high rainfall. May was extremely wet with 4.74 inches rain recorded, but June had a lower than average rainfall of only 0.2 inches (see Figure 6 and Table D).

Evaporation of dense brine from the Class A evaporimeter at Trench 10 appears to be about 70% of that recorded for freshwater at the main station. See Figure 7.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
March																																
Camp Rainfall	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	28	22	52
Camp Evaporation	45	nr	90	40	40	35	40	43	44	37	33	43	51	33	43	32	29	39	34	36	35	28	24	35	18	20	29	26	25	28	32	1092
T10 Rainfall																										0	0	0	0	0	9	9
T10 Evaporation																										21	21	20	17	31	17	127
April																																
Camp Rainfall	52	4	0	0	0	39	23	14	36	62	19	0	0	0	0	0	0	0	16	3	0	6	0	0	0	0	6	0	0	0		280
Camp Evaporation	33	16	20	24	28	11	8	0	5	17	3	15	12	16	14	14	26	13	4	9	8	14	11	14	18	12	10	12	16	18		421
T10 Rainfall	31	2	0	0	0	36	nr	nr	nr	nr	nr	nr	nr	nr	156	0	0	0	12	0	0	0	0	6	0	0	0	0	0	0		243
T10 Evaporation	26	7	13	17	25	0	nr	nr	nr	nr	nr	nr	nr	nr	64	14	12	11	1	3	4	5	10	16	10	9	4	9	14	18		292
May																																
Camp Rainfall	0	0	0	0	0	32	18	155	163	0	0	0	87	0	5	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	474
Camp Evaporation	12	14	12	10	11	27	3	13	28	10	7	7	15	5	7	9	13	9	8	7	9	6	14	10	9	8	8	5	6.5	8	10	320.5
T10 Rainfall	0	0	0	0	0												------------------------------Total--- 22 ------------------------------															
T10 Evaporation	14	11	10	5	8												------------------------------Total--- 36.24 ----------------------------															
June																																
Camp Rainfall	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	14		20
Camp Evaporation	8	16	15	7	6	6	6	9	7	9	12	10	11	6	7	10	6	6	6	8	7	6	5	4	6	8	10	10	17	17		261
T10 Rainfall	Total from 26th May.0 ---------------------- 0 -- 0																															
T10 Evaporation	" " " " " .76.4 -------------------- 38 --54																															

Table D Meteorological Data March through June 1974

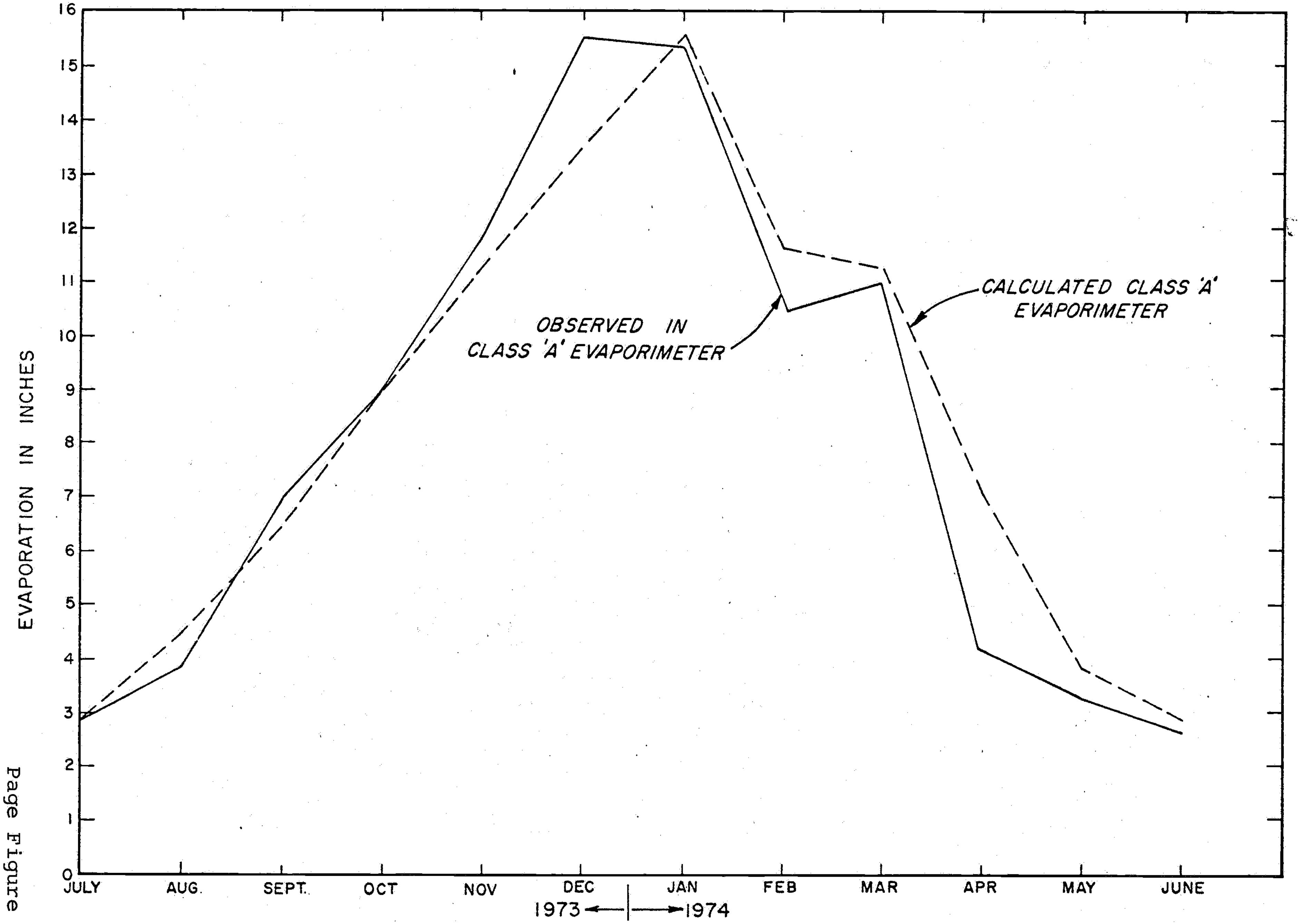
Table D.



RAINFALL - LAKE TORRENS

SOUTH GAP STATION

Figure 6.



EVAPORATION – LAKE TORRENS

Page Figure 7.

Page 17.

<u>Miscellaneous Work</u>

A detailed survey of the old seawall at Point Paterson was commenced in June 1974. The survey, which includes profiles every 100 feet from the top of the seawall to sealevel, will be used to estimate time and construction requirements for renovation. Drafted sections should be completed by August.

A proposed environmental guideline was received from the S.A. Department of Environment and Conservation. The guidelines were reviewed by Delhi and portions were submitted to various consultants for their comments and proposals. Dr. Allen Butler and staff, Department of Zoology, University of Adelaide, have been hired to compile a study of the fauna and flora of the mangrove area at Point Paterson. The resulting data will be compared with information from mangroves at Port Price, Osborne, and other salt works. Dr. Butler will commence work in the Point Paterson area in July 1974.

Future Work Program

Expenditures and work commitments are continuing in the following areas:

1. Environmental study is scheduled to commence on or about July 6, 1974.
2. Brine crystallisation laboratory test is in progress. The first bulk sample of brine has been crystallised and washing/screening/analysing tests are also in progress. Initial results appear to be most promising.
3. Long-term pump test on Trench 10 will be commenced as soon as surface floodwater subsides sufficiently to permit access to the area.
4. Drafting and engineering studies of the Point Paterson seawall are in progress.
5. Weather data, especially rainfall and evaporation, are now being compiled from observation at Trench 10 (with dense brine evaporimeter) and at the Base Camp.

Lake Torrens Exploration Program

Items	Expenditure
Salaries, wages & Associated Costs	66,944
Travel and Accommodation	3,763
Entertainment	397
Consultants	19,189
Operating Expenses	
Dragline	32,561
Pumps	2,555
Camp	12,302
Other Equipment	6,268
Equipment Rental	4,420
Assays	4,415
Capital Equipment Purchase	
Dragline	54,683
International Pick Up	6,760
Toyota swb	4,142
Toyota 1½ ton flat bed	3,488
BUE Earth Cruiser	2,863
Honda ATC 90 bikes x 7	3,990
ATV Vehicle	745
Walkie Talkies x 4	257
2 Way Radio	899
Generator-Petbowlister	2,406
Pumps K & L Diesel	5,176
Camp Equipment	1,244
Survey Gear	700
Power Auger	486
Miscellaneous	1,306
	$241,959

Ian R. Pontifex & Associates

1974 MAY 17 AM 9:37

MINERALOGY — PETROLOGY
GEOLOGY
SECTION PREPARATION

50 MARY STREET, UNLEY
SOUTH AUST. 5061
TEL. 272 2856. A.H. 31 3816

MINERALOGICAL REPORT NO. 1508

14th May, 1974

TO:	Mr. R.R. French, General Manager, Delhi Minerals Ltd., 33 King William Street, ADELAIDE, S.A. 5000
YOUR REFERENCE:	Samples delivered to McPhar Chemical Laboratories
MATERIAL:	Wet sediments from Lake Torrens, 12 samples nominated by 'phone
IDENTIFICATION:	All from line 2W, at coordinates 4N, 8N, 12N, 14N, 20N, 24N, 26N, 28N, various depths
WORK REQUESTED:	Sieve analysis, determine the mineralogical composition of sand and silt fractions

I R Pontifex

IAN R. PONTIFEX & ASSOCIATES

SIEVE ANALYSIS

The sands were wet-sieved through a bank of sieves designed to remove coarse, medium and fine sand sizes. The remaining silt-clay fraction (less than 240 mesh) was not generally separated since mineralogical analysis of the clays was not required.

The dry weight of each fraction was determined. The volume of each fraction was determined by measuring its displacement of water in a graduated flask, a procedure which provides an accuracy of the order of ± 5% relative.

The wt% and vol% and the S.G. of each fraction were compiled from these determinations and are given as follows:-

4N2W: 3'2" to 5'2" (no. 2)

Mesh size	wt%	vol%	S.G.
+ 30	1.17	0.87	2.95
- 30 + 60	5.94	5.49	2.51
- 60 +120	19.93	17.34	2.66
-120 +240	27.89	25.43	2.54
-240	45.05	50.87	2.05

4N2W: 6'2" to 8'1" (no. 4)

Mesh size	wt%	vol%	S.G.
+ 30	10.59	9.95	2.56
- 30 + 60	45.64	48.39	2.36
- 60 +120	15.17	13.71	2.66
-120 +240	10.85	7.52	3.24
-240	17.75	20.43	2.08

8N2W: 5'5" to 8'1" (no. 7)

+ 30	3.53	3.68	2.45
- 30 + 60	59.49	~~5.89~~ 58.9	2.59
- 60 +120	19.30	19.33	2.50
-120 +240	5.38	5.52	2.49
-240	12.28	12.58	2.49

12N2W: 1'10" to 3'4" (no. 10)

+ 30	1.04	0.92	2.60
- 30 + 60	12.82	10.90	2.71
- 60 +120	23.06	20.21	2.63
-120 +240	22.82	22.66	2.32
-240	40.26	45.36	2.05

12N2W: 6'11" to 8'11" (no. 12)

+ 30	< 1	< 1	-
- 30 + 60	0.33	0.33	2.4
- 60 +120	17.15	16.03	2.60
-120 +240	59.07	56.76	2.53
-240	23.36	26.71	2.12

14N2W: 3' to 4' (No. 14)

+ 30	0.13	0.09	-
- 30 + 60	0.66	0.67	2.4
- 60 +120	58.66	56.57	2.53
-120 +240	22.67	22.00	2.51
-240	17.88	20.65	2.11

20N 2W: 7'7" to 10' (no. 23)

+ 30	1.51	1.71	2.46
- 30 + 60	40.38	33.22	3.00
- 60 +120	29.88	32.53	2.56
-120 +240	6.77	7.19	2.62
-240	21.43	25.34	2.35

24N 2W: 6'8" to 7'10" (no. 27)

+ 30	1.27	1.30	2.50
- 30 + 60	41.29	41.21	2.55
- 60 +120	44.41	43.38	2.61
-120 +240	6.39	6.25	2.61
-240	6.63	7.86	2.14

24N 2W: 13'4" to 15' (no. 31)

+ 30	8.27	7.78	2.55
- 30 + 60	58.47	53.89	2.59
- 60 +120	24.32	22.01	2.64
-120 +240	8.94	8.35	2.56
-240	7.21	7.97	2.16

26N 2W: 9'1" to 9'4" (no. 32)

+ 30	7.07	6.87	2.57
- 30 + 60	26.59	25.72	2.58
- 60 +120	38.27	37.69	2.54
-120 +240	16.14	15.96	2.52
-240	11.94	13.74	2.17

26N 2W: 12'4" to 13'1" (no. 33)

+ 30	13.04	12.62	2.57
- 30 + 60	40.38	39.32	2.55
- 60 +120	25.56	25.24	2.52
-120 +240	12.63	12.13	2.58
-240	8.38	10.68	2.06

28N 2W: 6'9" to 7'7" (no. 35)

+ 30	15.05	15.29	2.54
- 30 + 60	53.83	53.25	2.61
- 60 +120	25.09	24.61	2.63
-120 +240	2.59	2.62	2.55
-240	3.43	4.23	2.08

MINERALOGICAL ANALYSIS

All fractions were examined under a binocular microscope and an identification of component grains and an estimation of their abundance was made. The silt-clay fraction was too fine to examine optically. Comments on the composition of individual fractions and samples, including some comparisons, are given where appropriate.

The results of these examinations are set out after the following brief and very general comments.

The sands consist predominantly of quartz grains. Iron oxide grains of apparently wind blown magnetite $\pm$ hematite and goethite are present in trace to accessory abundance.

Rock fragments in the coarse (+30) fraction consist of caprock material such as ferricrete, silcrete, calcrete and laterite. In the finer fractions they consist mainly of sericitic (and argillaceous) siltstone, and fine sericite schist. These may have the greenish color of unaltered sericite, or impregnated, often thoroughly by limonite.

Carbonate grains were identified by reaction to HCl, in the coarse fraction they are almost invariably calcrete with minor shell fragments. In the finer fractions the origin of the carbonate is indeterminate.

Muscovite occurs in most samples between 12N and 24N. Samples 24N 13'4" to 15', both samples from 26N and the sample from 28N are notably clean quartz sands, due to only relatively insignificant contamination by rock fragments and carbonate. No other trends in mineralogical composition throughout the suite are apparent since the composition of most samples and fractions from 4N to 24N (6'8" to 7'10") are essentially very similar.

- - -

INDIVIDUAL DESCRIPTIONS

4N 2W: 3'2" to 5'2" (no. 2)

	qtz grains	FeO grains	rk frags.	carbonate	others
+ 30	60-70	3-5	20-25	7-10	5
- 30 + 60	85-90	3-5	7-10	1-2	-
- 60 +120	70-75	2-3	20-25	1-2	3-5
-120 +240	75-80	1-2	15-20	1-2	2-3

The quartz grains are subrounded to well rounded, being relatibely less rounded in the finer fractions.

The FeO grains consist mainly of fine pellets of limonite (?goethite). Several chert grains are present in the +30 fraction. The carbonate occurs as milky white grains, which may or may not be related to calcrete fragments seen in the coarse fraction of other samples. The rock fragments are sericitic siltstone, with several very fine sericite schist varieties, almost invariably they are thoroughly impregnated by secondary iron oxides. Some appear to represent lateritic material.

"Others" include some 3-5% gypsum in the +30 fraction and muscovite in the two finer fractions.

4N 2W: 6'2" to 7'8" (no. 4)

	qtz grains	FeO grains	rk frags.	muscov.	carbonate
+ 30	65-70	1-2	20-25	-	10
- 30 + 60	70-75	1-2	25-30	-	
- 60 +120	70-75	2-3	20-25	2-3	-
-120 +240	60-70	7-10	20-25	3-5	-

The comments given for the above sample more or less apply to this sample. The "carbonate" in the +30 fraction is essentially calcrete, cementing fine residual quartz grains. Carbonate in the finer fractions has an indeterminate composition. Ferruginised, sericitic and argillaceous siltstone, and fine sericite schist constitute most rock fragments.

Minor ?glauconitic fragments occur in the -30+60 fraction.

Fine subhedral, equidimensional grains of magnetite are characteristic of the -120+240 sample and probably account for the relatively higher S.G. of this sample. Accessory rutile and tourmaline also occur in this size fraction.

8N 2W: 5'5" to 8'1" (no. 7)

	qtz grains	FeO grains	rock frags.	carbonate
+ 30	20-30	2-3	70-80	-
- 30 + 60	70	2-3	25-30	-
- 60 +120	60-70	2-3	30-35	2-3
-120 +240	60-70	3-5	20-25	7-10

The +30 fraction is dominated by fragments of calcrete, i.e. carbonate cementing fine quartz grains. Fragments of chert, laterite and siltstone are also present as in previous samples. The siltstone is sericitic and thoroughly impregnated by limonite. In fractions -30 to +120 mesh, calcrete forms only a minor proportion of the rock fragments, limonitic siltstone a major part.

A significant amount of carbonate, of almost certain calcite composition, occurs in the -120 +240 fraction. The grains are too fine to positively identify the origin of this calcite, it is probably related to the calcrete in the coarser fraction.

12N 2W: 1'10" to 3'4" (no. 10)

	qtz.grains	FeO grains	rk frags.	carbonate
+ 30	50-60	2-3	40-50	-
- 30 + 60	60-70	2-3	30-40	1-2
- 60 +120	65-70	1-2	25-30	5-7
-120 + 240	75-80	<1	15-20	5-7

The rock fragments in most fractions consist of sericitic siltstone (variably limonitised) and minor calcite (calcrete). As in formersamples, non ferruginised sericitic siltstone fragments have a characteristic greenish color.

The quartz grains are well rounded in the coarser fractions.

The carbonate grains in the finer fractions have an indeterminate origin.

12N 2W: 6'11" to 8' 11" (no. 12)

	qtz grains	FeO grains	rk.frags.	carbonate	muscovite
+ 30		-- negligible sample --			
- 30 + 60	80-85	1-2	10-12	1-2	5-7
- 60 +120	55-65	1-2	20-25	10-15	5-7
-120 +240	75-80	1-2	7-10	7-10	3-5

Rock fragments consist of sericitic siltstone as in previous samples, variably limonitised. The presence of muscovite, although only in minor abundance, is characteristic of this sample.

14N 2W: 3' to 4' (no. 14)

	qtz grains	FeO grains	rk.frags.	carbonate	muscovite
+ 30		-- negligible sample --			
- 30 + 60	60-65	1-2	25-30	3-5	5-7
+60 +120	60	1-2	30	5-7	3-5
-120 +240	60-70	2-3	25-30	3-5	3-5

Fine magnetite-hematite grains in the -120 +240 fraction are essentially the same as in the 4N2W sample in the same size fraction, their abundance has apparently negligible effect on the SG however.

20N2W: 7'7" to 10' (no. 23)

	qtz grains	FeO grains	rk.frags.	carbon.	muscovite
+ 30	75-85	1-2	10-20	5	3-5
- 30 + 60	55-60	2-3	30-35	5-7	3-5
- 60 +120	60-65	1-2	25-30	5-7	3-5
-120+240	75-80	2-3	10-12	5-7	2-3

The carbonate in the +30 fraction is calcrete. Silcrete, ferricrete, and siltstone constitute the rock fragments in this fraction. The rock fragments are highly sericitic, many are ferruginised, some appear to be glauconitic.

24N 2W: 6'8" to 7' 10" (no. 27)

	qtz grains	FeO grains	rk frags.	carbon.	muscovite
+ 30	75-85	1	10-20	5	-
- 30 + 60	60-65	1-2	30	7-10	1-2
- 60 +120	65-75	3-5	20-25	3-5	1-2
-120 +240	80-85	3	10-15	3-5	1-2

The comments relating to the +30 fraction for sample no. 23 also apply to this sample. Hematite-magnetite grains are slightly more abundant in the finer fractions than in most samples described above.

24N 2W: 13'4" to 15' (no.31)

	qtz.grains	FeO grains	rk.frags.	carbon.	muscovite
+ 30	95-100	tr	3-5	tr	-
- 30 + 60	95-100	1-2	3-5	1	-
- 60 +120	95-100	tr	3-5	tr	tr
-120 + 240	95-100	1-2	3-5	tr	tr

The +30 fraction of this sample is a notably clean sand, consisting essentially of well rounded quartz grains. The entire sample in fact, is clearly much "cleaner" than others in the suite. The quartz grains also are less coated by limonite stainings.

26N 2W: 9'1" to 9'4" (no.32)

	qtz.grains	FeO grains	rf.frags.	carbon.	muscovite
+ 30	80-85	1-2	5-7	10-12	-
- 30 + 60	90	1-2	3-5	3-5	-
- 60 +120	95	tr	3-5	1-2	-
-120 +240	90-95	1-2	3-5	1-2	-

The carbonate fragments in the +30 fraction are calcrete. The "rock fragments" have a variable silcrete to ferricrete composition; the sericitic siltstone seen in other samples above are generally absent. The finer fractions also contain far less sericitic rock fragments than in the samples described above.

26N 2W: 12'4" to 13'1" (no. 33)

	qtz.grains	FeO grains	rk. frags.	carbonate
+ 30	90-95	1-2	1-2	3-5
- 30 + 60	95	tr	2-3	1-2
- 60 +120	95	tr	2-3	1-2
-120 + 240	95	tr	2-3	1-2

The carbonate in the +30 mesh fraction is calcrete, as in the 24N 2W: 13'4" to 15' sample, this coarse fraction is a notably clean quartz sand. The quartz grains are well rounded. The finer fractions are also relatively, and consistently, clean.

28N 2W : 6'9" to 7'7" (no. 35)

	qtz.grains	FeO grains	rk.frags.	carbonate
+ 30	90-95	3-5	1-2	3-5
- 30 + 60	90-95	2-3	3-5	1-2
- 60 +120	95	tr	2-3	1-2
-120 +240	95	tr	2-3	1-2

This is also a relatively clean quartz sand, very similar to 26N2W : 12'4" to 13'1" in all fractions. Unusual iron oxide grains with a fine sintered texture occur in the coarser fractions.

THE IMPACT OF PROPOSED SALT WORKS AT POINT PATERSON ON TIDAL SWAMPS IN THE AREA

Report to

Delhi International Oil Corporation

by

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September, 1974

CONTENTS

CONTENTS cont'd..

CONFIDENTIAL

1. INTRODUCTION

Following discussions in May, 1974, about the proposed Point Paterson saltworks and their possible impact upon nearby tidal swamps, I submitted to Delhi a proposal dated 10 June, 1974. That proposal referred to the guidelines for the preparation of an Environmental Impact Statement provided by the Director of Environment and Conservation, and indicated that whilst some of the questions posed by the Director could not be answered in a short time, it would be possible to answer some of them by means of short surveys in the area chosen for the proposed pans and in other areas where salt-pans already exist.

This report presents the results of the work suggested in that proposal. The results and conclusions are arranged, broadly, into the sequence suggested by the Director of Environment; firstly a "Definition of the Existing Environmental Profile", secondly a prediction of the effect of the proposed saltfields on the "E.E.P.".

For quick reference, the gist of the report may be obtained by reading sections 3.6, 4.3 and 5.

2. INVESTIGATIONS CARRIED OUT

2.1 Field Programme

The area between Red Cliff Point and Point Paterson was visited twice; by three people including myself from 6 - 8 July and again by two people on 27 and 29 July. The area near the saltworks at Price, Yorke Peninsula, was visited by three people including myself on 13 - 14 July. Two people visited the old saltworks at Yorkey's Crossing, north of Port Augusta, on 28 July, and the area near the I.C.I. saltworks at Dry Creek on 5 - 6 August. On 18 August I drove along the seawall at the Dry Creek works.

2.2 Sampling Procedures

The information presented must be considered as qualitative observations. Although some potentially-quantitative procedures were used, it was impossible to obtain large enough numbers of observations to treat statistically in a meaningful way.

The sampling procedure was:

(i) Observation - Notes were made of sizes and condition of the mangrove trees, whether seedlings or dead trees were present, the extent of leaf-damage by insects, the nature of the sediments, and any other points of interest.

(ii) Surface Quadrats - A number (10, 15 or 20) of randomly-placed, 30 cm square quadrats were scored for animals which live on the surface of the mud, or on pneumatophores. Although this gave a very crude estimate of the abundance of the organisms, its purpose was mainly to standardise the effort put into searching for surface animals. This is true also of procedures (iii) and (iv) and, except for occasional remarks on abundance, the results are presented merely as species lists.

(iii) Mud Blocks - From one to five "blocks" of mud of area 360 cm^2 and depth about 15 cm were broken apart and seived in search of worms, crabs and molluscs which live within the mud.

(iv) Surface Scrapes for diatoms - Five or ten thin slices of surface mud (Area 25 cm^2, thickness 2-5 mm) were collected and returned in separate plastic bags to the laboratory. There, each mud-sample was suspended in a small amount of water in a Petri-dish; microscope cover-slips were laid on the surface of the slurry and, after enough time for the motile diatoms to rise to the surface, diatoms adhering underneath the coverslips were examined under 450x magnification, classified to genera, and counted on standard transects of the coverslips.

(v) Collections - Specimens of plants in the Chinaman Creek - Point Paterson area were collected. These were compared with herbarium collections; because they lacked reproductive structures they were not permanently stored.

We collected type-specimens of all mud-dwelling animals found at all sites. Of the animals found in quadrats and mud-blocks all worms were collected, whilst types of molluscs and crustacea were collected for identification and storage.

(vi) <u>Salinity Readings</u> - Salinities were measured in free water in creeks or pools. Groundwater salinity was measured where groundwater was found seeping from the banks of creeks, or where it seeped into holes produced with a corer. The instrument used was a Hamon Temperature-Salinity Bridge (Autolab Model 602).

It should be noted that we have not attempted to sample microflora other than diatoms. Nor have we considered bacteria, or microscopic animals such as protozoa. These are likely to be important in the tidal-swamp ecosystem (Fenchel, 1969) but we were not equipped to sample them; the task of setting up procedures to do so would have been a lengthy one.

3. 'EXISTING ENVIRONMENTAL PROFILE' - TIDAL SWAMPS

Only mangrove and samphire swamps are discussed below: Seagrass communities which lie to seaward of the mangroves and the communities to landward of the proposed saltpans have not been considered.

3.1 Extent of the Swamps

The mangrove and samphire communities are mapped in Figure 1. They are extensive at the Chinaman Creek end, becoming narrower to the north. Inland of the samphire community is a broad area of bare, salty mud and, to the north, the disused saltpans at Point Paterson. Hereafter I shall refer to this whole area of tidal swamps and salt flats as the "Point Paterson area".

Fig. 1 shows the sites visited during this investigation. Observations were made at all sites shown. The full sampling procedure (Under 2.2 above) was carried out at the sites whose numbers are double-circled.

3.2 The Physical Habitat

The mangroves and samphires in this area grow in fine pale-coloured sediment which is firm compared with the muds often found in tidal swamps. I understand that this sediment is marine clay which overlies an Avondale formation. The sediment was well-aerated compared with other such swamps in S.A. eg, at site 5 the black, anaerobic layer was more than 20 cm below the surface. Shellgrit dunes lie just inland of the mangroves in a number of places in the northern half of the area.

To seaward of the mangroves lie extensive mudbanks, covered in large part with eelgrass, Zostera sp. Thus, the energy of waves reaching the mangroves is low.

In mangroves in several places in South Australia there is evidence of appreciable changes in sediment-level having taken place within the life-span of a mangrove tree (probably some tens of years, at least) - accretion in some cases, erosion in others. I saw little to indicate such rapid changes in the Chinaman Creek - Point Paterson area. This is, of course, likely to be an area of accretion of sediment but it would appear to me that accretion is not extremely rapid.

The heights of the sediments relative to tidal fluctuations were not measured in this study. However, we saw no evidence that they differed from other such areas, where the mangroves grow from a little above mean sea level to a little below mean high water of spring tides, samphires growing up to a level reached only by extreme spring tides. That is, we might expect the floor of the mangrove forest to be flooded by most high tides, parts of the samphire only by spring tides.

It seems likely that there is very little freshwater runoff from the land through this area. Our first visit coincided with extensive rain; there had been prolonged rain before it; and yet salinities in the tidal creeks, surface pools and groundwater were all about that of the sea at the time, just above 4.2%.

3.3 The Species Present

In this section most of the species are merely listed in tables. Comments on their abundance and relationships will be made in section 3.4. The sites referred to in Tables 1, 3, 4 and 6 are those shown in Fig. 1.

Table 1. Macroscopic Plants

Family	Species	Common Name	Sites at which each species was recorded
Verbenaceae			
	Avicennia marina	Grey Mangrove	2,3,4,5,6,7,8, 9,10,11,12,13, 15,17,19
Chenopodiaceae			
	Salicornia australis	Samphire	1,14,18
	Arthrocnemum halocnemoides	Samphire	1,14
	Sueda australis	Seablite	14,18
	Kochia oppositifolia		14
Convolvulaceae			
	Wilsonia humilis		14
Frankeniaceae			
	Frankenia pauciflora	Sea-heath	14

Table 2. Diatoms

Genus	Common or Uncommon*
Amphora	C
Cocconeis	U
Cymbella	C
Diploneis	U
Epithemia	U
Gyrosigma	U
Hanzschia	U
Mastogloia	U
Navicula	C
Nitzchia	C
Pleurosigma	U
Tropidoneis	U

* The sampling-technique for diatoms was previously-untried. As it turned out, insufficient samples were taken for quantitative estimation, or even to be confident that we have seen all forms which occur at any given site. Therefore genera are not listed by sites. They are scored "common" if found at almost all sites, otherwise, "uncommon".

Table 3. Animals found in the Mud*

	Species	Sites at which recorded
Crustacea, Decapoda	Helograpsus haswellianus	All but 13, 18
Annelida, Polychaeta	Possibly several species. Sent to specialist for identification.	6, 13
Mollusca, Lamellibranchia	Katelysia sp.	13
	Modiolus sp.	13, 15
Mollusca, Gastropoda	Ophicardelus ornatus	1
	unidentified Littorinid	14

* "terrestrial" organisms, namely larvae of insects, have been omitted.

Table 4

Animals found on the mud and on pneumatophores, branches and trunks of trees*

	Species	Sites at which recorded.
Crustacea, Decapoda	*Helograpsus haswellianus*	All except 13,18
Crustacea, Cirripedia	?*Balanus* sp. (Sent to specialist for identification.	2,3,6,13,15,19
	Austrocochlea torri	15
Mollusca, Gastropoda	*Bembicium auratum*	3,11,13,14,15
	Bembicum nanum	3,6
	Ophicardelus ornatus	1,6
	Batillariella estuarina	6,13
	unidentified Littorinid	6
	Parcanassa pauperata	6

* Wood-boring organisms and terrestrial organisms such as insects and spiders have been omitted.

Table 5. Birds

Bird Species	Where Seen	Approx. No's	Seen at Other Salt Fields	*
Pied Cormorant (*Phalacrocorax varius*)	In Mangroves roosting, flying overhead	common, groups of 20	x	
Little Pied Cormorant (*Phalacrocorax melanoleucos*)	Flying overhead, in sea	single birds, few	x	
White-faced Heron (*Ardea novaehollandiae*)	In Mangroves	common	x	P
Wedge-tailed Eagle (*Aquila audax*)	Over mallee	1	?	P
Nankeen Kestrel (*Falco cenchroides*)	Not over Mangroves	several	x	P
Stubble-Quail (*Coturnix pectoralis*)	Samphires, flying	1		P
Pied Oystercatcher (*Haematopus ostralegus*)	Mud flats, salt pans	several	x	P
Sooty Oystercatcher (*Haemotopus fuliginosus*)	Mud flats, salt pans	several+ one group of 20	x	P
Red-capped Dotterel (*Charadrius alexandrinus*)	Samphire flats	several	x	P
Silver Gull (*Larus novaehollandiae*)	Over Mangroves, along coast	several, groups of ten	x	P

* P = Protected

Table 5 cont'd..

Bird Species	Where Seen	Approx. No's	Seen at Other Salt Fields	*
Pacific Gull (*Larus pacificus*)	Along coast	several (4+)	x	P
Caspian Tern (*Hydroprogne tschegrava*)	Shallow mud flats	2	x	P
Crested Tern (*Sterna bergii*)	Shallow mud flats	1	x	P
Crested Pigeon (*Ocyphaps lophotes*)	Saltbush, *Myoporum* scrub	several	x	P
Rock Dove (*Columba livia*)	Flying overhead	1 flock of 15	x	
Galah (*Cacatua roseicapella*)	In mallee, samphires, saltbush and flying overhead	common, pairs and small flocks	x	
Ringneck (Mallee) Parrot (*Barnardius barnardi*)	In mallee, also saltbush scrub	a few pairs		P
Mulga Parrot (*Psephotus varius*)	In mallee	1 pair		P
Blue Bonnet (*Northiella haematogaster*)	On edge of mallee, saltbush scrub	1 pair		P

* P = Protected

Table 5 cont'd..

Bird Species	Where Seen	Approx. No's	Seen at Other Salt Fields	*
Elegant Parrot (*Neophema elegans*)	In Mangroves, samphire, flying overhead	2 groups of 4	x	P
Pallid Cuckoo (*Cuculus pallidus*)	In dead tree in samphire-saltbush	1		P
Horsefield Bronze-Cuckoo (*Chrysococcyx basalis*)	In *Cassia* (large bushes) scrub	1	x	P
Sacred Kingfisher (*Halcyon sanctus*)	In mangroves	several pairs	x	P
Pacific Swallow (*Hirundo tahitica*)	Flying overhead, mangroves and samphire	several	x	P
Tree-Martin (*Petrochelidon nigricans*)	Flying overhead, mangroves and samphire	several	x	P
Pipit (*Anthus novaeseelandiae*)	In samphires and salt-bushes, on ground	several	x	P
Black-faced Cuckoo-Shrike (*Coracina novaehollandiae*)	Flying over samphires	2	x	P
White-browed Babbler (*Pomatostomus superciliosus*)	In bushy scrub next to mangroves	a small flock (6)		P
Brown Songlark (*Cinclorhamphus cruralis*)	In samphire and saltbush scrub	several	x	P

* P = Protected

Table 5 cont'd..

Bird Species	Where Seen	Approx. No's	Seen at Other Salt Fields	*
Rufous Songlark (*Cinclorhamphus mathewsi*)	In samphire and salt-bush scrub	several	x	P
White-fronted Chat (*Ephthianuta albifrons*)	In samphire	several small flocks	x	P
Eastern Whiteface (*Aphelocephala leucopsis*)	In *Cassia* scrub	several	x	P
Samphire Thornbill (*Acanthiza iredalei*)	In samphires and taller bushes	several	x	P
Chestnut-tailed Thornbill (*Acanthiza uropygialis*)	In *Cassia* scrub, mallee	2	x	P
Rufous Fieldwren (*Calamanthus fuliginosus*)	In samphires	2	x	P
Blue and White Wren (*Malurus leucopterus*)	In saltbushes and samphire	common	x	P
Purple-backed Wren (*Malurus lamberti*)	In *Cassia* scrub	flock (5)		P
Grey Fantail (*Rhipidura fuliginosa*)	In mangroves and saltbush scrub	several	x	P
Willie Wagtail (*Rhipidura leucophrys*)	Along fence, samphire-saltbush	2	x	P

* P = Protected

Table 5 cont'd..

Bird Species	Where Seen	Approx. No's	Seen at Other Salt Fields	*
Grey Shrike-Thrush (*Colluricincla harmonica*)	In *Cassia* scrub	1	x	P
Wedgebill (*Spenostoma cristatum*)	In large bushes near Mallee	1		P
Silvereye (*Zosterops lateralis*)	In saltbushes and bushy scrub, mangroves	small flock (6)	x	
Singing Honeyeater (*Meliphaga virescens*)	In saltbushes, samphire, mangroves	common	x	P
Yellow-throated Miner (*Myzantha flavigula*)	Flying overhead over samphire, mallee and *Myoporum*	1 flock of approx. 15 birds		P
Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*)	*Cassia* scrub, saltbushes	a few	x	P
Starling (*Sturnus vulgaris*)	Samphires, flying overhead	1 small flock (6)	x	
Grey Woodswallow (*Artamus cinereus*)	Samphires and saltbush scrub	fairly common		P
Grey Butcher-Bird (*Cracticus torquatus*)	In mallee	1	x	P
Australian (White backed) Magpie (*Gymnorhina tibicen*)	In samphires and mallee	several	x	P
Australian Raven (*Corvus coronoides*)	In mangroves, mallee,	common		

* P = Protected

N.B. No proclaimed rare birds were recorded.

Table 6.

Fish and other Nekton caught in the area*
and those assumed, from observations made elsewhere,
to enter the mangroves**

Species	Common Name	I or M+	
Rhombosolea tapirina	Flounder		M
Ammotretis spp	Flounder		M
Aldrichetta forsteri	Yellow-eye mullet	I	M
Upeneichthys porosus	Red Mullet	I	
Australuzza novaehollandiae	Short-finned pike		
Usacaranx georgianus	Trevally		
Arripis trutta esper	Australian Salmon		
Arripis georgianus	Ruff		
Chrysophrys unicolor	Snapper	I	M
Sillago bassensis	Silver (or School) Whiting	I	
Sillaginodes punctatus	King George (Spotted) Whiting	I	
Platycephalus fuscus	Dusky Flathead		
Mustelus antarticus	Gummy shark		
Galeorhinus australis	School shark		
Hemiramphus melanochir	Sea Garfish	I	
Penaeus latisulcatus	Western King Prawn	I	M
Sepioteuthis australis	Southern calamari		
Nototodarus gouldii	Gould's Squid		

* Shepherd (1973 and personal communication)

** It may be that more species than these enter the mangroves; others may depend upon smaller species which do spend some part of their lives in the mangroves.

\+ I = Important species commercially or for recreational fishing.
M = Assumed to enter the mangroves.

3.4 Status of the Species Present

(Abundance, condition, uniqueness, scientific and commercial importance).

(i) The Mangrove Trees - The mangroves in upper Spencer Gulf are classified as *Avicennia marina*, a species which has been divided into a number of varieties. The trees in this area have been assigned to *Avicennia marina* (Forst.) Vierh. var. *resinifera* (Forst.) Bakh., a widespread variety recorded from Victoria, N.S.W., Queensland, New Zealand, New Caledonia, New Guinea, Timor, Biliton, Mindanao, Panay. (Moldenke, 1960). However, there are differences of opinion on the taxonomy of these varieties.

The South Australian mangroves lie close to the most southerly latitude at which mangroves occur, and a long distance from "neighbouring" stands, at Bunbury, W.A. and Westernport Bay, Vic. Macnae (1966) has discussed the hypothesis that these are relict stands from a time when the climate was warmer and mangroves more extensive.

Thus, it is possible that the South Australian mangrove trees differ genetically from those elsewhere, having been isolated for some thousands of years in conditions which are somewhat unusual for mangroves. (Most mangroves grow in areas of higher rainfall and in salinities which are, at least for part of the year, much lower than those in northern Spencer Gulf (Macnae 1966, 1968).) This would make the trees themselves unique and interesting if it were so. The question of whether these trees have evolved to differ from their relatives elsewhere is an interesting one biologically, regardless of what the answer turns out to be; thus these trees must be considered a valuable resource for scientific reasons.

The mangrove trees in the Pt. Paterson area are generally healthy. A number near site 2 appear to have almost died and then regenerated. The stumps of old, large trees bear dead branches but also small, healthy, young branches. This is true also at site 4, between sites 8 and 10 and in a patch at site 10.

Saplings were found at sites 6, 9, 11,14, 15, 17, and small seedlings at sites 2, 6, 8, 9, 11, 15, 17.

At the seaward edge of the forest, there are a number of trees which are small but do not appear young, as they have thickened stems with a gnarled appearance (eg. site 7). However, young saplings (with straight green trunks) occur on the seaward margin at sites 7, 11, 15, 17 and small seedlings at sites 11, 12, 15, 17. This may indicate a gradual spreading of the forest to seaward.

At the times of our visits, trees were fruiting abundantly at sites 2, 3, 5, 14, 19.

Trees declined in height, moving northwards from Chinaman Creek to site 10 and some dead wood appeared; however there were large trees in the region of sites 10 - 12 and 13, 15, 17, 19.

Damage to leaves by caterpillars and other insects was strikingly lower than in the Port Adelaide region with which we are most familiar.

In short these appear to be healthy stands of mangrove trees, except for the evidence of some die-off at an earlier date, which I shall mention again in section 4.

(ii) The Samphire Species - The plants identified from the samphire areas were all species which occur widely in similar salt-marshes elsewhere in S.A. Their distribution is not disjunct like that of *Avicennia marina*, and it seems unlikely that they should be considered as varieties possibly unique to the area in the way that the mangroves should.

The samphires appear healthy. They were not reproducing at the times of our visits. They become more sparse moving inland, until the boundary with the area of bare mud. Inland of this boundary very few chenopods are found and they are tiny specimens.

(iii) Diatoms - The diatoms collected belong to genera occurring in similar habitats elsewhere. They were not identified beyond genera.

(iv) Worms in the mud - The worms from mud-samples have not yet been identified; it is impossible to comment on their status as rare or unique species.

We know very little about the abundance of worms in mangrove sediments. Certainly it varies widely, for reasons that are not clear. The numbers of worms in the Chinaman Creek - Point Paterson area seemed low (1 or 2 per sample of about 5.4 l. volume), but not exceptionally so.

(v) Other animals in and on mud - The other animals are all species which occur in similar habitats elsewhere in S.A. We have too little information, either in this area or elsewhere except at Port Adelaide, to say whether there is anything remarkable about the abundance of any of them. There was nothing that struck me except that the numbers of gastropod molluscs seemed rather low in some places.

(vi) Birds - The birdlist (Table 5) was compiled during cloudy, very windy conditions with heavy rain squalls. These conditions are not good for observing birds.

Fifty species were seen in the mangroves, samphires and adjoining scrub. The list is similar to other bird-lists taken from similar areas in which salt-pans are also present. (Price, I.C.I. Dry Creek, Whyalla). The list is short on Charadriiformes (Plovers and Dotterels); there would be more species and greater numbers of these in summer. No positive breeding was noted. No proclaimed rare birds were seen in the area.

Birds seen in the adjoining mallee and bushy scrub (*Cassia*) have been included in the birdlist as some of these are often seen in mangroves in other areas.

(vii) Fish and Prawns - I suggest that the State Fisheries Department be consulted concerning the abundance and importance of these species. Certainly several of them (marked "I" in Table 6) are fished in considerable quantities in the nearby waters.

3.5 Dynamics of the Tidal-swamp ecosystem

Any adequate assessment of an "environmental profile" must not consist merely of a list of species. It must consider the dynamics of their numbers, their relationships with each other, with the physical parts of the habitat and with surrounding habitats. These relationships can only be worked out by means of observations and experiments over a long period. Such work has of course not been done in the present study, and very little has been done by other workers on South Australian tidal swamps.

We must therefore consider work which has been done on similar though not identical ecosystems elsewhere, and make the most cautious assumptions about what appears likely to be the case in the Point Paterson area.

In a frequently-cited study in Florida, Heald and Odum have worked out the pathways of energy flow in a forest of red mangrove, Rhizophora mangle, at salinities varying from freshwater to about 2.5%. (Heald and Odum 1970, Odum 1971, Heald 1971). The major source of energy was leaves dropped by mangroves at the rate of about 2.9 dry tons per acre per year. About half of this was consumed within the mangrove swamp by bacteria, fungi and larger detritus-feeding animals, especially crustaceans; most of the remainder was flushed out into the nearby coastal embayments where it was available as food for detritus-feeders there.

The detritus-feeders in turn became food for a large group of fishes including juveniles of all of the Florida game-fishes.

In short, the game-fisheries of Florida as well as fisheries for shrimp and crabs, appeared to depend on the food supply produced in the mangroves. Not all of these commercial species entered the mangroves to feed, but they were nonetheless feeding upon detritus carried out from the mangroves or upon smaller detritus-feeding animals.

It would seem to be true of other "tidal-marsh" systems that productivity is based on plant detritus and that productivity is high. (eg. Schelske and Odum, 1962).

Thus, I think we should assume, until relevant evidence can be collected, that our tidal swamps are likewise productive and essential, either directly or indirectly, to the nearby fisheries.

Is this only mangrove or are samphire included as well.

Such observations as we have made so far support this idea: detritus does decompose in the mangrove sediment; it is eaten by small organisms, molluscs and especially crabs; juveniles of commercial prawns and several species of commercial fish can be found amongst mangroves at times; some litter from mangroves is transported to nearby seagrass beds. The details and the quantities involved are, however, unknown.

I have so far mentioned flows of energy. It has also been suggested that there may be important relationships between salt-marsh, mangrove and seagrass communities with respect to nutrients. For example, nitrogen fixation may occur in one part of the system and the nitrogen so fixed may be important for productivity in another part. I know of some conflicting reports in this field but I do not know of any work yet published on systems closely similar to our own. Once again, I suggest we must consider that such relationships are possible and see to it that no part of the interrelated group of communities is damaged until we understand what we are dealing with.

The mangroves may have a physical role in stabilising sediments. It is often suggested that mangroves act in "land-building" (eg. Davis, 1940). It may be that mangroves can only "build" land where sediment is in any case being deposited and where sea levels are changing appropriately, and that they cannot prevent erosion where conditions are such as to cause erosion. Nevertheless, they may greatly change the rates of such sedimentary processes, and may be very important in stabilising an area which is usually a low energy area but experiences occasional storms. Thus, the mangroves at Point Paterson may substantially reduce the rate at which sediment moves about in the area; this may be extremely important for the stability and productivity of the seagrass communities. We should protect the mangroves until we understand any such role that they may have.

In summary, we have little direct evidence but it is plausible that the saltmarsh and mangrove communities are linked in several ways to the communities in the shallow water to seaward and that the integrity of the whole system is important to the production of a number of commercially and recreationally important species.

Under the heading "dynamics" we ought also to consider fluctuations in the conditions under which the community lives and in the numbers and biomasses of the organisms present. We know very little. Certainly this system experiences varying physical conditions. Salinities in upper gulf waters reach perhaps 48% in summer; they are lower in winter; what happens at the inland margin of the tidal swamps during a period of neap tides during a hot, dry summer we can only guess. I shall refer to this point in Section 4.

3.6 Summary: Status of the Tidal Swamps and appropriate Land Uses.

The mangrove and samphire communities in the Chinaman Creek-Point Paterson area appear healthy except for evidence of a past die-off which I shall consider in Section 4.

These communities seem likely to be important in contributing to the productivity of commercial and recreational fisheries in the area.

They are interesting communities. As a system the mangrove community is most unusual amongst mangrove swamps elsewhere in the world because of the climate in which it occurs. South Australian mangroves are separated by great distances from other mangroves, so that the trees themselves may be in some way unique. Apart from this uniqueness, the life of the community is of great interest and therefore the area is of value for scientific reasons and as a study-area for educational groups.

It should also be mentioned that some people - myself included - experience feelings of atavism, peacefulness, solitude when visiting such areas. They have the qualities of first-rate "wilderness areas".

For these reasons it is my opinion that the proper land-use for these areas is that they be kept in their natural state. Access by people should be allowed, but with various restrictions which are not relevant here. It would be most unwise to undertake any development which may threaten these communities; we do not understand them, but we have reason to consider them valuable.

4. EFFECT OF THE PROPOSED SALT-PANS ON THE E.E.P.

4.1 Clearing, filling and flooding; effect at the actual sites of the pans.

Any pans or earthworks which are placed on areas of samphire or mangrove will destroy those communities. It is for Delhi to state in detail where the proposed pans will be sited, and what construction works will be necessary, but Fig. 1 shows the sites of the proposed pans as I understand them, and shows that most of the area of the pans will be on what is at present bare salt-flats or former salt-pans.

The area inland of site 11 was difficult to interpret from the aerial photographs. It probably contains patches of samphire but only a small part of this is included in a corner of the proposed pan.

Thus, it would appear that only a small area of patchy samphire (perhaps ½ km^2) is threatened by the proposed development. Any proposal to destroy larger areas of healthy tidal swamps should, in my opinion, be opposed.

4.2 Effect of the Salt-pans on neighbouring Tidal Swamps

(i) Sites of existing saltpans in South Australia -

A) Price, Yorke Peninsula

Five sites were examined at Price, at varying distances from the salt pans operated by Ocean Salt Pty. Ltd. The sites are numbers 23-27, shown in Fig. 2.

Details of the collections and counts are available if required but are not included here.

The sediment in this area was pale in colour and firm underfoot. It is my impression that the area is more similar to the Point Paterson area than the areas at Dry Creek or Port Augusta.

At site 23, close to a pan containing brine of salinity about 6.5%, the mangrove trees were large and healthy. Leaf damage was moderate. There was nothing unusual in the list of fauna or their abundance.
Salinities measured at mid-ebbtide were 4.23% in creek water and 3.96% in groundwater about 60 cm below the mud surface.

Site 24 was closer to the salt pan, in samphire dominated by Salicornia. Its flora and fauna were normal except for small patches of dead samphires where it appeared that there was seepage through the wall of the salt pan.

At sites 25 - 27 the ground was higher above sealevel, so that samphire plants occurred amongst the mangroves. Some of the mud-dwelling animals which are usually more numerous lower in the intertidal were rare or absent, and very few worms were found. Very fine silt lay on the mud-surface and on trees. But species which would be expected at this high level, such as the crab Helograpsus and the gastropod Bembicium, were present in moderate numbers. The trees were large and healthy.

Sites 25 and 26 were on the seaward side of a wide and deep creek which fills with sea-water at high tide and is almost empty at low water of spring tides. It seems unlikely that they are influenced by an effect which the salt pans may have on groundwater.

On the other hand site 27 is on the same side of the creek as the crystallising pans and closer to them. Its flora and fauna were similar to those of sites 25 and 26. Sites 23 and 24 were closest to the salt pans and had the richest flora and fauna. It would appear that the composition and height of the sediment has more influence than the presence of the salt pans. Except in very small patches of samphire close to the wall, the pans appear to have no adverse effect.

B) Dry Creek, Port Adelaide

Sampling was conducted at sites 28 - 34, to seaward of various parts of the I.C.I. Dry Creek Saltfields (Fig. 3). At site 28, trees were large. They bore heavy leaf-damage (as do trees on Garden and Torrens Islands). There were seedlings of varied sizes. The sediment was brown and soft, unlike that at the Point Paterson area. A normal "Torrens Island" fauna was present; worms were more abundant than at most sites.

At site 29 and more so at site 30, surface mud was very fine and sticky, there were fewer animal species and worms were fewer. The trees were equally healthy. I think that the difference in animal numbers can be attributed to the different sediment.

Sites 31 - 33 north of St. Kilda differ greatly from Point Paterson in the presence of large quantities of litter consisting of seagrasses (*Zostera*, *Posidonia*) and especially sea lettuce (? *Ulva*). Beneath the litter the mud is soft, though containing many shells, and anaerobic. The fauna is different from that at other areas. There are no seedlings or young trees and there are many dead mangrove trees. Leaf-damage to some of the trees is heavy.

It is not clear why the mangroves are unhealthy here, but it seems likely that the explanation is associated with the masses of plant litter and with anaerobic conditions in the sediment. Heavy growth of Ulva is often associated with nutrient-rich conditions. Whether such conditions could be produced by seepage from a salt pan remains to be investigated. Another possible hypothesis is that the nearby outfall from Bolivar sewage treatment works contributes nutrients to this area. Thus, whilst we must not dismiss this observation, we do have another explanation, and we do not have similar observations near other salt pans.

However, I suggest that Delhi might contact I.C.I. for details of the contents and seepage rate of the pond adjacent to sites 31 - 33, which may throw some light on the observation.

"Site 34" refers to a drive along the embankment between the two arrows in Fig. 3A There were some dead mangroves at the point marked "X". These trees stood in stagnant water although the tide was low at the time, and I suspect that their death is due to the E.T.S.A. causeway having interrupted tidal flow to them. Elsewhere, immediately adjacent to the seawall of the salt pans, the mangroves were healthy, fruiting and there were young trees present.

C) Disused Salt pans, Point Paterson

This area has been covered in the discussions of E.E.P., section 3. Invariably, plants within the pans have died. Only in the initial pan, which is now regularly flooded by the tide, are samphires (but not mangroves) regenerating. Immediately outside the walls of the pans, samphires or mangroves (as the case may be) appear normal and healthy, similar to those further south away from the salt pans. If there was an adverse effect of the salt pans, it is no longer evident. An inspection of aerial photographs (September 1954; the salt pans were not abandoned until 1958) suggests that there was little damage to the dominant plants when the pans were in use, as mangroves can be seen, apparently quite healthy, adjacent to the seawall.

D) Disused Salt pans, Yorkey Crossing, North of Port Augusta

Sites 20 - 21 were examined near the old railway bridge at Yorkey Crossing (Fig. 4). A large channel breaks through the seawall between sites 20 and 21. There is strong regrowth of samphire within the pond; crab-holes were common at site 20.

At site 21 there were samphires (Salicornia, Arthrocnemum) and mangroves and there was a "typical" list of fauna and microflora. Young mangroves of varied ages, down to small seedlings, were present. Most of the mangroves in this area appeared young. There were occasional larger trees but no evidence of previous die-off, as noted in the Point Paterson area.

Site 22, 100 m. south of the wharf and about 0.8 km south of site 21, was similar to site 21, but was backed by sandhills instead of old salt pans to landward. The trees were rather larger and amongst them were a few old trees with dead wood, but otherwise the flora and fauna were similar.

If the Yorkey Crossing saltworks caused damage to nearby mangrove and samphire communities, it is no longer evident in the form of dead wood, and the communities seem to be recolonising the area.

E) Conclusions from the examination of sites of existing and former salt pans

There has, of course, been only time for a cursory inspection of these sites. However, the following comments can be made on the basis of this inspection.

Apart from Point Paterson itself, only one site (Price) seems similar, in sediment and topography, to the site of the proposed pans.

Only one site - not Price or Pt. Paterson, but St. Kilda - showed recognisably poor 'health' of the tidal-swamp communities. This should be further examined (see B) above) but it appears that there may be an explanation other than any influence of the salt pans.

The conclusion to be drawn at Price is that with respect to the characteristics we observed, local physiography has more influence on the flora and fauna than the salt pans, although small areas were damaged by local seepage through the seawall.

At Pt. Paterson, the communities outside the disused salt pans now appear healthy with the exception of a few dead trees near the breach in the seawall. Further, in earlier aerial photographs living plants can be seen immediately adjacent to the seawalls.

Thus, we can conclude that if direct leakage of very dense brine through the walls is prevented, if the effect of the pans on physical and hydrological characteristics of the area is like the effect of the Price pans or of the old Pt. Paterson pans, then there is unlikely to be any significant damage to adjacent mangrove and samphire communities.

(ii) Information from Literature

I know of no work conducted in South Australia on salinity-tolerances of the mangrove and samphire species. Clearly, they are adapted to tolerate fairly high salinities. Salinities are periodically low, and rates of freshwater runoff high, in most mangrove swamps, but *Avicennia* extends into regions of low rainfall and high evaporation, such as northern Spencer Gulf. (Macnae, 1968)

But we have no information on the ranges of tolerance of the plants in our local communities, which may differ genetically from those elsewhere (section 3.4.(i)).

Elsewhere, Macnae (1966) has recorded stunted trees of *Avicennia marina* living at Inhaca Island, Queensland, in soil with a salinity of over 9.0%. It can also live at low salinities. He remarks that it "appears to reach an optimum development at salinities around and below that of normal seawater" and that "possibly it is the presence of calcium ions in the soil that enables the trees to grow normally in conditions of unfavourable salinity".

Adequate drainage appears important to _Avicennia_ (Macnae 1966) and this may explain the deaths of trees in salt pans and other areas of standing water even at moderate salinities.

Clarke and Hannon (1970) studied growth of mangrove and salt marsh species of the Sydney district in relation to salinity and waterlogging. These plants included ones classified as the same as our species - _Avicennia marina_ var _resinifera_, _Arthrocnemum australasicum_, _Arthrocnemum halocnemoides_ (citing results of another worker), _Sueda australis_, _Juncus maritimus_, - although it is conceivable that they may differ physiologically from ours. Some of Clarke's and Hannon's findings are summarised briefly below.

There was retarded and reduced germination of seeds of salt-marsh species at "high" salinity (40% - 100% _seawater_, ie. presumably 1.4% - 3.5% salinity). Thus, it seems that at Point Paterson seeds of _Arthrocnemum_, _Sueda_ and _Juncus_ would only germinate after rain.

Growth of _Avicennia_ seedlings was best in 20% seawater (salinity .7%) with added nutrients; salinities above 60% seawater (salinity 2.1%) inhibited growth. "Very few seedlings were able to tolerate salinities in excess of 100% seawater for more than a few weeks and no leaves were produced in solutions exceeding 125%".

Older seedlings were more tolerant of salinity, but it appears that establishment of seedlings of *Avicennia* at Point Paterson may occur only sporadically, during periods of low salinity.

Young *Arthrocnemum* plants can tolerate much higher salinities than young *Avicennia* but, as indicated in Clarke and Hannon's Table 4, reproduced below, both species would appear to be living at Point Paterson in conditions which are harsh for them. (I assume that a salinity of 4.5% is about 13.0% seawater in Clarke and Hannon's terms).

Table 4 from Clarke and Hannon (1970)

Effect of high salinity for 3 months on the growth of *Avicennia* and *Arthrocnemum*

Species		Seawater concentrations (%) (nutrients added)				
		100	125	150	175	200
Avicennia	% survival	33	8	3	3	0
	% showing leaf growth	10	3	0	0	0
Arthrocnemum	% survival	45	46	36	5	2
	Mean shoot wet mass (mg)	664	291	204	100	Not recorded
	Mean number of cladode segments	49	26	20	12	5

The significance of these results in the present context is that, if they are physiologically similar to the Sydney populations. the mangrove and samphire species at Pt. Paterson are living in conditions which are near their limits of tolerance for salinity. Growth, and more importantly the establishment of seedlings, may take place only intermittently. During hot, dry periods when salinity in the gulf reaches 4.5% or more, the plants may barely survive. I suggest that the dieback which we observed at several sites (Section 3.4(i)) may have occurred during such a period, for if Gulf salinity was above 4.5% and there was a period of hot weather and neap tides, soil salinities at the landward edge of the mangrove forest could rise much higher. These trees have subsequently regenerated, but the observation supports the idea that these plants are living near the limits of their tolerance and in fluctuating conditions which occasionally, and locally, exceed lethal limits.

Thus, seepage of dense brine from a salt pan at a critical time, when Gulf salinity is high and the weather hot and dry, might be expected to have a far more destructive effect at Point Paterson than at, say, Port Adelaide where the natural conditions are less severe.

4.3 Summary: Effects of the proposed salt pans on the E.E.P.

It is for Delhi to predict the effect of the proposed pans on groundwater. As I understand it, the structure of the proposed seawalls will be like that of the old Point Paterson walls, if not even less permeable. I also understand that these walls will be in effect continuous with the Avondale clay underlying the marine sediment on the floors of the pans, and that the pans will have very low permeabilities.

Observations in other areas in South Australia, where salt pans are in use at present, indicate that there are no observable effects on samphire and mangrove communities immediately adjacent to the pans, unless there is seepage of concentrated brine directly through the walls of the pans. Plants occurring within the pans, however, will die. Observations at areas where salt pans have formerly been operated, including Point Paterson itself, also gave no indication that there was any harmful effect. Further, regeneration of samphires is occurring within the "initial" pans, which do not have floors of salt.

Published data obtained near Sydney suggest that the mangrove and samphire plants at Point Paterson may be living near the limits of their tolerance for high salinity. Growth, and the establishment of young plants, may be sporadic. Observations in the Point Paterson area suggest the hypothesis that the lethal limits of the mangroves may occasionally be exceeded. This means that these plants may be more vulnerable to a man-made increase in salinity than those further south.

The structure of the mangrove and samphire communities, and very likely their productivity and value to fisheries, depends on the dominant plants. Therefore great care should be taken to ensure that salinities in ground and surface waters, especially in the landward fringe of the mangroves, are not raised above the already high figures which occur naturally.

Providing that the walls and floors of the pans are of such low permeability that salinities in the tidal swamps are not measurably raised, I foresee no adverse effects of the salt pans on these communities, except on that small part actually occupied by the pans.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

(i) The tidal swamps in the Point Paterson area have been little studied. The species appear not unique, but the mangroves at least may differ from those elsewhere. As a system these communities are unusual and interesting, and it is likely that they are important to the commercial and recreational fisheries in the area. They have the qualities of "wilderness areas".

(ii) Any area of mangrove or samphire actually occupied by a saltpan will be destroyed. Communities immediately adjoining salt pans may be expected not to be influenced by the pans, provided that seepage from the pans does not measurably increase the salinities of ground and surface waters. It is likely that the plants are living near the limits of their tolerances for high salinity, so that a small increase over naturally-occurring values may be extremely damaging.

5.2 Recommendations

The following suggestions are my opinions of what should be done given the above conclusions.

(i) The tidal swamp communities should be preserved in their natural state. They should be protected from any adverse effects of industrial developments and from other human interference such as bait-gathering, shooting or trail-bike riding.

To this end, if the proposed salt pans are to be constructed, I would make the following, more specific, recommendations.

(ii) That the condition of the communities be regularly monitored, commencing immediately. As a minimum, this monitoring should comprise the following. Salinities of ground and surface waters should be regularly measured at a number of sites within the mangroves and samphires.

These measurements would give a small amount of "baseline data" before the pans came into use and thereafter would give warning of any leakage which may be occurring. Salinity can be measured rapidly; I would suggest that at least 30 permanent stations be sampled at short intervals, perhaps fortnightly.

(iii) That the mangroves and samphires, together with a wide border of the adjoining mudflats and seagrass beds to seaward, be declared a sanctuary.

(iv) That the saltfields and as much as possible of the adjoining mallee and bushy scrub be declared a sanctuary.

(v) That small islands be constructed (or merely allowed to remain) within the lower-salinity saltpans to provide waterfowl with refuge from predators and possibly with breeding-sites.

(vi) That visitors be permitted after obtaining approval to enter parts of these areas to observe birds or conduct other studies.

6. ACKNOWLEDGEMENTS

John Brewster, Peter Chesson, June Chesson, David Paton and Margaret Woodruff helped with the fieldwork. David Paton compiled the birdlist. David Thomas identified the diatoms and some of the molluscs. Margaret Woodruff sorted specimens, examined most of the diatom-samples and drew Figure 1. My thanks to all of them. Thanks to Robert R. French and John Allen of Delhi for their invaluable help on two field trips.

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Figure 1.

The Chinaman Creek - Point Paterson area, showing distribution of tidal swamps and the sites inspected. North lies to the right of the map.

The outline of the seaward edge of the proposed saltpans, from a map provided by Delhi, is roughly sketched in red.

The map was prepared from aerial photographs (1-2-1970). The dashed line shows where the boundary of the samphires was difficult to determine precisely from the photographs. Inland from site 11, the boundary of the samphire was diffuse. It may extend, patchily, into the corner of the proposed saltpan.

MANGROVES IN SOUTH-AUSTRALIA REDCLIFF AREA, SPENCER GULF

CONFIDENTIAL

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Figure 2.

Sketch map showing sites sampled near Price, Yorke Peninsula.

Mangroves near sampling-sites are shown hatched.

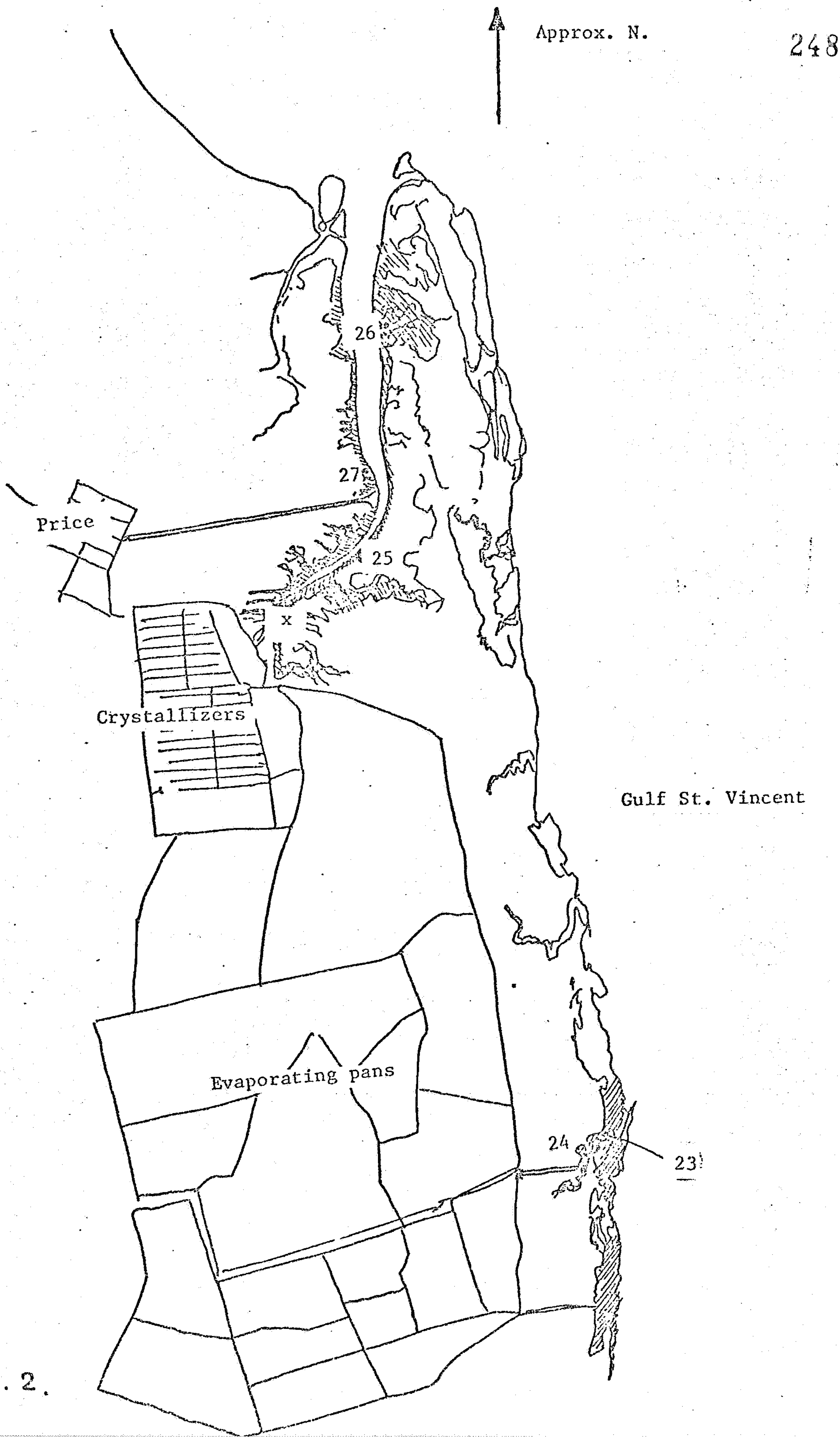

Approx. N.
26
27
Price
25
x
Crystallizers
Gulf St. Vincent
Evaporating pans
24
23

FIG. 2.

Figure 3A.

Sketch map showing sites sampled near I.C.I. Saltfields at Dry Creek.

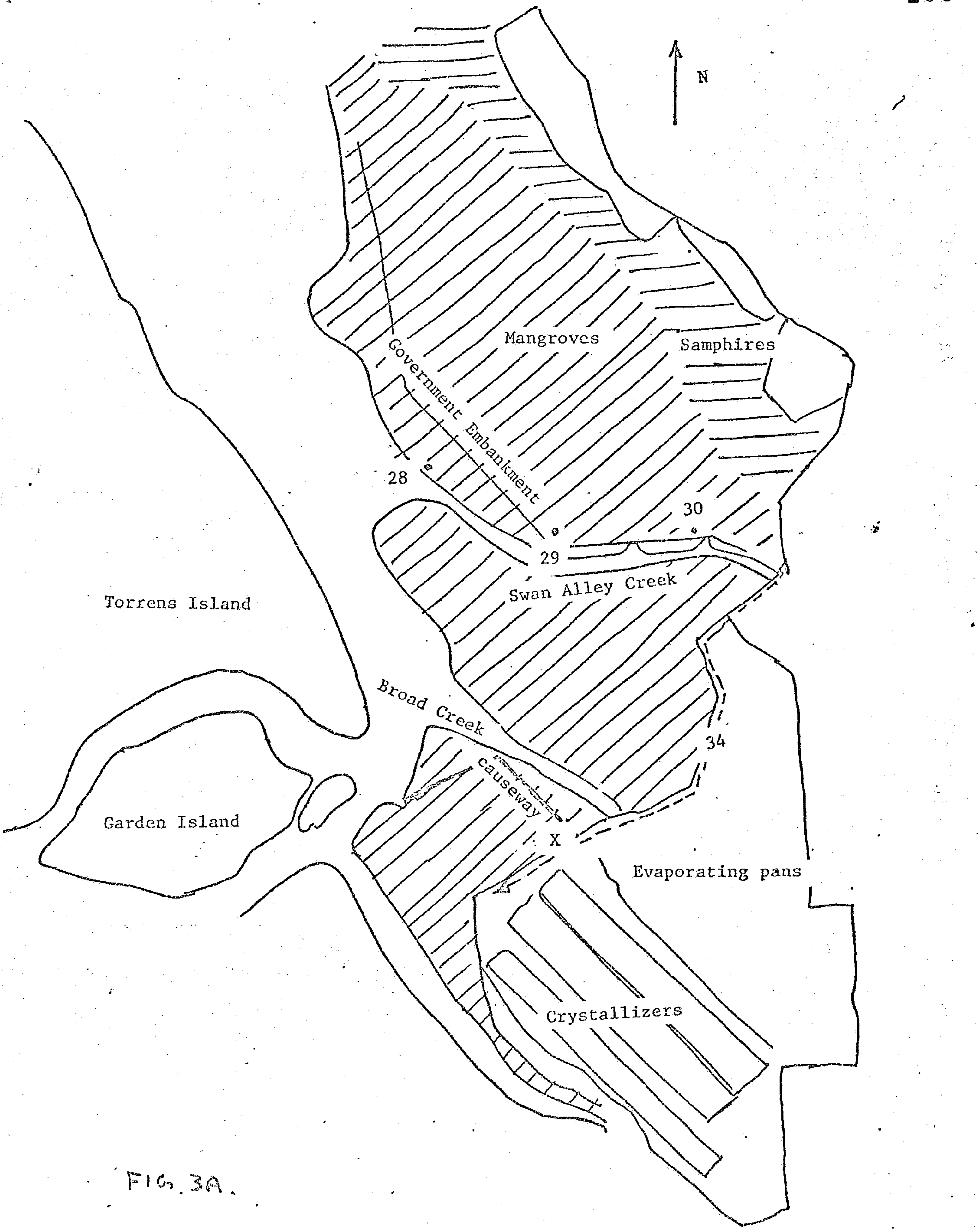

N
Mangroves
Samphires
Government Embankment
28
29
30
Swan Alley Creek
Torrens Island
Broad Creek
causeway
34
Garden Island
X
Evaporating pans
Crystallizers

FIG. 3A.

Figure 3B.

Sketch map showing sites sampled near I.C.I. Saltfields at St. Kilda.

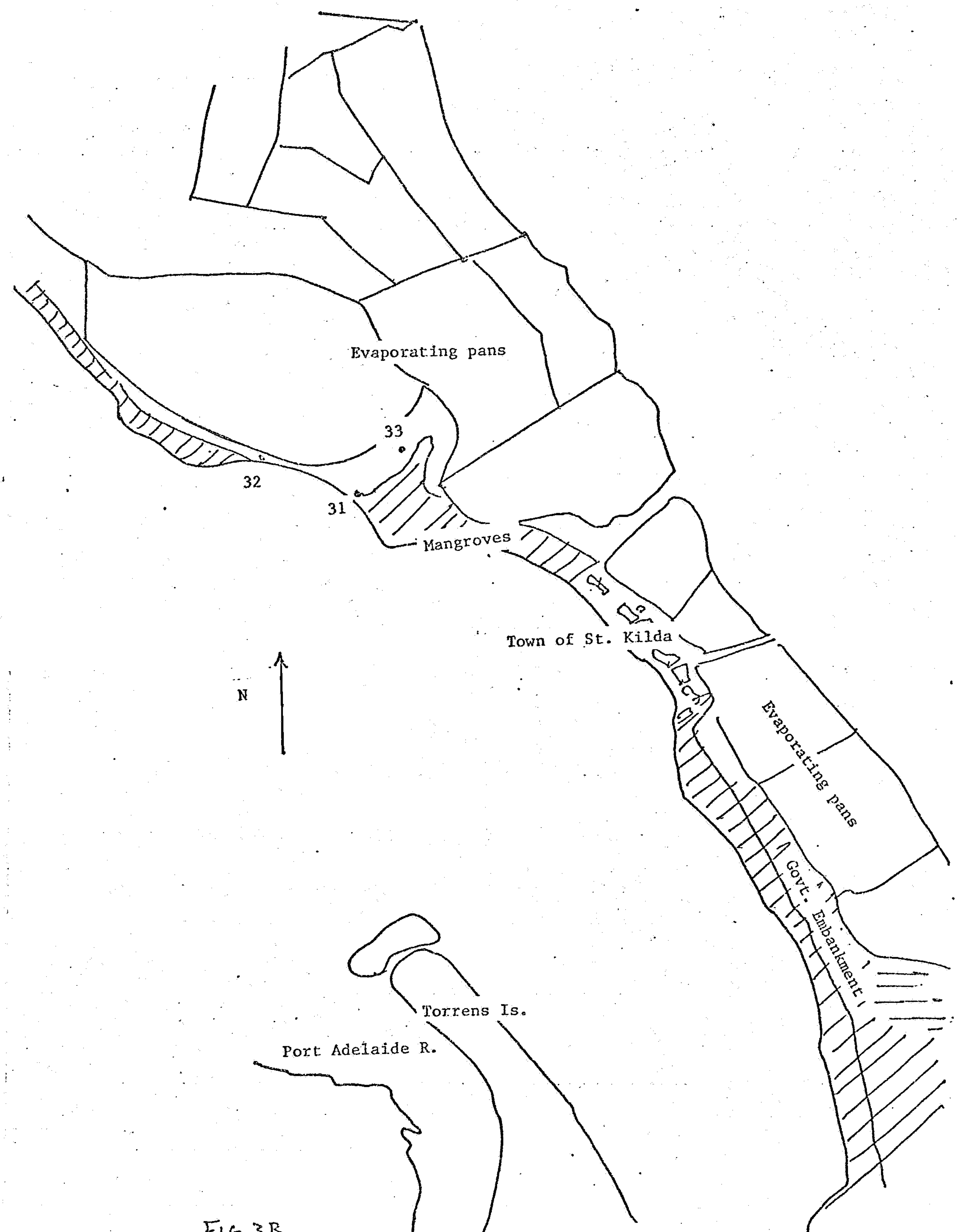
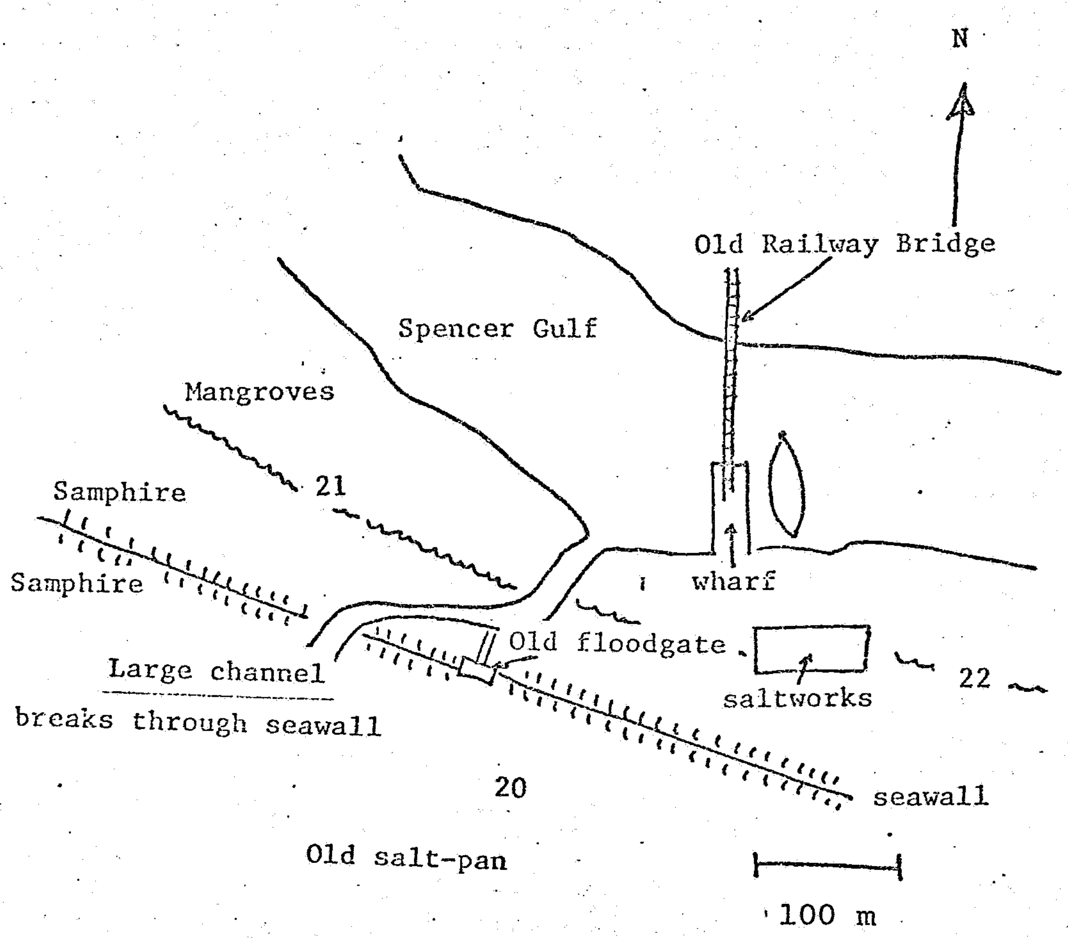

Evaporating pans
33
32
31
Mangroves
Town of St. Kilda
N
Evaporating pans
Govt. Embankment
Torrens Is.
Port Adelaide R.

FIG. 3B.

Figure 4.

Sketch map showing sites sampled at Yorkey Crossing, north of Port Augusta.



N
Old Railway Bridge
Spencer Gulf
Mangroves
21
Samphire
Samphire
wharf
Old floodgate
saltworks
22
Large channel
breaks through seawall
20
seawall
Old salt-pan
100 m

FIG. 4

DELHI INTERNATIONAL OIL CORPORATION

255

\\\\

INTER-OFFICE CORRESPONDENCE

Date 27th September 1974

To Robert R. Blair (NAME) Adelaide (LOCATION) From Robert R. French (NAME) Adelaide (LOCATION)

Subject Expenditures for salt projects
ONLY ONE SUBJECT TO BE CONTAINED ON THIS SHEET

As per your request of 27 September I have compiled expenditure data on both the Lake Torrens and Point Paterson salt projects.

D.I.O.C. expenditures through August 1974 total $417,850.09.

RRFrench

RRF:cb

QUARTERLY REPORT

EXPLORATION LICENCE 60

for period

July 1, 1974 to September 30, 1974

EXPLORATION LICENCE 60

Summary of Activities July 1, to September 30, 1974

During the quarter ending September 30, 1974 Delhi International Oil Corporation conducted an environmental impact study of the Point Paterson area. A major part of the investigation was performed by members of the Zoology Department, University of Adelaide under the supervision of Dr. Alan Butler.

Delhi also performed a detailed survey of the former Port Augusta Salt Works northern seawall and submitted the data to K.C. Dodd, Consulting Engineer for evaluation and costs estimating. The Lake Torrens campsite was conducted on a care and maintenance basis with the meteorological station fully operational. Crystallisation and beneficiation of Lake Torrens brine was continued through A.C.S. Laboratories.

An independent review of the Lake Torrens exploration program was initiated by the S.A. Department of Mines and was conducted with the assistance of AMDEL, Coffey and Hollingsworth Pty., and Messrs. K.C. Dodd and C. Bleys and Associates.

<u>Exploration</u>

Detailed exploration to date, i.e. 99 test pits, 10 trenches, auger holes, and hand-dug sample pits, now extends over approximately 90 square miles and is considered sufficient to prove the existence and availability of sufficient quantities of dense brine. Reconnaissance sampling west of the Torrens Homestead area extended the reserve area over approximately 200 square miles. Previous drilling by the S.A. Department of Mines indicated the area may be further extended northwards to the vicinity west of Motpena, a total of 800 square miles.

No further exploration pits or trenches were excavated during the July-September period.

Geochemistry

The first bulk sample crystallisation test of Lake Torrens brine was completed by A.C.S. Laboratories (Adelaide) in July.

The experiment was conducted with 39.49 litres of brine containing 88,830 g. dissolved salts. Initial precipitates were discarded at S.G. 1.196 and salts were recovered at 4 stages in the range S.G. 1.205 to 1.210.

Precipitated salt impurities were as follows:

	Ca		Mg		SO4	
	Measured	Computed	Measured	Computed	Measured	Computed
Max.	0.80	0.28	0.444	0.100	1.57	0.72
Min.	0.49	0.17	0.098	0.014	0.86	0.36
Ave.	0.66	0.24	0.170	0.030	1.29	0.58

Approximately 91.4% or 81,189 g. of salts were recovered with the initial batch (S.G. 1.205) containing the greatest percentage of Ca and SO_4 contamination and the final batch containing the most Mg ions. This distribution was anticipated and a second test will be conducted within closer parameters.

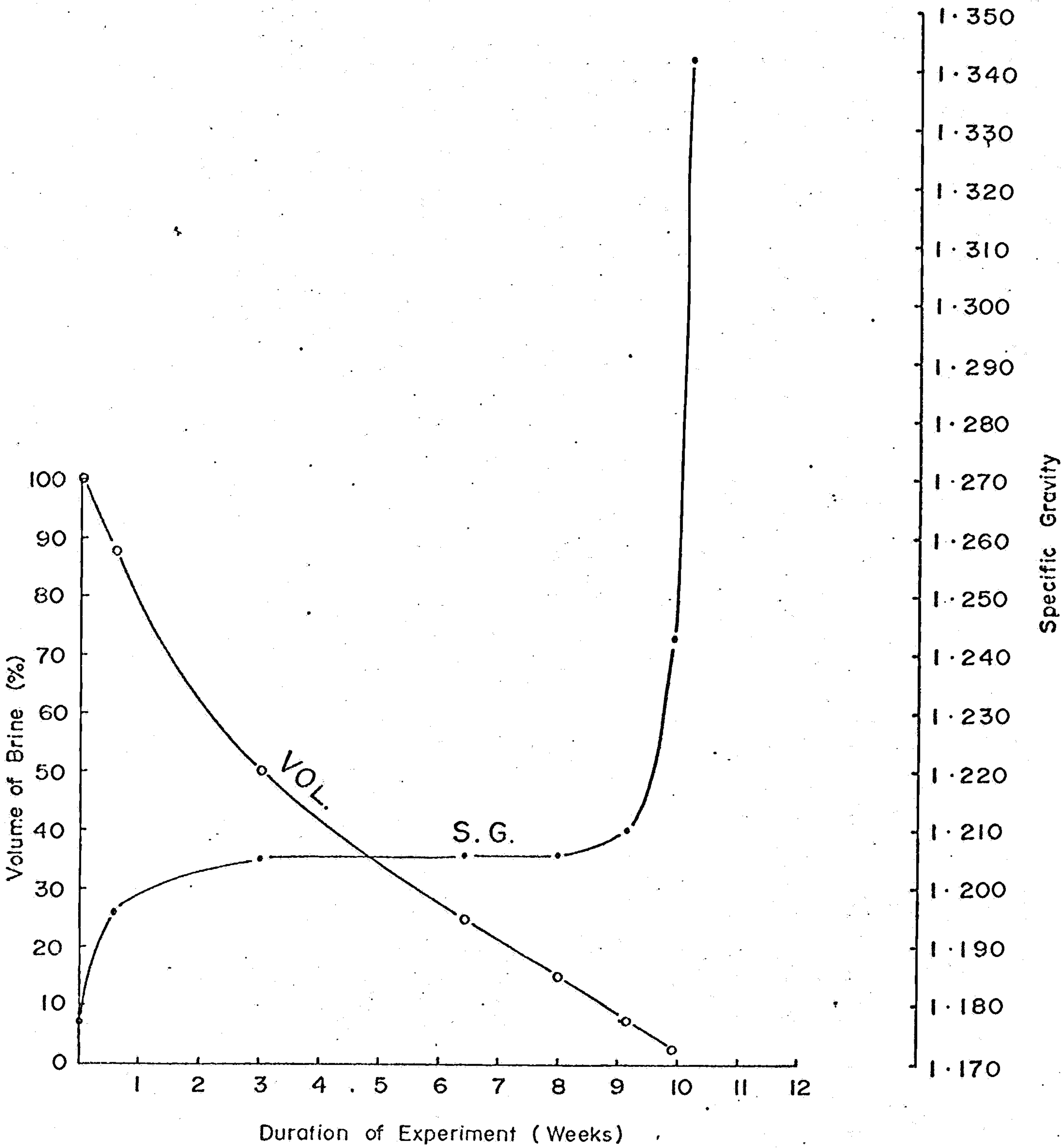

Volume of Brine (%)
100
90
80
70
60
50
40
30
20
10
0
VOL.
S.G.
1 2 3 4 . 5 6 7 8 9 10 11 12
Duration of Experiment (Weeks)
1·350
1·340
1·330
1·320
1·310
1·300
1·290
1·280
1·270
1·260
1·250
1·240
1·230
1·220
1·210
1·200
1·190
1·180
1·170
Specific Gravity

Figure 1

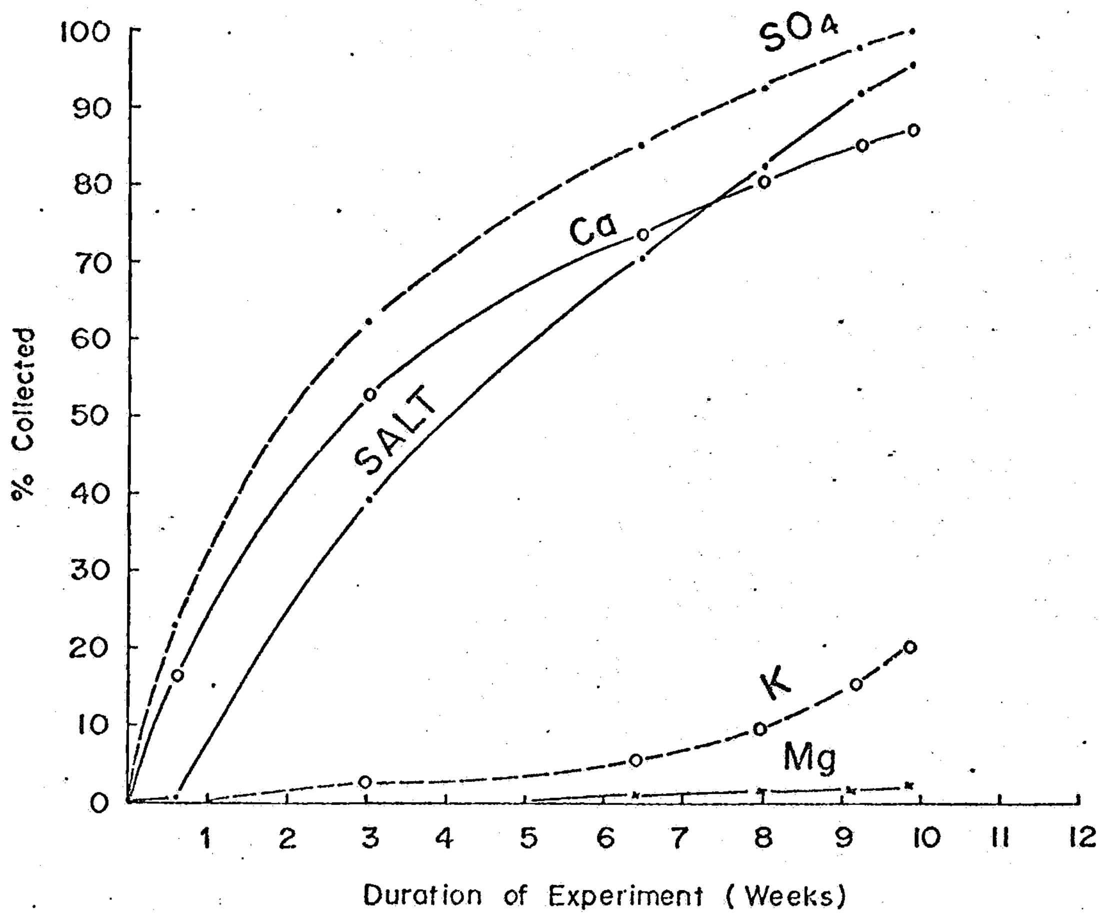
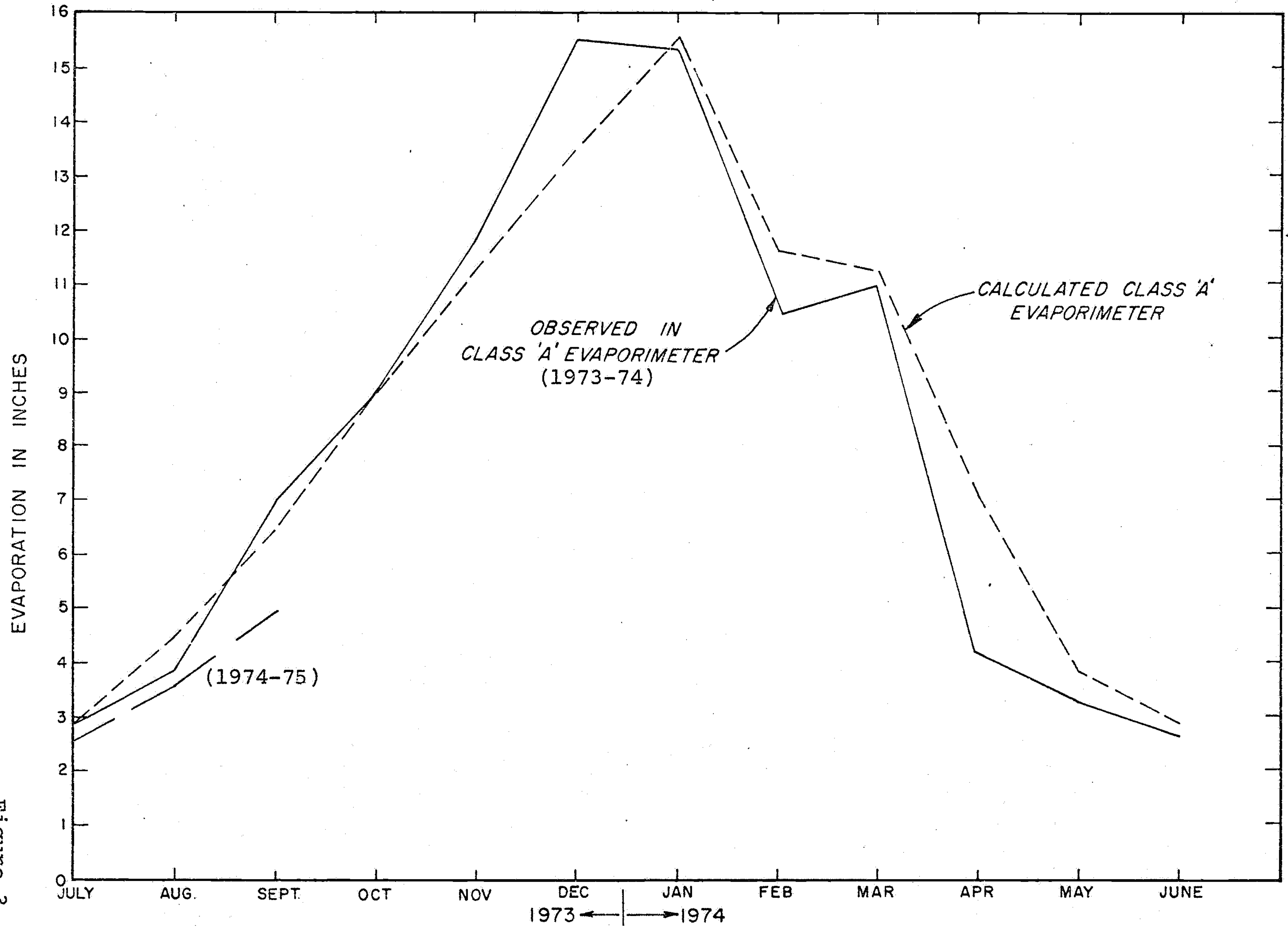

100
90
80
70
60
50
40
30
20
10
0
% Collected
SO4
Ca
SALT
K
Mg
1
2
3
4
5
6
7
8
9
10
11
12
Duration of Experiment (Weeks)

Figure 2

Weather

Meteorological data compiled during the last quarter indicated a higher than average rainfall of 3.96 inches and about normal evaporation of 11.10 inches. The data have been plotted on the existing graphs.



EVAPORATION - LAKE TORRENS

Figure 3.

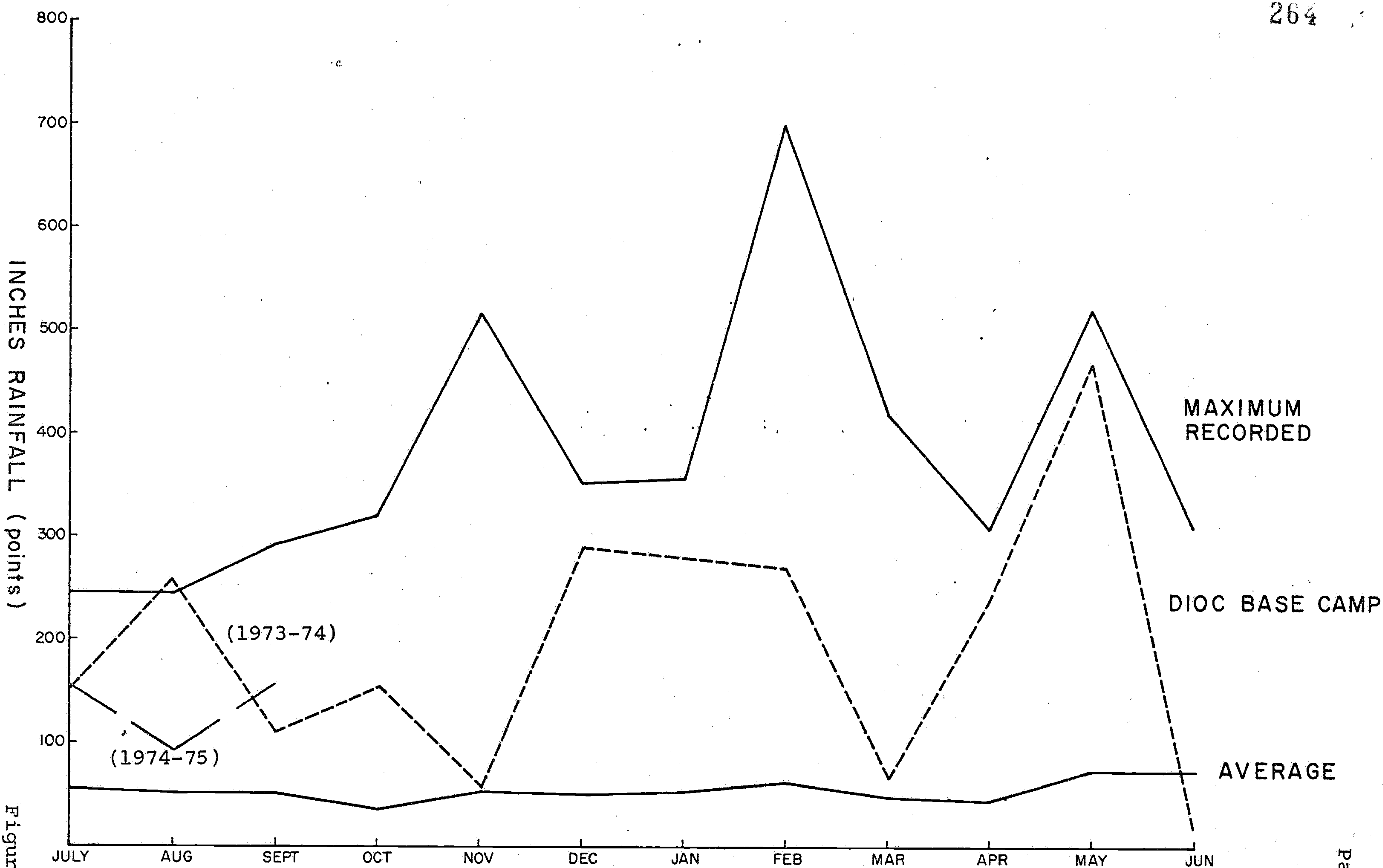


Figure 4.

Page 8.

COMPARISON OF AVERAGE & MAXIMUM RAINFALL RECORDED AT SOUTH GAP STATION (1882-1965) WITH DIOC BASE CAMP (JULY 1973-JUNE 1974)

Lake Torrens Flood Overflow Survey

During July, 1974 a survey was carried out to determine the flood overflow level of the southern end of Lake Torrens and to determine the maximum height of flood control banks to be constructed on the lake surface to protect possible concentrator and crystalliser ponds.

A cross-sectional traverse of approximately 2.25 miles was surveyed from the south-eastern corner of the lake, (South Bay) southwards to Soakage Swamp with cross sections run at 400' centres.

The maximum height of the water level during this current flood was determined to be R.L. = 102.1'. This represents a maximum depth of water (at south end of lake) of 6'. The water level determined on 21st July 1974 was 101.7'.

This survey showed that the present water level would have to rise a further 7' (R.L. 109') before the water would overflow the lake and proceed southward to Soakage Swamp and beyond.

A contour map, scale 1" = 500', has been prepared showing line of traverse, cross section locations and contoured at 1' intervals.

Re-Evaluation of Lake Torrens

On 12 June the Department of Mines requested that Delhi International Oil Corporation provide all necessary exploration data to Mr. R. Rallings (Coffey and Hollingsworth Pty) and Mr. W. Walker (AMDEL) so that an independent evaluation of potential salt production might be conducted The information was made available and the evaluation was coordinated with Mr. W. Boucaut of the S.A. Department of Mines. Delhi also requested independent hydrological and engineering consultants to review the results of the program and its re-evaluation.

The consensus of opinion is that the sediments of Lake Torrens are sufficiently permeable to allow economic extraction of dense brine. Also, that transportation of the brine via pipeline to Yorkey Crossing is technically feasible. The only minor variances in the professional opinions forwarded by Messrs. Rallings, Walker, Dodd and Bleys relate to the degree of effective permeability and the size-cost of certain facilities. All parties concede that there is a sufficiently large safety factor in the overall scheme so as to accommodate the most conservative approach.

Surveying (Pt. Paterson Sea-Wall)

During the period May through August 1974, surveys of the former Pt. Augusta Salt Company's northern and northwestern seawalls were carried out. These surveys were undertaken to provide the basic data for a possible re-design and re-construction of these, the main walls of the No. 1 concentrator pond.

A centre line was established along both the northern and northwestern walls and pegged at 100' intervals. Each peg was levelled and additional vertical ties were made to:

1) Qasco B.M. #27
2) Harbours Board Department B.M. at old pump house
3) Alexander and Symons B.M. on edge of western wall.

A total of 55 level cross sections were run on:

a) 200' centres where there did not appear to be any change in the shape of the seawall, and
b) 100' centres where detailing was necessary.

The length of the cross-sections from the centre line varied due to the swampy ground conditions and ranged from 120' to a maximum of 900'.

Level point distances along the section lines ranged from 30' on the flats to 5' over the wall proper.

A dinghy was used by the rod-man in running the sections on the western end of the north wall and the northern end of the northwestern wall, where these walls cut across the main inlet channel (commonly known as "Salt Works Creek") and where the main breach in the seawall is located.

Three level traverses were completed across the inlet channel, north of the main wall and 4 traverses completed across the extension of the inlet channel, south of the main wall and inside the No. 1 concentrator pond. A number of spot heights were also taken inside the concentrator pond to more closely define the sand bars existing in the centre of the channel, and at the mouth of the breach, and to provide fill-in points between the random spaced traverses.

A horizontal tie was made from the western wall, centre line, to two galvanised iron poles established by the Harbours Board as landward markers for the old proposed off-shore salt loading terminal.

Datum of Elevations

All elevations were reduced on M.S.L. = 0 Pt. Adelaide through the connection to the Qasco B.M. No. 27. This datum was preferred rather than the Pt. Augusta datum which is the Commonwealth Railway datum, L.W.O.S.T. = 98.33', (ie. 98.33' below L.W.O.S.T.) because this datum has not been accurately determined, nor has the value for M.S.L. at Pt. Augusta been accurately determined with respect to this datum.

However, after reducing the value of the Harbours Board B.M. at the pump house onto M.S.L. = 0 Pt. Adelaide and comparing it with the value determined on Pt. Augusta datum plus the published height of mean sea level above this low water datum, (M.S.L. = 104.24') a difference of 0.3' appears to exist between the two M.S.L. values, Pt. Augusta M.S.L. being 0.3' higher than Pt. Adelaide, ie. R.L. of 115.91' on Pt. Augusta datum reduces to 115.91 - 104.24 = 11.67' (M.S.L. = 0 Pt. Augusta), cf. 11.97' (M.S.L. = 0 Pt. Adelaide).

Two tide gauges have recently been installed by the Department of Marine and Harbours, one off Red Cliff Point and the other on the Pt. Augusta town jetty. When the data from these gauges become available a more definite value can be placed on M.S.L. at Pt. Augusta.

Results of Survey

The main seawall breach is approximately 250' wide. Depths in the actual mouth of the breach range from 2' to 9' below M.S.L. However, immediately west of this breach and in the main channel depths in excess of 14' below M.S.L. were recorded.

A second breach exists and is located approximately 1500' south of the main breach and in the western seawall. This breach is approximately 230' wide and its depth appears to coincide with the level of mean high water springs ie. 5' above mean sealevel and therefore has not been subjected to deep scouring as in the case of the main breach.

Severe erosion of the north seawall has occurred between sections A+3900' and A+4100' (immediately east of old pump house). Although the lowest elevation recorded was 7.8' above M.S.L., it was noted that wave run-up water, just runs over the top. This was noted on two occasions, both at high tide with a strong (20 knots) N-NW wind.

All data recorded is represented in the form of

1) Contour map - scale 1" = 500' (ex Qasco) showing contours and location of sections.
2) Cross section profile - scale 1" = 20'. (Plotted on Pt. Adelaide datum with Pt. Augusta values superimposed).
3) Cross-section profile - scale 1" - 50' (plotted on Pt. Adelaide datum only).

Environmental Study, Point Paterson

An environmental study, consisting of two reports, was prepared and forwarded to the Department of Mines, Department of Environment and Conservation, and the Premier's Department.

The study was comprised of an Existing Environmental Profile (E.E.P.) and an Environmental Impact Statement. Dr. Alan Butler and other members of the Department of Zoology, University of Adelaide acted as consultants during the E.E.P. study. Delhi personnel provided field support for Dr. Butler's staff and performed additional field sampling and mapping duties.

The studies were designed to evaluate the possible effects of a seawater solar evaporation plant in the Point Paterson - Red Cliff Point area. It was generally concluded that no detrimental long-term effects would eventuate unless improperly constructed ponds leaked dense brine into the coastal mangrove area. This is considered unlikely.

The reports also contain detailed descriptions of the geology, hydrology, zoology, ornithology, etc., of the area involved, and references to field examinations of similar areas such as the Port Price, Osborne, and Port Augusta salt fields.

Future Work

Excessive rainfall and flooding of the Lake's surface has prevented the initiation of a 'long-term' pump test. Data derived from such a test is considered necessary in order to determine space requirements between production trenches. This test will be conducted as soon as practicable.

Laboratory experiments to determine the optimum limits of crystallisation, screening, and washing of Lake Torrens salt are continuing.

Engineering and costs estimates are proceeding on the basis of preliminary plans for both Point Paterson and Lake Torrens production sites.

Meteorological observations will continue and the Lake Torrens facilities will be conducted on a care and maintenance basis pending a decision to proceed with the project.

EXPENDITURE TO DATE

Lake Torrens Exploration Program

Items	Expenditure	
Salaries, wages & associated costs	85,233	18289
Travel and accommodation	4,049	286
Entertainment	419	22
Consultants - Dodd	19,913	729
Operating Expenses		
Dragline	32,561	–
Pumps	3,254	699
Camp	12,899	597
Other Equipment	8,486	2218
Equipment rental	5,620	1200
Assays	8,228	3813
Capital Equipment Purchase		
Dragline	55,098	415
International Pick Up	6,760	
Toyota swb	4,142	
Toyota 1½ ton flat bed	3,488	
BUE Earth Cruiser	2,863	
Honda ATC 90 bikes x 6	3,990	
ATV vehicle	745	
Walkie Talkies x 4	257	
2 way Radio	899	
Generator-Petbowlister used	2,406	
Pumps K & L Diesel	5,217	41
Camp Equipment	1,244	
Survey Gear	700	
Power Auger	486	
Miscellaneous	1,306	
	$270,263	28304

Suggest request breakdown of expre for quarter under review

Mf.

QUARTERLY REPORT

EXPLORATION LICENCE 60

for period

October 1, 1974 to December 31, 1974

EXPLORATION LICENCE 60

Summary of Activities October 1 to December 31, 1974

During the quarter ending December 31, 1974 Delhi International Oil Corporation conducted an evaluation drilling program on Playa 3 (Yorkey Crossing) in order to determine the possibility of establishing salt crystallising ponds in the area.

The Lake Torrens base camp and meteorological station was staffed with a maintenance crew engaged in equipment repair, road construction, and brine sampling duties.

A considerable amount of effort was expended in negotiations both interstate and overseas with potential users of salt in South Australia.

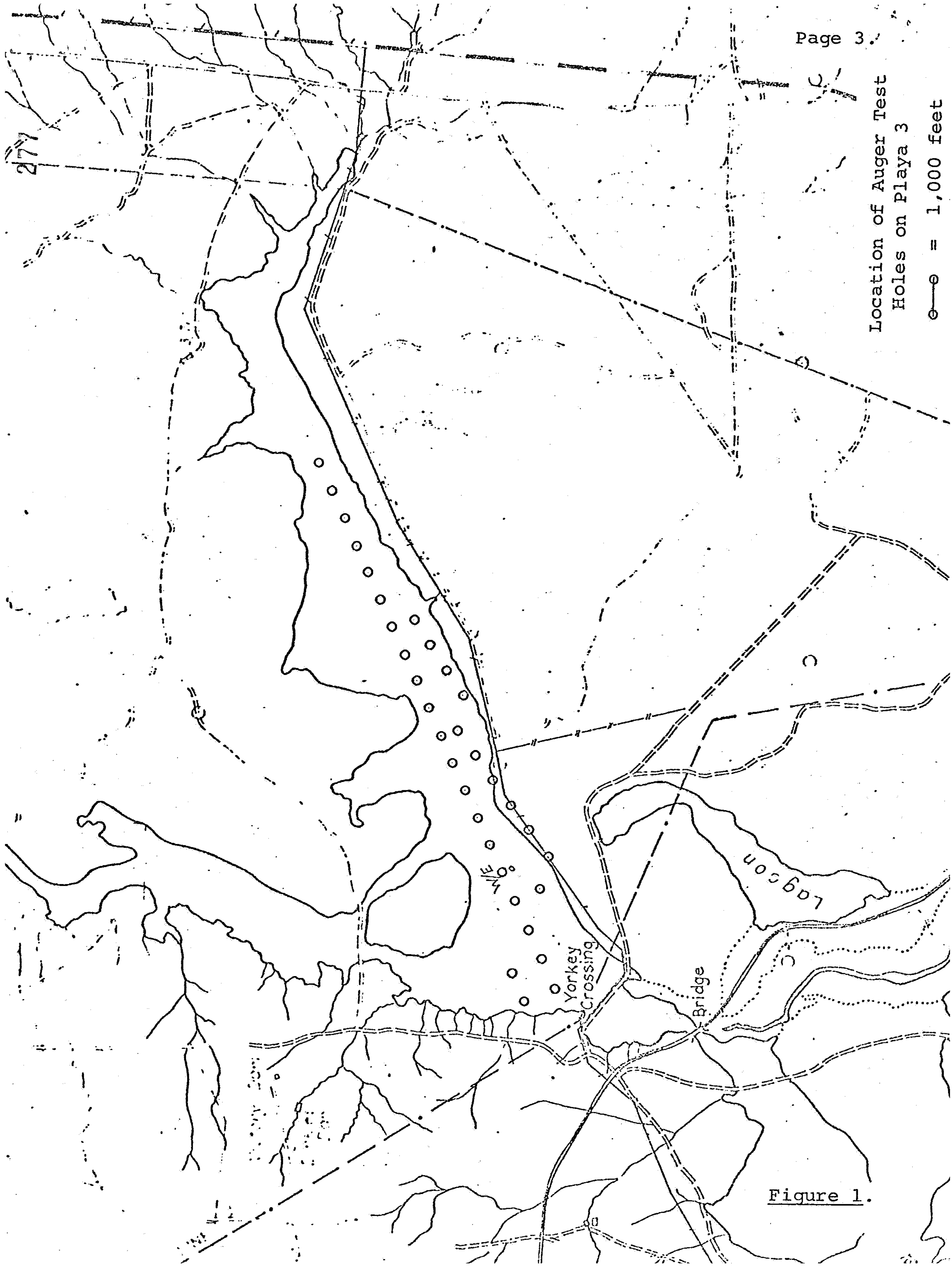
Exploration

During the quarter ending December 31, 1974 a test program was conducted on Playa 3 (Yorkey Crossing) to determine the suitability of the area for construction of crystalliser ponds.

The program consisted of surveying, auger drilling, and sampling of 32 locations, as shown in Figure 1. Each location was augered and sampled to a depth of six feet.

There appears to be sufficient impermeable clay in the area to allow construction of satisfactory ponds. The sediments of Playa 3 vary greatly from the more northern lakes. Playa 3 contains remnants of discontinuous coquina beds and zones of organic debris suggesting that it was formerly a mangrove-type area, probably an extension of the present tidal channel.

Logs of the stratigraphic section in Playa 3 are being prepared and will be included in the next quarterly report.



Location of Auger Test
Holes on Playa 3

o—o = 1,000 feet

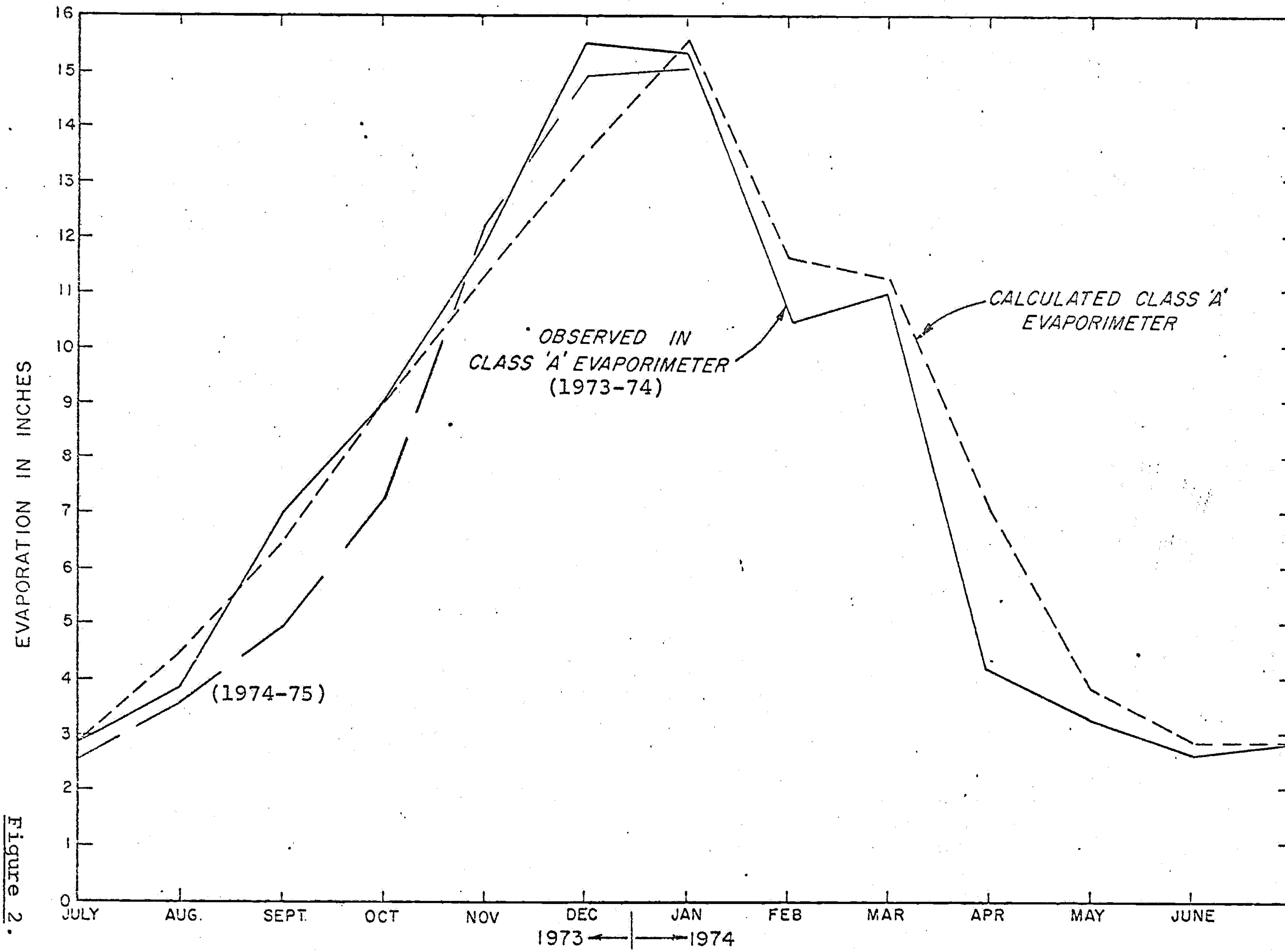
Figure 1.

Meteorological Data

Rainfall recorded at the Delhi International Oil Corporation Base camp during the last quarter of 1974 proved to be most erratic when compared with the South Gap records. Precipitation in October was 342 points and exceeded the maximum recorded for that month at South Gap between the years 1882 and 1965. November rainfall at the Base camp was much less than average and no precipitation was recorded during December.

Evaporation, as measured at the Delhi International Oil Corporation Base camp, continues to compare very favourably with that calculated from the regional maps compiled by the Bureau of Meteorology. Evaporation was 7.25, 12.18 and 14.87 inches for the last three months of 1974, respectively, Figure 2 and Table 1.

The first comprehensive records of hours of sunshine, temperature and wind are illustrated in Figures 3 and 4. It should be noted that evaporation appears to be more closely related to wind velocity and duration that it is to hours of sunshine in this area.



EVAPORATION - LAKE TORRENS

Figure 2.

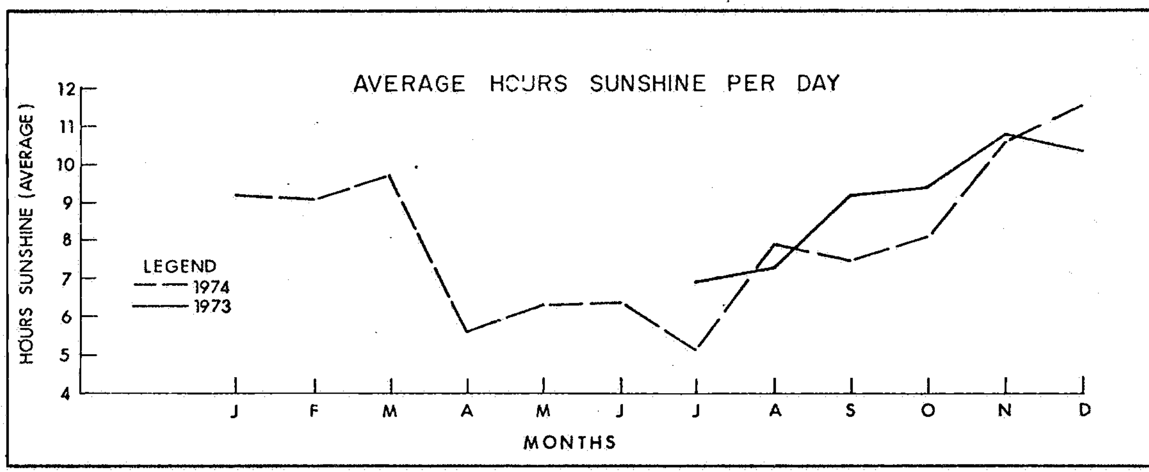
LAKE TORRENS

AVERAGE DAILY METEOROLOGICAL DATA

1973/1974

		January	February	March	April	May	June	July	August	September	October	November	December
1973													
Temperature Dry Bulb °C	Min.							6.7	6.1	9.5	12.1	13.6	16.7
	Max.							10.7	12.0	15.3	18.4	20.2	24.5
Temperature Wet Bulb °C	Min.							9.9	10.5	13.2	15.4	16.9	20.3
	Max.							17.9	18.6	24.0	26.4	29.3	32.7
Sunshine hours/day								6.9	7.3	9.2	9.4	10.8	10.4
Rainfall Points								5	8	4	5	2	5
Evaporation Points								9	13	23	30	39	50
Wind miles/day								103.6	120.3	158.4	117.4	194.1	196.9
1974													
Temperature Dry Bulb °C	Min.	22.0	17.8	17.8	13.6	8.5	4.0	6.2	6.7	6.6	11.6	12.4	15.1
	Max.	26.4	22.7	25.1	17.8	13.4	9.8	10.9	11.2	13.4	18.0	19.9	22.7
Temperature Wet Bulb °C	Min.	22.8	18.8	20.3	15.4	11.9	8.5	9.4	9.8	10.2	13.5	13.9	15.9
	Max.	34.9	32.2	32.4	23.2	19.3	17.6	17.7	19.3	20.3	24.3	29.2	32.3
Sunshine hours/day		9.2	9.1	9.7	6	6.3	6.4	5.1	7.9	7.5	8.1	10.6	11.6
Rainfall Points		9.5	9.7	17	9	15	1	5	3	5	11	1	0
Evaporation Points		49.5	35	35	14	10	9	9	12	16.5	23	41	48
Wind miles/day		242.2	192.5	189.7	133.6	102.3	99.1	124.1	156.0	121.4	160.9	202.5	211.7

Table 1.


AVERAGE HOURS SUNSHINE PER DAY
HOURS SUNSHINE (AVERAGE)
12
11
10
9
8
7
6
5
4
LEGEND
1974
1973
J F M A M J J A S O N D
MONTHS

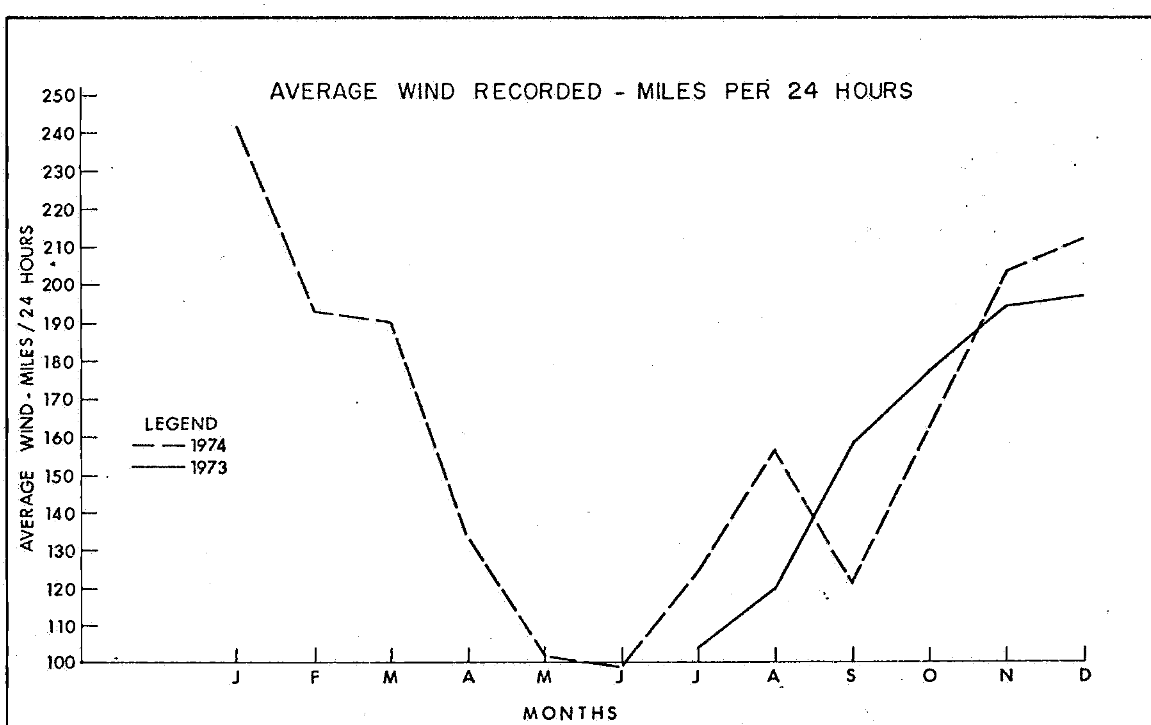
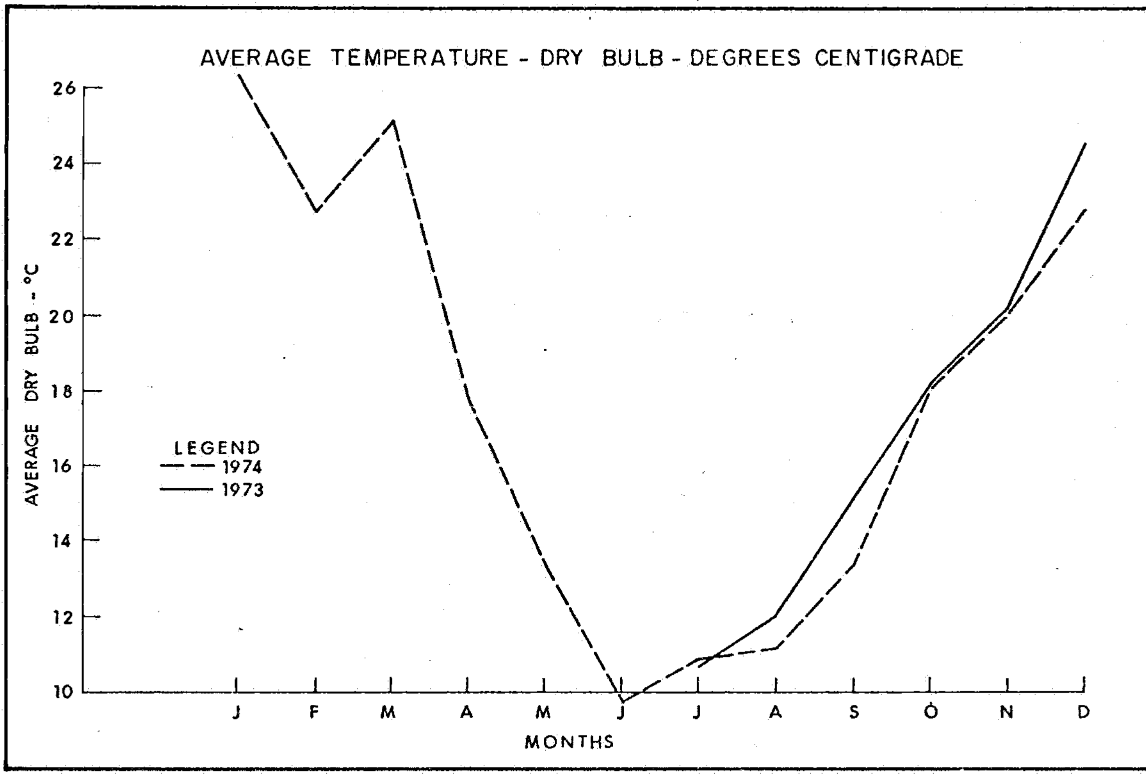

AVERAGE WIND RECORDED - MILES PER 24 HOURS
AVERAGE WIND - MILES / 24 HOURS
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
LEGEND
1974
1973
J F M A M J J A S O N D
MONTHS

Figure 3.


AVERAGE TEMPERATURE - DRY BULB - DEGREES CENTIGRADE
AVERAGE DRY BULB - °C
26
24
22
20
18
16
14
12
10
LEGEND
1974
1973
J F M A M J J A S O N D
MONTHS

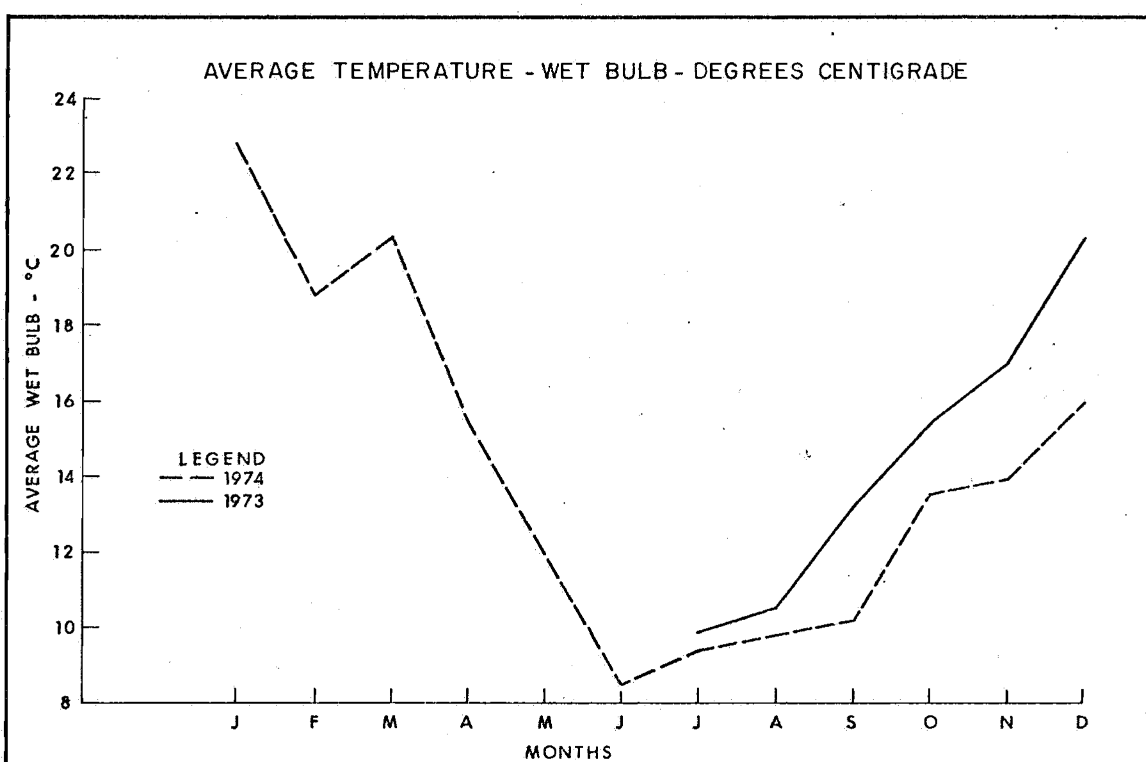

AVERAGE TEMPERATURE - WET BULB - DEGREES CENTIGRADE
AVERAGE WET BULB - °C
24
22
20
18
16
14
12
10
8
LEGEND
1974
1973
J F M A M J J A S O N D
MONTHS

Figure 4.

Surface Brine

The heavy rains which fell in October 1974 resulted in almost complete flooding of the lower part of Lake Torrens.

During October 1974 some 3.42 inches of rain fell in the vicinity of southern Lake Torrens, this coupled with overflows from Willochra Creek carrying surface water from the Flinders Ranges, resulted in almost complete flooding of the work area.

Depth of surface water ranged from a few inches on the topographic highs to as much as six feet in the southern bay areas. Density of surface water shortly after flooding was in the order of 1^{o} Baume.

Surface water in the southern bays was monitored up to the end of 1974 when only an inch or two of brine remained in the lowest areas. The rate at which the surface brine evaporated and/or increased in density is recorded in Table 2.

Table 2 Densities of Surface Water*

	Sample Location	°Be & temperature as measured	°Be Corrected
15 November, 1974	South Bay	5.6° Be at 83°F	6.2
	West Bay	5.9° Be at 75°F	6.3
	Trench 1	6.3° Be at 80°F	6.8
	East Bay	6.1° Be at 82°F	6.6
2 December 1974	South Bay	7.6° Be at 83°F	8.2
	West Bay	8.2° Be at 89°F	8.9
	East Bay north	8.0° Be at 91°F	8.8
	East Bay south	6.9° Be at 82°F	7.4
9 December 1974	South Bay	9.2° Be at 83°F	9.8
	West Bay	8.5° Be at 78°F	8.9
	East Bay	8.8° Be at 78°F	9.5
16 December 1974	South Bay	12.0° Be at 88°F	12.7
	West Bay	9.2° Be at 85°F	9.8
	East Bay	8.1° Be at 85°F	8.7

* Following heavy rains in October and flooding of the Willochra Creek surface water on Lake Torrens was ponded to a depth of several feet (6' max. est.) in the southern shore area. None of the surface water appeared to be overflowing or seeping southwards into Playa 11.

Table 2.

EXPENDITURE FOR PERIOD
OCTOBER 1, 1974 to DECEMBER 31, 1974

Lake Torrens Exploration Programme

Items	Expenditure
Salaries, wages & associated costs	21,824
Travel and accommodation	426
Entertainment	58
Consultants - Dodd	716
Operating Expenses	
Pumps	1,392
Camp	
Other equipment	2,303
Equipment rental	1,158
Assays - McPhar	45
	$29,731

Exploration Licence 60

Summary of Activities January 1, 1975 to April 13, 1975

During the three months ending April 13, 1975 Delhi International Oil Corporation continued an exploration programme in order to evaluate the potential reserves of NaCl and availability of suitable pond sites required for the proposed Redcliff Petrochemical Complex.

Although the proposed petrochemical project has recently been deferred for two years, Delhi has proceeded with its programme of evaluation and market development. Work completed during the year consisted of exploration using an amphibious dragline, geochemical and petrographic analysis, compilation of meteorological data, detailed surveying of the Point Paterson seawall, bulk crystallisation and beneficiation studies, environmental investigations, and auger drilling of the Yorkey Crossing (Playa 3) area. Delhi also assisted Amdel and Coffey and Hollingsworth Pty Ltd. in their independent assessments on behalf of the South Australia Department of Mines, and Mr. C. Bleys, Consultant to the Redcliff Petrochemical Consortium.

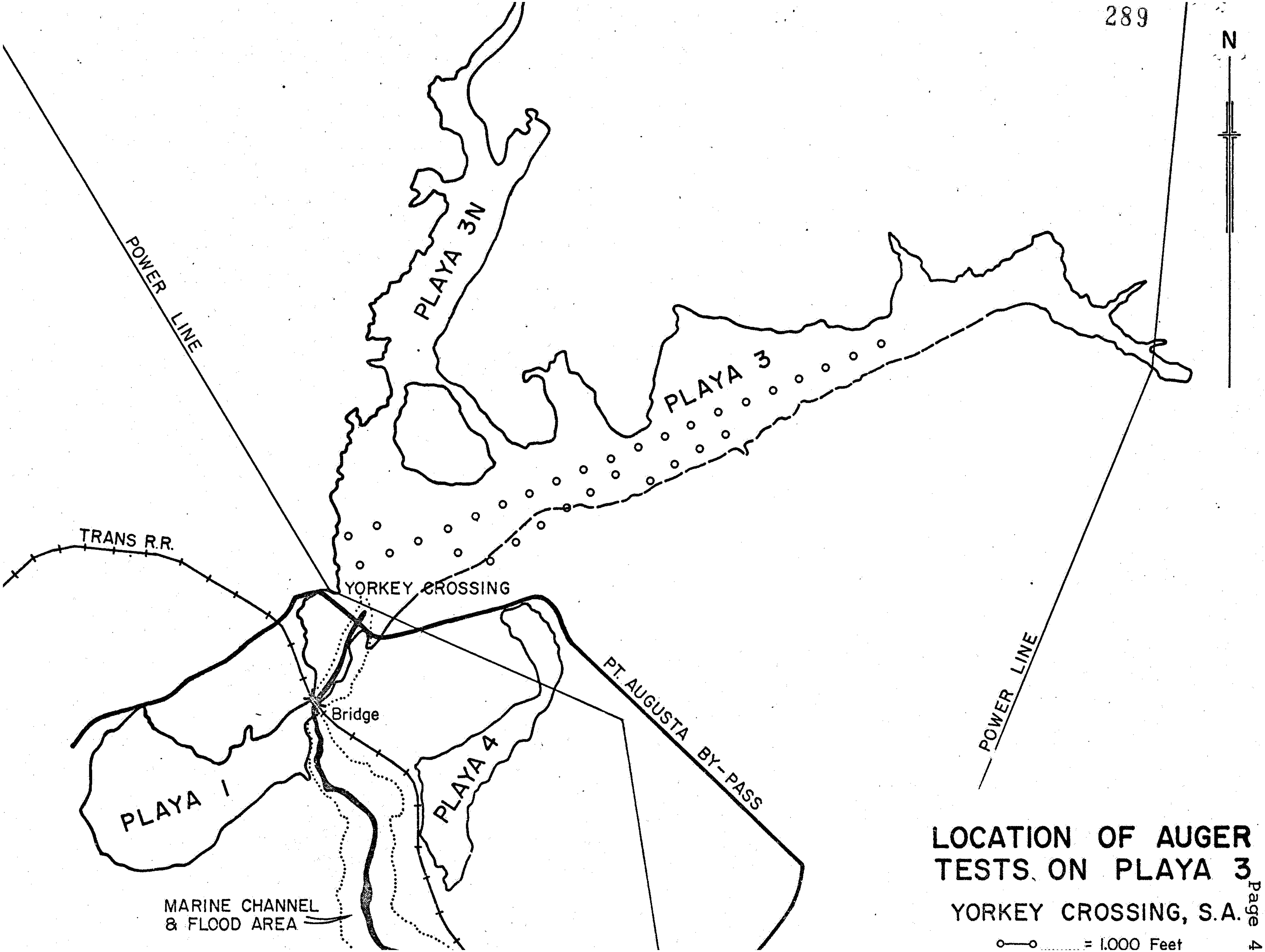
Exploration data from Lake Torrens has now been evaluated by staff of Dow Chemical Company, Mr. C. Bleys (consultant to the Redcliff Petrochemical Consortium), Coffey and Hollingsworth Pty Ltd. (consultant to the Department of Mines), and by Delhi's own consultants Mr. K.C. Dodd and Associates, and staff. The consensus of opinion indicates the lake sediments are sufficiently permeable and the brine exists in adequate amounts so as to provide for an economically viable recovery system.

Work conducted during the last Quarter of the period was therefore directed toward developing market contacts, repair and maintenance of equipment and camp at Lake Torrens, and continued operation of the Class "B" meteorological station.

Exploration

A programme of auger drilling in the Yorkey Crossing (Playa 3) area was completed on January 4, 1975. Thirty-two locations were surveyed and augered to a depth of 5 to 6 feet.

Stratigraphic logs, attached hereto indicate the Yorkey Crossing area was probably once an extension of Spencer Gulf. Strata of shell-rich clays and coquina, intermixed with impermeable clays and organic debris strongly suggest an environment similar to that which now exists between Port Augusta and Yorkey Crossing. Chemical analyses of brines collected from the area during an earlier reconnaissance programme confirm that overall the sediments are relatively impermeable and that no significant amounts of seawater move through the strata.



LOCATION OF AUGER TESTS ON PLAYA 3

YORKEY CROSSING, S.A.

Page 4

YORKEY'S CROSSING

Auger Hole Logs
(Second Phase)
January 3, 1975

1000W/8000S

0	-	1'	Sand, buff, fine grained
1'	-	2'	Clay, light grey/light buff, sticky
2'	-	3'	Clay, mottled light grey/brown, in part silty
3'	-	4'	Clay, light grey, sticky
4'	-	5'	Sand, light grey - very poor sample recovered
5'	-	5'6"	Sand - no sample

1000W/00

0	-	1'	Clay, mottled light grey/buff, in part silty - dry
1'	-	2'	Clay as above, sticky
2'	-	2'6"	Clay as above, very sticky
2'6"	-	3'6"	Clay, blue-grey, sticky with minor very small shells and shell fragments
3'6"	-	4'3"	Shelly clay, blue-grey, large shells and shell fragments - 50% shell
4'3"	-	5'6"	Shelly clay as above with numerous fibrous plant remains. 30% shells. Clay, sandy 5' - 5'6".

Hole making water slowly - standing 4'6" after logging

2000W/00

0	-	1'	Clay, buff, sticky
1'	-	2'	Clay, mottled light grey/buff, sticky
2'	-	3'	Clay as above grading to grey
3'	-	4'	Clay, dark grey, in part sandy with minor fibrous plant remains
4'	-	4'6"	Clay as above with minor small shells
4'6"	-	5'6"	Shelly clay, dark grey, sandy, shells 50%. Minor fibrous plant remains. Few shells near base.

Water standing 4' after logging.

3000W/00

0 - 1'		Clay, mottled light grey/buff
1' - 2'		Clay as above, sticky
2' - 2'6"		Clay as above, in part silty and sandy. Minor plant remains and root tubes.
2'6" - 3'		Sand, banded dark grey/light grey, fine grained with fibrous plant remains.
3' - 4'		Sand, dark grey as above with minor plant remains
4' - 5'		Sand as above with few shells 4'9" - 5'.
5' - 5'6"		Shelly sand, dark grey as above, fine-medium grained with abundant fibrous plant remains. 50% shells.

Water standing 1'6" after logging.

4000W/00

0 - 1'		Silty clay, dark brown, dry
1' - 2'		Clay, mottled light grey/buff, in part silty
2' - 3'		Clay as above, sticky with minor very fine root tubes.
3' - 4'		Clay as above
4' - 5'		Clay, blue-grey, silty in part
5' - 5'6"		Sandy clay, dark grey with very small shells and shell fragments. 10% shells.

Water standing 2' after logging.

4000W/1000N

0 - 1'		Gypseous, silty clay, dark brown, dry
1' - 2'		Clay, mottled light grey/buff, minor very fine root tubes.
2' - 3'		Clay as above, silty in part.
3' - 4'3"		Clay as above, sticky.
4'3" - 5'		Shelly sand, dark grey, clayey, very fine-grained-fine grained with minor fibrous plant material. 20% shells.
5' - 5'6"		Sand as above grading to medium-coarse grained. Numerous fibrous plant remains.

Water standing 4' after logging.

3000W/1000N

0	-	3"	Silty clay, dark brown
3"	-	1'	Silty clay, mottled light grey/buff
1'	-	2'	Clay as above, sticky
2'	-	3'	Clay as above with minor very fine roots and root tubes.
3'	-	4'	Clay, blue-grey, sticky with occasional shells and shell fragments.
4'	-	5'	Clay, as above.
5'	-	5'6"	Sand? No sample

Water standing 1'6" after logging.

YORKEY'S CROSSING

Auger Hole Logs
December 15, 1974

00E

0	-	4"	Sandy, clay, dark brown
4"	-	2'6"	Clay, light grey/cream, sticky
2'6"	-	5'6"	Clay, blue grey, sticky. Shells and shell fragments 3'-5'6" with fibrous plant material. 5'-5'6" becoming sandy

00'E Offset (on Sth fence line)

0	-	1'	Sand, silty, brown, medium grained
1'	-	2'	Sand, silty, brown/buff, fine-medium grained
2'	-	3'	Clay, light grey/buff, sticky
3'	-	4'	Clay as above
4'	-	5'	Clay as above
5'	-	5'3"	Sand, light grey, very coarse grained-grit
5'3"	-	5'6"	Clay, grey, sticky

1000'E Offset (on Sth fence line)

0	-	1'	Sand, brown, medium grained
1'	-	2'	Clay, buff, sticky
2'	-	3'	Clay, light grey, sticky
3'	-	4'	Clay, blue-grey sticky
4'	-	5'6"	Clay as above

1000'E

0	-	1'	Clay, buff, sticky
1'	-	2'	Clay, buff/light grey, sticky
2'	-	3'	Clay, light grey, sticky
3'	-	4'	Clay, blue-grey, sticky
4'	-	5'6"	Sand, blue-grey, shelly, gritty with clay matrix. Abundant fibrous plant material.

2000'E

0	-	1'	Clay, buff/light brown
1'	-	2'	Clay, light grey/buff, sticky with blebs deep red clay
2'	-	3'	Clay, blue-grey, sticky with few plant remains
3'	-	3'6"	Clay as above
3'6"	-	4'	Sand, dark grey with minor clay, medium-coarse grained. Numerous fibrous plant remains
4'	-	5'6"	Sand, dark grey, clayey, medium-coarse grained, shells and shell fragments with fibrous plant remains.

2000'E Offset (on Sth fence line)

0	-	1'	Clay, buff, silty, sticky
1'	-	2'	Clay, buff/light grey, sticky
2'	-	3'	Clay, light grey, sticky
3'	-	4'	Clay, blue-grey, sticky
4'	-	5'6"	Sandy clay, dark grey with abundant shells and shell fragments.

3000'E (thin salt crust underlain by brine)

0'	-	1'	Clay, light grey/buff, sticky
1'	-	2'	Clay as above, mottled
2'	-	2'6"	Shell grit, sandy
2'6"	-	3'	Sandy clay, blue-grey with numerous fibrous plant remains
3'	-	4'	Sand and grit, dark grey with minor clay. Numerous shells and shell fragments.
4'	-	5'6"	Clay, blue-grey with bedded shells and numerous fibrous plant remains.

3000'E Offset (on production of Sth fence line)

0	-	2'	Clay, light grey/buff, mottled, sticky
2'	-	4'	Clay, blue-grey, sticky with numerous shell fragments and fibrous plant remains at base.
4'	-	4'6"	Clay as above
4'6"	-	5'	Sand, dark grey, coarse-very coarse grained with shells and shell fragments.
5'	-	5'6"	Sand as above, fine-medium grained with clay lenses.

4000'E (thin salt crust underlain by brine)

0	- 1'	Clay, buff, sticky
1'	- 2'	Clay, light grey, sticky
2'	- 3'	Clay, as above becoming sandy at base
3'	- 4'	Clay as above becoming more sandy
4'	- 5'	Clay as above
5'	- 5'6"	Sandy clay, dark grey with numerous shells and fibrous plant remains

4000'E Offset (on production of Sth fence line)

0	- 1'9"	Clay, light grey/buff, sticky
1'9"	- 3'	Sand, buff/light grey, shelly, medium-coarse grained
3'	- 3'6"	Clay, blue-grey, sticky
3'6"	- 5'	Sand, dark grey, shelly with minor clay
5'	- 5'6"	Clayey sand, grey, fine grained with numerous shells and shell fragments.

5000'E (thin salt crust underlain by brine)

0	- 1'	Clay, very light grey, sticky
1'	- 1'6"	Clay, light grey, sticky
1'6"	- 2'	Shell grit, yellow/brown with light grey clay
2'	- 4'	Clay, dark grey, sticky with shell fragments and fibrous plant remains
4'	- 5'	Clay, blue-grey, sticky, with shells and fibrous plant remains

5000'E Offset (on production of Sth fence line)

0	- 1'	Clay, light grey/buff, sticky
1'	- 1'8"	Clay, as above
1'8"	- 3'	Sand, buff/light grey, medium grained
3'	- 3'9"	Sand, buff/brown, medium-coarse grained
3'9"	- 4'	Sand, buff, coarse grained-grit with numerous shell fragments
4'	- 5'	Sand, as above becoming clayey
5'	- 5'6"	Sandy clay, buff, sticky

6000'E (Thin salt crust underlain by brine)

0	-	1'	Clay, mottled buff/light grey, sticky
1'	-	2'	Clay as above
2'	-	3'	Clay, dark grey with thin bedded shell lenses. Few fibrous plant remains.
3'	-	4'	Clay as above with more abundant plant remains.
4'	-	5'6"	Clay, grey, sticky with few shells and shell fragments and less plant remains than clay above.

6000'E Offset (Sth fence line)

0	-	1'	Clay, buff/light grey, sticky
1'	-	2'	Sand, buff/light grey, coarse grained
2'	-	3'	Shelly sand, light grey, coarse grained-grit
3'	-	4'	Sand, dark grey as above
4'	-		Clay, dark grey, with numerous plant remains and few shell fragments.

Hole caved

7000'E

0	-	1'	Silty clay, buff/light grey
1'	-	2'	Clayey sand, grey, very fine grained
2'	-	3'	Sand as above
3'	-	4'	Sand as above
4'	-	5'	Clayey sand, dark grey, very fine grained with numerous shells and shell fragments
5'	-	5'6"	Clay, sandy, dark grey with shell fragments and fibrous plant remains.

7000'E Offset (Sth fence line)

0	-	1'	Clay, buff/light grey, sticky
1'	-	1'9"	Clay, light grey, sticky
1'9"	-	2'	Gritty sand and shell grit, buff
2'	-	2'6"	Clay, dark grey with abundant shells
2'6"	-	4'	Sand and shell grit, dark grey, coarse grained
4'	-	5'	Clay, dark grey with shells and shell fragments with abundant fibrous plant remains (30%)
5'	-	5'6"	Clay as above.

8000'E

0	-	1'	Clay, buff/light grey, sticky
1'	-	2'	Clay, light grey, sticky
2'	-	3'	Clay, light blue-grey, sticky
3'	-	4'	Clay, dark grey, sticky, few sandy lenses. Few shell fragments, numerous fibrous plant remains.
4'	-	5'6"	Clay, grey, sticky with very minor shell fragments, numerous fibrous plant remains.

* Good clean dry hole.

8000'E Offset (Sth fence line)

0	-	1'	Sandy clay, buff/light grey, sticky
1'	-	2'	Clay, grey, sticky, silty in part
2'	-	2'6"	Clay, dark grey, sticky
2'6"	-	3'	Sand dark grey, medium-coarse grained
3'	-	3'3"	Sand as above with numerous shells and shell fragments
3'3"	-	4'	Clay, dark grey, sticky with abundant fibrous plant remains with minor shell fragments
4'	-	4'6"	Clay as above
4'6"	-	5'	Sand, grey, coarse grained-shell grit
5'	-	5'6"	Clay, dark grey, sticky with abundant fibrous plant remains with minor shell fragments

9000'E

0	-	1'	Clay, mottled grey/brown, sticky
1'	-	2'	Clay, light grey, sticky
2'	-	3'	Clay, dark grey, sticky with few shell fragments and fibrous plant remains
3'	-	4'	Clay, as above with numerous fibrous plant remains.
4'	-	5'	Clay as above
5'	-	5'6"	Clay as above with very minor shells and shell fragments

* Good clean dry hole

9000'E Offset (Sth fence line)

0	-	1'	Clay, mottled grey/brown, sandy
1'	-	2'	Clayey sand, dark grey
2'	-	3'	As above, becoming more clayey
3'	-	4'	Sandy clay, grey with few shells and fibrous plant remains
4'	-	5'	Clay, grey with numerous fibrous plant remains
5'	-	5'6"	Clay as above with few shells and shell fragments

10,000'E

0	-	1'9"	Clay, light grey/buff, sticky
1'9"	-	3'	Sand, light grey, coarse-very coarse grained
3'	-	4'	Shell grit, light grey
4'	-	5'	Sand, grey with numerous shells
5'	-	5'6"	Clay, blue-grey with minor shells and fibrous plant remains

11,000'E

0	-	1'	Clay, light grey/buff, in part sandy, sticky
1'	-	1'6"	Clay, light grey/buff, sandy
1'6"	-	2'	Clayey sand, blue-grey with numerous shells
2'	-	3'	Clay, blue-grey, very sandy with shells
3'	-	4'	Sandy clay, blue-grey with few shells
4'	-	5'	Clay as above, less sandy
5'	-	5'6"	Clay, blue grey, sticky

12,000'E

0	-	1'	Clay, brown, sticky
1'	-	2'6"	Clay, grey/green, mottled, sticky
2'6"	-	3'4"	Shell grit, grey/green
3'4"	-	4'	Clay, grey/green, sticky with abundant fibrous plant remains
4'	-	5'	Clay, blue-grey, sticky with few bedded shells
5'	-	5'6"	Clay, blue-grey, sticky

13,000'E

0	-	4"	Silty clay, brown
4"	-	1'6"	Clay, grey/green, mottled, sticky
1'6"	-	2'	Clay, blue-grey, sticky.
2'	-	3'	Clay as above
3'	-	4'	Sand, grey, medium grained with numerous shells
4'	-	5'6"	Sand, grey, fine-medium grained - no shells

14,000'E

0	-	1'	Clay, dark brown
1'	-	2'	Clay, grey/green, sticky
2'	-	2'9"	Clay, blue-grey, sticky
2'9"	-	3'3"	Clay as above with abundant shells
3'3"	-	4'	Clay, dark grey, sticky with few shells and fibrous plant remains
4'	-	5'	Clay, as above
5'	-	5'6"	Sand, dark grey, clayey, very fine grained

15,000'E

0	-	4"	Clay, dark brown
4"	-	1'	Sand, buff, medium-coarse grained
1'	-	2'	Silty sand, brown, fine-medium grained
2'	-	3'	Sand as above, clayey
3'	-	4'	Sandy clay, light grey/yellow, mottled
4'	-	5'	Sand, light grey, medium-coarse grained
5'	-	5'6"	Clayey sand, light grey, medium-coarse grained

Meteorological Data

Evaporation rates during the first three months of 1975 were 15.14, 13.50, and 10.82 inches respectively, and indicate that a reliable average effect may now be calculated for the area. It is expected that an average of about 95.7 inches evaporation per year is predictable for Lake Torrens. Evaporation of dense brine during the winter months has been shown to be well in the order of 70 to 80 percent (average 77%) of that measured in the Class "A" evaporimeters.

LAKE TORRENS

AVERAGE DAILY METEOROLOGICAL DATA

1973/1974

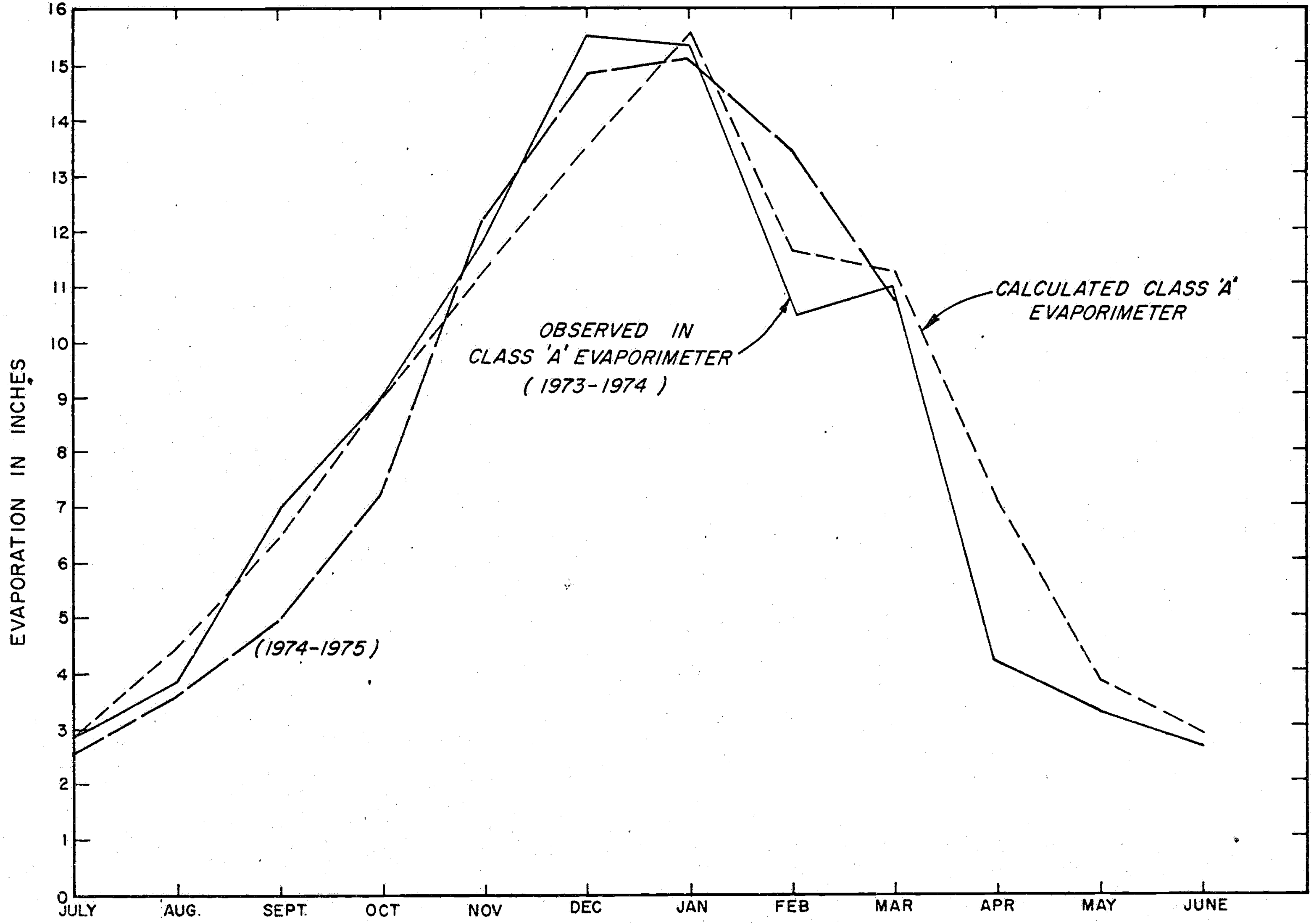
1973		January	February	March	April	May	June	July	August	September	October	November	December
Temperature °C	Min.							6.7	6.1	9.5	12.1	13.6	16.7
	Max.							17.9	18.6	24.0	26.4	29.3	32.7
Wet Bulb °C								9.9	10.5	13.2	15.4	16.9	20.3
Dry Bulb °C								10.7	12.0	15.3	18.4	20.2	24.5
Sunshine hours/day								6.9	7.3	9.2	9.4	10.8	10.4
Rainfall Points								5	8	4	5	2	5
Evaporation Points								9	13	23	30	39	50
Wind miles/day								103.6	120.3	158.4	117.4	194.1	196.9
1974													
Temperature °C	Min.	22.0	17.8	17.8	13.6	8.5	4.0	6.2	6.7	6.6	11.6	12.4	15.1
	Max.	34.9	32.2	32.4	23.2	19.3	17.6	17.7	19.3	20.3	24.3	29.2	32.3
Wet Bulb °C		22.8	18.8	20.3	15.4	11.9	8.5	9.4	9.8	10.2	13.5	13.9	15.9
Dry Bulb °C		26.4	22.7	25.1	17.8	13.4	9.8	10.9	11.2	13.4	18.0	19.9	22.7
Sunshine hours/day		9.2	9.1	9.7	6	6.3	6.4	5.1	7.9	7.5	8.1	10.6	11.6
Rainfall Points		9.5	9.7	17	9	15	1	5	3	5	11	1	0
Evaporation Points		49.5	35	35	14	10	9	9	12	16.5	23	41	48
Wind miles/day		242.2	192.5	189.7	133.6	102.3	99.1	124.1	156.0	121.4	160.9	202.5	211.7

LAKE TORRENS

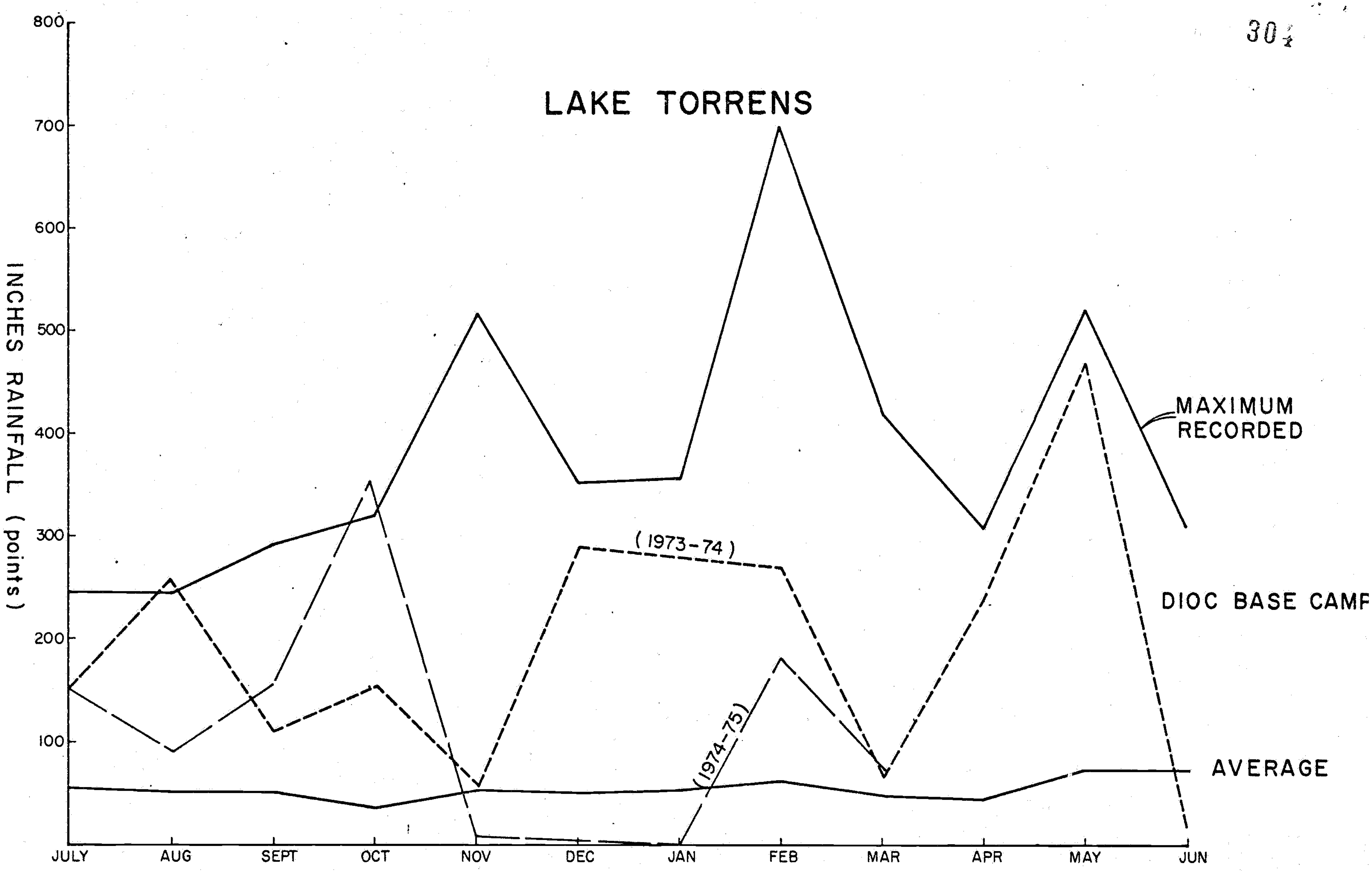
AVERAGE DAILY METEOROLOGICAL DATA

1975

	January	February	March
Dry Bulb °C	22.3	25.1	21.6
Wet Bulb °C	17.1	21.1	15.9
Temp. Minimum °C	15.4	20.2	14.7
Temp. Maximum °C	33.0	35.1	29.9
Sunshine hours/day	12.0	9.0	9.5
Rainfall Points	.1	6.25	2.03
Evaporation Points	49	48	35
Wind miles/day	213.2	187.7	167.7



EVAPORATION - LAKE TORRENS



COMPARISON OF AVERAGE & MAXIMUM RAINFALL RECORDED AT SOUTH GAP STATION (1882-1965) WITH DIOC BASE CAMP (JULY 1973-MARCH 1975)

Expenditures

Expenditures on the Lake Torrens Prospect during the two-year term of Exploration Licence 60 are $320,966, or 181% of the sum committed under the terms of the licence. Operating expenses continue to be incurred while the camp, meteorological station and maintenance duties are staffed by field personnel.

All of the major exploration activities itemised in Exploration Licence 60 have been successfully completed.

EXPENDITURE TO DATE

Lake Torrens Exploration Program

Items	Quarter Ending 30-3-75	Year Ending 30-3-75	Total to 30-3-75
Salaries, wages and associated costs	18,188.57	76,521.83	125,245
Travel and accommodation	102.70	1,281.23	4,578
Entertainment	225.00	312.27	477
Consultants - Dodd		1,808.50	20,854
Operating Expenses			
Dragline	54.74	54.74	32,616
Pumps		3,649.04	4,646
Camp	1,662.34	5,014.29	16,370
Other Equipment	138.94	5,730.34	10,917
Equipment rental	600.00	3,825.00	7,345
Assays - McPhar		5,325.50	8,273
Capital Equipment Purchase			
Dragline		15,948.14	55,098
International Pick Up			6,760
Toyota swb			4,142
Toyota 1½ ton flat bed			3,488
BUE Earth Cruiser			2,863
Honda ATC 90 bikes x 6			4,001
ATV vehicle			745
Walkie Talkies x 4			257
2 way Radio			932
Generator-Petbowlister used			2,406
Pumps K & L Diesel			5,217
Camp Equipment			1,244
Survey Gear			700
Power Auger			486
Miscellaneous		82.30	1,306
Totals:	$20,972.29	$119,553.18	$320,966