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TITLE: REPORT ON EXPLORATORY DRILLING
FOR WATER AT JURIE BAY, W.A.

K. Berliat, D.Sc.
AUTHOR: K.H. Morgan, B.Sc.

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REPORT ON EXPLORATORY DRILLING FOR WATER AT JURIEN BAY, W.A.

by

K. Berliat, D.Sc., Senior Geologist
and K.H.Morgan, B. Sc. Geologist.

Record No. 1962/1.

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ABSTRACT

A deep exploratory bore for water at Jurien Bay was abandoned at 628 feet in Lower Triassic Kockatea Shale without locating water of domestic quality. Subsequent shallow drilling indicated that limited supplies of fresher ground water overlie the main body of salt water. The salinity of this water is near the maximum permissible for domestic use.

JURIEN BAY NO. 1 DEEP EXPLORATORY BORE

General Information, Origin and Purpose of the Drilling Programme

The drilling programme at Jurien Bay originated from a request for assistance submitted to the Hon. Minister for Fisheries by Ross International Fisheries Ltd. This firm advised that it had drilled a number of shallow holes (less than 50 feet deep), but had been unsuccessful in the attempt of locating ground water for domestic purposes. The matter was referred to the Geological Survey which advised that, in the absence of any sub-surface information, a drilling programme would be entirely of an exploratory nature. It was recommended to sink an exploratory bore to a depth of 1,000 feet in order to obtain information on the deeper aquifers that might exist in the coastal area, and also to study the problem of possible salt water encroachment. The project was approved, and tenders for the construction of the bore were subsequently called from private contractors.

The drill site was selected within the boundaries of Jurien Bay townsite, close to the centre of consumption, and approximately 25 chains from the coast.

Jurien Bay, an expanding centre for the crayfish and fishing industry, and a seasonal holiday resort, is situated on the Indian Ocean, 194 miles by road north of Perth via Moora and Badgingarra. At the present stage permanent residents number less than 50, but the peak population is probably

2.

ten times that figure.

Bore History.

General Data.

Bore Name and Number: Jurien Bay No. 1.

Location: Latitude $30^{\circ} 18' S$ (approx).

Longitude $115^{\circ} 2' E$ (approx).

At S.W. corner of Victoria Location 969 (Jurien Bay Townsite) on Jurien Bay-Badgingarra road reserve.

Ground Elevation: 10 feet (approx).

Date commenced: 13th December, 1961.

Date Completed: 18th February, 1962.

Depth of Bore: 628 feet.

Status: Abandoned.

Drilling Data.

Name and Address of Drilling Contractor: Westphal Bros. & Co.
415 William Street, Perth.

Type of Rig: Ruston Bucyrus 22 R.W. Percussion.

Hole Size: $10\frac{1}{2}$ inch from surface to 65 feet.

$8\frac{1}{2}$ inch from 65 feet to 501 feet.

$6\frac{1}{2}$ inch from 501 feet to 628 feet.

Casing: 10 inch to 30 feet and cemented.

8 inch to 501 feet

6 inch to 628 feet.

Casing left in completed hole: 10 inch from surface to 30 feet.

Geology

General Statement.

The drilling area lies in the Perth Basin, to the west of the "Beagle Ridge", a shallow sub-surface basement ridge, bounded to the east by the Beagle Ridge Fault. This fault, extending north and south from Latitude $29^{\circ} 30' S.$ to Latitude $30^{\circ} 40' S.$, runs from 5 to 8 miles east of the coast.

None of the sediments of Proterozoic (?), Permian, Triassic, Jurassic, and Cretaceous age, known to crop out

elsewhere within the Basin, are exposed in the vicinity of the drill site. The nearest outcrops of Lower Jurassic Cockleshell Gully Sandstone occur approximately 8 miles to the east. In the coastal area the older formations are obscured by Pleistocene Coastal Limestone and, closer to the coast, by beach sand dunes, in which the drill site is located.

Lithology

The lithological sequence encountered is described in the following bore log:

From (feet)	To (feet)	Thick- ness (feet)	Lithological Description
0	30	30	SAND, calcareous, medium to fine grained with shell fragments, light grey.
30	87	57	COASTAL LIMESTONE, coarse grained calcarenite with shell fragments, and occasional grains of chert and quartz.
87	90	3	SILTSTONE, argillaceous, calcareous, yellow, contains fragments of limestone.
90	239	149	SILTSTONE, argillaceous, calcareous, partly carbonaceous, grey; contains grains and fragments of limestone.
239	305	66	SILTSTONE, argillaceous, grey.
305	320	15	SANDSTONE, argillaceous, fine grained, grey, with occasional grains of limestone.
320	358	38	SILTSTONE, argillaceous, grey.
358	390	32	MUDSTONE, slightly silty and micaceous.
390	425	35	SILTSTONE, argillaceous, slightly micaceous, with minute limestone fragments.
425	505	80	SILTSTONE, argillaceous, micaceous, grey.
505	560	55	SANDSTONE, micaceous, argillaceous, medium grained, well sorted, grey.
560	595	35	SANDSTONE, argillaceous, fine-grained, moderately sorted, grey.
595	628	33	MUDSTONE, silty, micaceous, grey.

Stratigraphy

Two samples, from depths of 500 feet and 620 feet, were submitted to Mr. B. Balme, Senior Lecturer at the University of Western Australia, for palynological examination. Mr. Balme's helpful co-operation is gratefully acknowledged.

A middle to Upper Triassic age is indicated for the 500 feet sample. The 620 feet sample can be correlated with the Upper (non-marine ?) section of the Lower Triassic Kockatea Shale. (Personal communication from Mr. Balme).

In view of its lithological character there can be no doubt that the whole succession penetrated below the Pleistocene Coastal Limestone is of Triassic age.

Age	Formation	Formation Top below ground level	Thickness
Recent	Dune sands	Surface	30 feet
Pleistocene	Coastal Limestone	30 feet.	57 feet
Middle to Upper Triassic	Siltstone and sandstone	87 feet	508 feet
Lower Triassic	Kockatea Shale	595 feet	Unknown.

Hydrology

Two aquifers were encountered in the bore hole, viz. in the 10 feet to 87 feet interval, and the 505 feet to 595 feet interval. Because of their high salinities neither of the aquifers was pump-tested, but according to the drillers' report yields were large. The water level in the completed bore stands at 6 feet below the surface.

The top aquifer derives its supply from superficial dune sands and the underlying Coastal Limestone. It will be seen from the analytical results (Appendix) that salinities within the aquifer increase extremely with depth, i.e. from 4710 p.p.m. (292 grains per gallon) at 20 feet to 27600 p.p.m. (1952 grains per gallon at 87 feet (total dissolved solids).

The second aquifer produced from a Middle to Upper Triassic sandstone interval overlying the Lower Triassic Kockatea Shale. The salinity of this aquifer is extreme, total dissolved solids amounting to 49300 p.p.m. (3451 grains per gallon).

Reasons for Discontinuing Deep Drilling.

Although the bore was originally planned to penetrate to a depth of 1,000 feet, it was abandoned at 628 feet. The decision was based on the fact that the Kockatea Shale which was intersected at about 595 feet has, from all previous experience, no potential whatsoever of yielding water of useful quality. The formation is very tight, has low permeability, and the intraformational permeable horizons are known to contain only highly saline water. This information is based on results obtained from bores in the Geraldton area, and more recently, on those from B.M.R. No.10 and No.10A stratigraphic holes at Beagle Ridge, some 35 miles north of Jurien Bay. In the latter two bores electric logging indicated highly saline water in the Kockatea Shale.

The Kockatea Shale has a thickness in excess of 1,000 feet and is underlain by sediments of Permian age, equally unsuitable as a source for domestic water.

Contribution to Geological and Hydrological Knowledge.

The exploratory deep bore has shown that Jurassic beds, containing favourable aquifers elsewhere, are absent in the coastal area to the east of Jurien Bay. The Coastal Limestone is underlain by sediments of Triassic age, including extremely saline aquifers only.

Conclusions.

As the saline Triassic horizons overlie thick, equally saline Permian formations, any further deep drilling in the search for useful water would be a venture doomed to failure. The belt of country to which this statement applies extends

from Jurien Bay in an easterly direction to the Beagle Ridge fault, approximately 6 miles inland. The only legitimate area to carry out further deep exploratory work lies to the east of the Beagle Ridge Fault, where Lower Jurassic beds can be expected to be present.

SHALLOW EXPLORATORY DRILLING AT JURIEN BAY.

Introduction

Aim.

Following abandonment of Jurien Bay No. 1 deep bore, an investigation was undertaken to test the shallow ground water potential in the vicinity of Jurien Bay townsite. The aim of the programme, consisting of a small number of shallow bores, was to establish whether or not a volume of fresher ground water, sufficiently large for the domestic requirements of the town population, was overlying the main body of saline ground water. It was also proposed to obtain by means of pump testing, information on the equilibrium conditions that exist between waters of different salinities.

Area Selected

The area selected for testing is approximately 40 chains wide, parallel to the coast, and from 20 to 60 chains distant from it. It is bounded to the east and west by low lying saline belts 3 to 5 feet above sea level. The drilling area stands about 10 feet above sea level, and has subdued topographical features. A characteristic is long beach ridges, 1 to 3 feet high, paralleling the present shore line. These persistent ridges produce a striking pattern on air photographs.

The region consists of poorly consolidated aeolianites, beach deposits, and shallow water marine sediments, with a thickness of approximately 30 feet. These accumulations were formed since the last retreat of the sea, approximately 1,500 years B.P. Underlying these poorly consolidated sands are hard Quaternary limestones. They crop out one to two miles

eastward to form a pronounced coastal ridge.

Previous information

From previous established bores and wells in the area the following hydrological conditions were known --

- (1) Near the shore line and beneath the modern fore-dunes is a thin accumulation (less than 10 feet in thickness) of water containing approximately 80 to 100 grains NaCl per gallon. Salinity appears to increase rapidly with depth. This source is utilised widely in the townsite for household use by means of hand pumps.
- (2) At distances from 10 to 20 chains from the fore-dunes and on slightly lower country water is reported to be saline (e.g. bore no. 1).
- (3) Inside the drilling area, approximately 40 chains from the shore line is the Fremantle Fishermans Co-operative bore (marked "Windmill" on Plate 1). This bore is 30 feet deep, yields water containing 70 to 90 grains NaCl per gallon (90 to 110 grains Total Solids per gallon), and is pumped by a windmill (probable pump rate of 3,000 to 4,000 gallons per day).
- (4) At a distance of 50 chains from the coast, saline marly soil with halophytes and shallow saline water accumulations occurs in low-lying land.

It would appear on this evidence that a layer of water of lower salinity occurs across the more elevated drilling area.

Drilling and Pump Testing.

Lay-out of the Programme.

The drilling programme consisted of a line of test holes at right angles to the shore line, and at 20 chain intervals, to test the east-west profile of the accumulation. Four holes (no.1A, no.2, no.2A, no.3) were sufficient for this purpose. This was followed by testing the north and south

extension of the accumulation with bores no.4 and no.5
(see Plate 1).

The results of drilling and testing are tabulated
below:

Bore Logs.

Test hole no. 1A.

Location: 100 feet west of Jurien Bay no.1 deep bore,
on the south-west corner of turn-in roadway
to Ross International Fisheries.

Date drilled: 19th February, 1962.

Total depth: 17 feet.

Status: Abandoned.

R.L. of ground surface: approximately 10 feet (\pm 3 feet) a.s.l.

Lithology	Hydrology
0-12 feet Sand. Unconsolidated pale yellow, fine to medium grained calcareous, foraminifer- al sand.	
12-17 feet Sand. Poorly consol- idated, pale yellow, fine to coarse grained, calcareous sand with foraminifera, fragmentary mollusca, bryozoa and lithoth- amnion showing original colour- ation.	12-13 feet Water first observ- ed. Salinity 80 gr./gal. NaCl. pH 8. Strong H ₂ S odour. 15 feet Salinity 200 gr./gal. NaCl. pH 7.5. Dark in colour, clearing on aeration. 17 feet Salinity 260 gr./gal. NaCl. pH 7.5. Water is dark in colour with a strong fetid odour. Colour and odour sub- dued after several days of aeration.

Test hole no. 2.

Location: 20 chains on a bearing 110° magnetic from hole
no.1 and 280 feet on a bearing of 70° magnetic
from the Fremantle Fishermans Co-operative
windmill.

Date drilled: 22nd February 1962 to 2nd March, 1962.

Total depth: 35 feet.

Status:

Abandoned.

R.L. of ground surface: approximately 10 feet(\pm 3 feet) a.s.l.

Lithology	Hydrology
<u>0-21 feet</u> Sand. Unconsolidated, pale yellow, fine to coarse grained, foraminiferal with fragmentary mollusca and bryozoa.	<u>11-12 feet</u> Water first observed.
<u>21-25 feet</u> Sand as above, with abundant coloured Phasianella and sea weed thallus in fragments 1-2 mm. in diameter and up to 1 cm. in length. Probably basal parts of Posidonia.	<u>13 feet</u> Salinity 105 gr./gal. NaCl. Clear, odourless, small supply.
<u>25-29 feet</u> Fine to medium grained sand with an abundance of small turreted gastropods.	<u>15 feet</u> Salinity 70-75 gr./gal. NaCl.
<u>29-30 feet</u> Sand. Poorly consolidated with an abundance of colourless bivalves and small gastropods. Fragments of rootlet limestone.	<u>17 feet</u> Salinity 60-65 gr./gal. NaCl. pH 7.5. Colourless, odourless.
<u>30-31 feet</u> Coquina. Calcareous cemented fragments of thick shelled reef mollusca including Ninella whitleyi, and Regozara sp.	<u>19 feet</u> Salinity 55 gr./gal. NaCl. pH 7.5. Colourless, odourless.
<u>31-35 feet</u> Limestone. Hard, grey, travertine and dark yellow, sandy limestone.	<u>21 feet</u> Salinity 75-80 gr./gal. NaCl. pH 7.5. Strong fetid odour.
	<u>23 feet</u> Salinity 70 gr./gal. NaCl. Slight odour.
	<u>25 feet</u> Salinity 75 gr./gal. NaCl. pH 8.
	<u>27 feet</u> Salinity 95 gr./gal. NaCl.
	<u>29 feet</u> Salinity 65 gr./gal. NaCl.
	<u>31 feet</u> Salinity 65 gr./gal. NaCl.
	<u>34 feet</u> Salinity 115 gr./gal. NaCl.
	The hole was cemented at the contact of the hard limestone. Supply between 31 feet and 35 feet was poor. The plant was moved to site no. 2A in order to test the surface 0 to 30 feet zone sealed by cement.

Test hole no. 2A.

Location: 7 feet north of hole no. 2.
 Date drilled: 2nd March, 1962.
 Total depth: 22.5 feet.
 Status: Abandoned.
 R.L. of ground surface: approximately 10 feet (\pm 3 feet) a.s.l.

Lithology	Hydrology
<u>0 -22 feet</u> Sand as in bore no.2.	Identical to bore no.2. For additional information see pump test data.
<u>22-22.5 feet</u> Reef limestone.	
<u>22.5 feet</u> Limestone, hard, dark yellow, sandy limestone.	

Test hole no.3.

Location: 20 chains on a bearing 110° magnetic from hole no.2.
 Date drilled: 10th March, 1962.
 Total depth: 24 feet.
 Status: Abandoned.
 R.L. of ground surface: approximately 3 to 5 feet a. s. l.

Lithology	Hydrology
<u>0-23 feet</u> Sand. Light grey, marly, fine to coarse grained, foraminiferal and carbonate concretions (thought to be a lagoon deposit in the upper part).	<u>13 feet</u> Water first observed.
	<u>14 feet</u> Salinity 260 gr./gal. NaCl.
	<u>16 feet</u> Salinity 300 gr./gal. NaCl.
	<u>18 feet</u> Salinity 320 gr./gal. NaCl.
	<u>20 feet</u> Salinity 310 gr./gal. NaCl.
<u>23-24 feet</u> Coquina. Fragments of heavy shelled marine reef fauna and fragments of hard coastal limestone.	<u>22 feet</u> Salinity 310 gr./gal. NaCl.
	<u>24 feet</u> Salinity 260 gr./gal. NaCl.

Test hole no.4.

Location: 25 chains on a bearing 20° magnetic from hole no.2.

Date Drilled: 11th March, 1962.

Total depth: 30 feet.

Status: Abandoned.

R.L. of ground surface: approximately 10 feet (\pm 3 feet) a.s.l.

Final water level below surface: 9.75 feet.

Lithology	Hydrology
<u>0-29 feet</u> Sand. Light yellow to dark yellow, fine to coarse grained, calcareous and foraminiferal quartz aeolian sands.	<u>14-15 feet</u> Water first recorded.
	<u>15 feet</u> Salinity 105 gr./gal. NaCl
	<u>17 feet</u> Salinity 105 gr./gal. NaCl fetid odour.
	<u>19 feet</u> Salinity 90 gr./gal. NaCl. fetid odour.
<u>29-30 feet</u> Coquina. Heavy shelled molluscan reef fauna such as <i>Ninella whitleyi</i> and <i>Regozara</i> sp. and fragments of coastal limestone.	<u>21 feet</u> Salinity 90 gr./gal. NaCl. fetid odour.
	<u>23 feet</u> Salinity 180 gr./gal. NaCl. fetid odour.
	<u>25 feet</u> Salinity 160 gr./gal. NaCl. fetid odour.
<u>30 feet</u> Travertine surface of coastal limestone.	<u>27 feet</u> Salinity 165 gr./gal. NaCl. fetid odour.
	<u>30 feet</u> Salinity 175 gr./gal. NaCl. High fetid odour.

Test holes nos.5 and 5A.

Location: 20 chains on a bearing 200° magnetic from hole no.2.

Date drilled: 15th March, 1962.

Total depth: 33 feet.

Status: No.5 abandoned and redrilled as no.5A. No.5A -12 feet of screen set between 18 feet and 30 feet depth. Casing set from surface to 21.5 feet.

R.L. of ground surface: approximately 10 feet (\pm 3 feet) a.s.l.

Final water level below surface: 12 feet.

Lithology	Hydrology
<u>0-13 feet</u> Sand. Grey to pale yellow, foraminiferal sand.	<u>12 feet</u> Water first observed.
<u>13-17 feet</u> Sand. Abundance of small fragments of mollusca, bryozoa, echinodermata and crustacea (pebble crab <i>Leucosia pubescens</i>).	<u>14 feet</u> Salinity 60 gr./gal. NaCl.
<u>17-19 feet</u> Sand. Mainly coarse grained.	<u>16 feet</u> Salinity 70 gr./gal. NaCl.
<u>19-20 feet</u> Sand. Light yellow, fine to medium grained foraminiferal sand.	<u>18 feet</u> Salinity 70 gr./gal. NaCl.
<u>20-27 feet</u> Sand, with abundance of algae fragments (thought to be the basal parts of <i>Posidonia</i>), woody material, fragments of thin shelled mollusca, echinodermata, crustacea and polychaeta.	<u>20 feet</u> Salinity 70 gr./gal. NaCl.
<u>27-28 feet</u> As above, with an abundance of complete, coloured gastropods (inc. <i>Phasianella</i>) <i>Dentalium</i> , <i>Pinna</i> and echinodermata. (Shell bed "in situ").	<u>22 feet</u> Salinity 120 gr./gal. NaCl. High salinity may be due to contamination by drilling waters.
<u>28-33 feet</u> Sand with abundance of hard rootlet limestone and fragments of thick shelled reef mollusca.	<u>24 feet</u> Salinity 70 gr./gal. NaCl. Fetid odour.
<u>33 feet</u> Coastal Limestone.	<u>26 feet</u> Salinity 75 gr./gal. NaCl. Fetid odour, dark colour.
	<u>28 feet</u> Salinity 80 gr./gal. NaCl. Fetid odour.
	<u>30 feet</u> Salinity 80 gr./gal. NaCl.

Results of Pump Tests.Test hole no. 2A.

Depth: 22.5 feet.
 Screen: Exposed between 18 and 21.5 feet.
 Pump: Finsbury $1\frac{1}{2}$ inch centrifugal.
 Initial pump rate: 530 gallons per hour.
 Water level before commencement of pumping: 9 feet.

Time	Drawdown in feet	Salinity (grains NaCl per gallon)
0 min.	0	
5 min.	1	
10 min.	4.7	65
15 min.	5	60
20 min.	5	55
25 min.	5	60
30 min.	5	50
45 min.	5	55
1 hour	5	50
2 hours	5	60
3 hours	5	60

A Stalker pump was inserted and pump rate increased to 800 gallons per hour. This was the maximum steady flow the bore would yield with the inlet at a depth of 20 feet.

Time	Drawdown in feet	Salinity (grains NaCl per gallon)
0 min.	0	60
15 min.	5	80
30 min.	5	50
45 min.	5	60
1 hour	5	60
2 hours	5	55
3 hours	5	60
4 hours	5	50 H ₂ S odour.
5 hours	5	55
6 hours	5	50

Test hole no.5.

Depth: 33 feet.
 Screen: Exposed between 18 and 25 feet.
 Depth of pump inlet: 24.7 feet.
 Pump: Stalker.
 Initial pump rate: 500 gallons per hour.
 Water level before commencement of pumping: 12 feet.

Time	Drawdown in feet	Salinity (grains NaCl per gallon)
0 min.	0	
10 min.	3	70
30 min.	3	70
1 hour	3	75
2 hours	3	70
<u>Pump rate increased to 1200 gallons per hour.</u>		
2 hrs.30 mins.	7	90
3 hours	8	70
4 hours	8	75
<u>Pump rate increased to 2,000 gallons per hour.</u>		
4 hrs.10 mins.	12	75
4 hrs.30 mins.	12	60
5 hrs. 0 mins.	12	60
5 hrs.30 mins.	12	-
6 hours	12	70
6 hrs.30 mins.	12	60
7 hours	12	70
8 hours	12	75
9 hours	12	70

Conclusions

The programme has proved that limited quantities of fresher water overlies the main body of saline ground water. The quality of the water is generally poor, and salinities are near the maximum permissible for domestic use. Water containing less than 70 to 80 grains of sodium chloride per gallon is unlikely to be obtained from any bore. Treatment for hardness and an unpalatable organic content will also be necessary.

Pump tests of 9 hours' duration, carried out on Test holes no. 2A and no.5, at rates near the maximum yields of the holes and with the pump placed near the base of the fresher water zone, did not produce a detectable salinity rise.

For a reliable assessment of safe pumping rates further details on salinity distribution, water table gradients, surface relief, and pumping data would be required. A very broad estimation of safe yield, based on the scant information from only five test holes, indicates that the area shown in cross-hatching in Plate 1 would yield a maximum continuous supply of approximately 16,000 gallons per day. This would probably be sufficient for the present needs of the town over the larger part of the year.

Test hole no. 5A was left cased and screened, and is ready for use.

Recommendations

The following future exploration is recommended in the area:

- (1) Testing southward from no.5 bore to prove the southerly extent of the low-salinity water encountered in no.2A and no.5 bores (see Plate 1, recommended test site no.6).
- (2) If larger supplies are required at any future time, exploration of the country between the coastal limestone and the salt flats east of the

drilling area is recommended. It is thought that supplies of better quality water may be available in this belt (See Plate 1, recommended test sites nos. 7, 8 and 9).

Future production bores within the drilling area should preferably be located between no. 2 and no. 5 bores. Bores in this area should be restricted in depth to 15-18 feet below the water table. Bores to the north of no. 2 should not be deepened beyond 8-10 feet below the water table.

As a cheap means of preliminary, shallow exploration the use of spears is recommended. This will determine the quality of the ground water, and also give some indication as to the supply. Favourable sites can subsequently be selected for the construction of producing bores.

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A P P E N D I X

Water Analyses

Complete analyses of water samples were made by the Government Chemical Laboratories for the following bores:

Jurien Bay No. 1.

Jurien Bay No. 2A.

Jurien Bay No. 4.

Jurien Bay No. 5.

The sample from No. 1 bore was collected at a depth of 600 ft., and is representative of the aquifer interval between 505 feet and 595 feet. The other samples were taken in the completed bores, at the end of the pump tests.





The results are presented below.

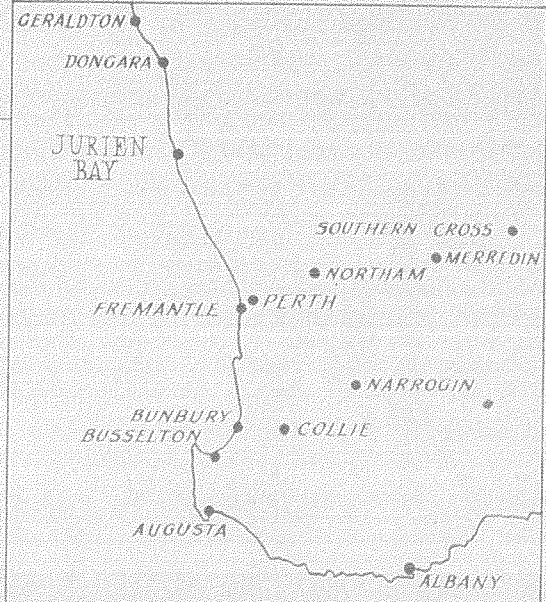
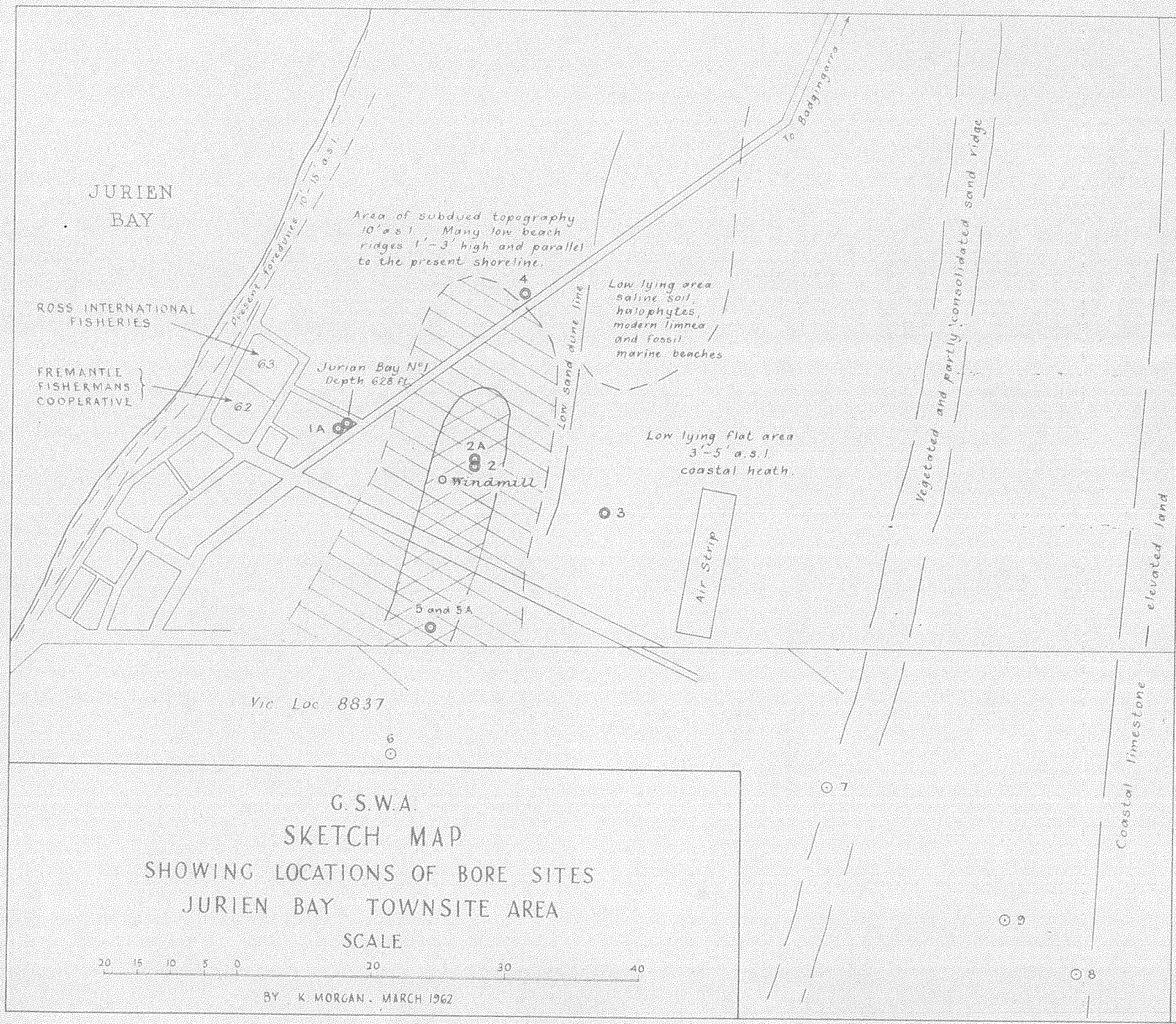
18.
Water Analyses

(mineral matter expressed in parts per million).

	Jurien Bay No. 1.	Jurien Bay No. 2A	Jurien Bay No. 4	Jurien Bay No. 5
Reaction and pH.	Neutral 6.7.	Neutral 7.7.	Neutral 7.3.	Neutral 7.6.
Calcium, Ca.	1280	57	92	50
Magnesium, Mg.	1210	76	107	88
Sodium, Na.	15400	200	677	226
Potassium, K.	570	6	24	6
Bicarbonate, HCO_3	64	427	462	438
Carbonate, CO_3	nil	nil	nil	nil
Sulphate, SO_4	3160	45	135	52
Chloride, Cl.	27700	353	1170	404
Equivalent to Sodium Chloride, NaCl.	45700	-	-	-
Nitrate, No.3.	2	2	3	4
Total (by evaporation)	49300	1166	2670	1268
Hardness Calculated as calcium carbonate				
Total hardness	8180	455	670	487
Bicarbonate (temporary) hardness	52	350	379	359
Non-carbonate (permanent hardness)	8128	105	291	128
Calcium hardness	3200	142	230	125
Magnesium hardness	4980	313	440	362

INDEX

-  Area of small unreliable supplies. Probable area where more than 10 feet of water with a salinity of less than 100 grains per gallon of Sodium Chloride will occur.
-  Area recommended for future pump sites.
-  2 Completed bore sites
-  5 Sites recommended for future tests



G.S.W.A.
HYDRO-GEOLOGICAL CROSS-SECTION DIAGRAMS
OF
JURIEN BAY TOWNSITE AREA

HORIZONTAL SCALE : 1 INCH 7 CHAINS
VERTICAL SCALE : 1 INCH 40 FEET

----- ISHALINE (Grains SODIUM CHLORIDE per gallon.)
----- TOP OF THE COASTAL LIMESTONE

