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A STUDY OF THE FREE WORLD MARKETS FOR SALT - PHASE I.

for

GEOSURVEYS OF AUSTRALIA PTY. LTD.

December 5th, 1968.

by

M. G. Roth and R. W. Hale

BATTELLE MEMORIAL INSTITUTE

I N T E R N A T I O N A L T E C H N I C A L S E R V I C E S L T D .

202 East Terrace, Adelaide, South Australia. 5000.

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INTERIM REPORT

on

PHASE I - A STUDY OF THE FREE WORLD MARKETS FOR SALT

to

INTERNATIONAL TECHNICAL SERVICES LIMITED
(Geosurveys of Australia Pty. Ltd.)

October 2, 1968

by

M. G. Roth and R. W. Hale

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INTRODUCTION

Geosurveys of Australia Pty. Ltd. is considering the exploitation of a Yorke Peninsula brine discovery in the State of South Australia. Because of other extensive developments within the salt industry, particularly in Western Australia, Battelle was asked to conduct a study on the Free World Market for Salt.

This study consists of two phases. Phase I consists of a general identification of apparent markets by virtue of current size or growth potential. Phase II would be concerned with the determination of the probable penetration that could be achieved by a new producer on the Yorke Peninsula in the selected markets.

These preliminary conclusions have been requested by the Sponsor due to the time requirements. This interim report is based on research and analysis conducted only under Phase I of the study.

PRELIMINARY CONCLUSIONS ON THE MARKET POTENTIAL FOR SALT

There has been considerable activity within Western Australia during the past two years to develop additional productive facilities for salt (NaCl). Successful operations will increase the production and supply of salt for domestic use and for export much above current levels. Since the Sponsor is anticipating the initiation of its own facilities in South Australia, there is concern about the ability of the market to absorb this great increase in supply.

While Australia's domestic consumption is expected to steadily increase, most of the new supply of salt probably will seek export markets, primarily in Japan. However, the Western Australian Government is concerned about the competition and price levels for established companies. Therefore, it is anticipated that only two or three of the six newly formed companies will be granted export licenses.

On the basis of an analysis of this increase in production and export supply of salt and the projected import requirements of Japan, it is expected that there will be a considerable excess available for export to that and other markets. While during 1969 and 1970 this surplus should not be excessive, between 1970 and 1980 much greater quantities will be involved. In addition, the potential for increased imports of salt into other countries in Asia and other nearby markets does not appear very promising. One exception may be Malaysia. While this country presently imports over 3,000 tons of salt annually from Austalia, there is a possibility of increasing the amount to 10,000-25,000 tons annually over the next few years. The only other markets that offer reasonable potentials are the United Kingdom, Canada, and Brazil. However, the shipping distances to these markets form a major deterrent.

Therefore, the feasibility of the Sponsor's establishing new production facilities in South Australia appears to hinge on the Japanese market. At this time there appears to be a reasonable chance for being able to supply that market even though large supplies are available from Western Australia. This conclusion is based on the internal competition between Japanese trading companies.

Most of the new companies in Western Australia are either joint ventures or have sales contracts with Japanese importers. Since three or four of these companies may not receive export licenses to supply the Japanese market, there appears to be an opportunity for a company in South Australia. Therefore, it is suggested that several Japanese trading firms be contacted for the purpose of determining interest in long-term contracts for the supply of salt. This should be done immediately, with emphasis on the potential lack of supply from established suppliers due to insufficient capacity and to political reasons, the competitiveness of salt shipped from South Australia with most of Japan's current suppliers, and the long-standing trade relationships between South Australia and Japan in salt.

BASES FOR CONCLUSIONS

These conclusions are based on analysis and interpretation of the following information. Although considerable detail about the activities and needs of individual countries is lacking, the available information is believed sufficient for a preliminary evaluation.

TREND OF THE AUSTRALIAN SALT INDUSTRY

While Australia's production of salt has grown over 20 percent during the past five years; in 1966 it still represented less than one percent of world production. As shown in Table 1, production of salt in Australia increased from 463,000 tons in 1960 to 644,500 tons in 1966. Imports of salt have been a minor and declining factor, with nearly all quantities originating in the United Kingdom. Exports have varied considerably from year to year, accounting for up to 20 percent of domestic production. Nearly all those shipments have been from South Australia to Japan and New Zealand, with small quantities to contiguous island economies. The inferred domestic consumption of salt in Australia has fluctuated between 1960 and 1966; however, there has been considerable growth during 1965 and 1966.

TABLE 1. AUSTRALIA SALT INDUSTRY
(Thousands of Tons)

Year	Domestic Production	Exports	Imports	Inferred Domestic Consumption
1966-1967*	644.5	93.4	6.8	557.9
1965-66	654.2	113.5	6.8	547.5
1964-65	545.5	116.6	8.0	436.8
1963-64	581.5	119.9	5.8	467.4
1962-63	536.0	74.5	7.7	468.2
1961-62	508.7	59.6	11.8	460.9
1960-61	463.3	18.3	19.4	464.4

* Fiscal year July 1, 1966 to June 30, 1967

Source: Australian Department of Trade and Industry

During the past couple of years, there has been extensive interest in a developing salt industry in Western Australia. This has progressed to the point of the government granting reserves to newly formed companies and preliminary investment in and development of productive facilities. Included in this group of companies have been the following:

(1) Shark Bay Pty., Ltd., Shark Bay, W.A., owned by Adelaide Steamship Company Ltd. (60 percent) and Garrick Agnew Pty., Ltd. (40 percent). Contracted to sell to Mitsui Dussan Kaisha, Ltd., 1.6 million tons of salt over a seven-year period; first shipments made in 1968. The company plans to produce 500,000 tons annually of salt in 1969. Located near Useless Loop in Western Australia, the company has formed evaporating ponds by enclosing the inlet and built shiploading facilities on an off-shore island.

(2) Leslie Salt Company of San Francisco, California, U.S.A. Biggest solar salt producer in the U.S.A. has contracted with Leslie Ishirjama, Inc., of San Francisco to supply the Japanese market through Tashoku, Ltd. Expects to begin exporting 475,000 tons annually in 1969 and increase this to 1,000,000 tons annually by 1975 if demand warrants. Has leased 40,000 acres of tidal salt marsh 30 miles East of Port Hedland, W. A. Seawater is to be circulated through eight ponds and brine pumped into a canal to flow 18 miles to a crystallizer pond adjoining Port Hedland Township.

(3) Dampier Salt, Ltd. Owned by Comalco Industries Pty., Ltd. (50 percent), Marubeni Iida Co. Ltd. and Nissho Co. Ltd. of Japan (32 percent combined), British Tobacco Ltd. (14 percent), and C.M.L. Society Ltd. (4 percent). To start construction on a salt plant near port of Dampier. Plans to produce 650,000 tons annually by 1970.

(4) Texada Mines, Ltd., of Texada, B.C., Canada. Agreement with W.A. government for two-year research program on the feasibility of a potash facility on Lake McLeod. To extract economical volume of potash, the company anticipates a by-product of 3,000,000 tons of salt annually.

(5) Norseman Gold Mines N.L. (51 percent) and Sumitomio Shoji Kaisha Ltd. (49 percent). A joint venture for exporting salt obtained from Lake Lefroy near Norseman to Japan through Port of Esperance. Feasibility of the project depends on construction of a railway to Esperance and lowering of the freight rate by the government of Western Australia. Company anticipates shipping 200,000 tons of salt by 1969, increasing to 500,000 tons annually over the next 5-10 years.

(6) Exmouth Salt Co., of Exmouth Gulf, Western Australia. Owned by group of individuals from Perth with interest in acquiring a Japanese equity. Anticipate getting into production for export in 1970 with goal of 1,500,000 annually in subsequent years.

These very ambitious plans would increase the total volume of salt production by 1970 nearly 400 percent over current levels. This is based on Battelle's estimates of production from current facilities and the volume expected to be forthcoming from the new facilities by 1970.

POTENTIAL SALT PRODUCTION: 1970

	Tons
Current Facilities	700,000
New Facilities	
Shark Bay Pty. Ltd.	300,000
Leslie Salt Co.	500,000
Dampier Salt, Ltd.	100,000
Texada Mines, Ltd.	500,000
Norseman Gold Mines N.L.	500,000
Exmouth Salt Co.	100,000
TOTAL PRODUCTION	2,700,000

Source: Battelle estimates; Australian Mining Journal

Assuming a normal growth in domestic consumption to an estimated 600,000-630,000 tons in 1970, a little over 2,000,000 tons would be available for export.

However, it appears the total amount of new salt production will not actually reach 2,000,000 tons. Much depends on the awarding of export licenses to the new companies. Although the W. A. Government is believed to favor foreign capital participation, and most of the new companies have either Japanese or U.S. equity, it also is very much concerned about competition in terms of total supply

and price levels and the availability of markets. It is understood that only Shark Bay, which exported 120,000 tons during 1968, Leslie Salt, and Texada have prospects of getting export licenses. And these companies' exports have been limited, along with other stringent controls, by the W. A. Government.

This reduction in new productive capacity lowers the prospective volumes considerably during the next few years. A summary of the estimated production and quantities available for export between 1968 and 1980 are shown in Table 2.

It is believed production of salt in 1968 will be approximately 870,000 tons, imports should increase to around 10,000 tons, and domestic consumption will be about 594,000 tons. This leaves approximately 286,000 tons of salt to be exported. By 1969, production is expected to jump to 1,670,000 tons, and with normal growth in consumption, the amount for export should increase to 1,068,000 tons. Production is expected to reach 3,030,000 tons by 1975, with 2,320,000 tons available for export, and in 1980 production should increase to 3,330,000 tons and 2,600,000 tons would need to be exported.

EXPORT POTENTIAL

The export markets for salt are very complex and illusive in nature. Nearly all countries produce some of their own salt. Even those that are net exporters may import varying amounts of their requirements. In some instances, countries with a considerable supply deficit also export to other countries. In other cases, some countries enjoy the advantage of being relatively near to large, fully industrialized markets and have developed long-standing trading relationships.

The primary world import markets for salt consist of the regions of North America, Europe, and Asia. The amounts of imports used by these regions and the other major regions of the world are as follows:

WORLD IMPORTS OF SALT, 1965

	Tons
Asia	3,650,000
Africa	283,000
Europe	2,950,000
South America	298,000
North and Central America	2,620,000
TOTAL	9,801,000

Source: U.S. Bureau of Mines

Based on a total world production of approximately 119,500,000 tons of salt in 1965, the 9,801,000 tons of imports represents about 8.2 percent of the total supply. With the expanding need for salt by industrialized countries and the

TABLE 2. ESTIMATED AUSTRALIAN SALT PRODUCTION
1968-1980 (Tons)

Company	Years				
	1968	1969	1970	1975	1980
I.C.I.A.N.Z.	550,000	600,000	650,000	1,000,000	1,250,000
Shark Bay	120,000	250,000	300,000	300,000	300,000
Leslie Salt	--	400,000	500,000	1,000,000	1,000,000
Texada Mines	50,000	250,000	250,000	500,000	500,000
B.H.P.-Whyalla	50,000	60,000	80,000	80,000	80,000
Others	100,000	110,000	110,000	150,000	200,000
Totals	870,000	1,670,000	1,890,000	3,030,000	3,330,000
Plus imports	10,000	10,000	10,000	10,000	10,000
Less inferred domestic consumption	594,000	612,000	630,000	720,000	740,000
Export supply	286,000	1,068,000	1,270,000	2,320,000	2,600,000

Source: ITS and BMI estimates.

growth of developing countries, the trend of world imports of salt related to total production through 1980 is estimated to be as follows:

WORLD TREND OF SALT IMPORTS
(Tons)

	Production	Exports	Percent
1965	119,500,000	9,801,000	8.2
1970	126,000,000	11,350,000	9.0
1975	146,000,000	14,600,000	10.0
1980	175,000,000	17,500,000	10.0

Source: Battelle estimates; U.S. Bureau of Mines

Australia's estimated share of world imports related to the supply available for export would be as follows:

AUSTRALIA'S SHARE OF WORLD SALT IMPORTS
(Tons)

	Total World Imports	Australia Exports	Percent
1965	9,801.000	113,500	1.2
1970	11,350,000	1,270,000	11.2
1975	14,600,000	2,320,000	16.0
1980	17,500,000	2,600,000	14.8

Source: Battelle estimates

Salt, especially industrial and rock salt, is a very low-value commodity. Consequently, there are definite limitations on the distances it can economically be transported, although there are several instances in world trade where it is shipped thousands of miles. Therefore, the existence of large industrialized countries within acceptable shipping distances of the exporting countries is of primary importance. In this respect, Australia is at a disadvantage due to its distance from the major industrial areas of Europe and North America.

Table 3 indicates Australia's exports for 1966-67 by general types of salt, destinations, quantities and approximate values per ton. Although these data may differ from those of other sources, there is general agreement, and any discrepancies are probably due to the exclusion of some minor markets.

The most significant aspects of Australia's exports are that (1) the major portions of shipments are made to Japan, New Zealand and Malaysia, and (2) the prices for large quantities of refined salt range from $A 15.00 to $A21.00 per ton, while industrial salt ranges from $A 3.40 to $A 3.90 per ton.

TABLE 3. AUSTRALIAN SALT EXPORTS
1966-67 FISCAL YEAR

Type of Salt	Destination	Tons	Approximate F.O.B. Value $A /Ton
Table salt (in packages not exceeding 14 lb. net weight)	N/A	390	64.10
Other table salt	New Zealand	1,364	14.67
	Other countries	630	15.87
Common salt, N.E.I.	Brunei	500	34.00
	Fiji	897	15.60
	Japan	78,759	3.40
	Malaysia	3,325	3.90
	New Zealand	6,569	17.65
	Other countries	711	21.10
TOTAL EXPORTS		93,145	

Source: Australian Department of Trade and Industry.

Another important factor is that well over 95 percent of Australia's exports up to 1966-67 originated from South Australia. Table 4 details the destinations, quantities, and approximate values of thos shipments. It will be noted that over 85 percent of South Australia's exports are to Japanese trading companies.

TABLE 4. SOUTH AUSTRALIAN SALT EXPORTS
1966-67 FISCAL YEAR

Destination	Tons	Approximate Value/Ton
Fiji	1,282	12.85
Gilbert & Ellice Is.	10	15.80
Japan	78,759	3.30
Malaysia	3,325	3.85
New Caledonia	13	22.15
New Hebrides	6	14.13
New Zealand	7,883	17.90
Papua/New Guinea	378	17.47
Samoa (American)	19	14.42
Tonga	42	15.09
Western Samoa	222	15.51
TOTAL	91,939	

Source: Australian Department of Trade and Industry.

It has been indicated that satisfactory buyer/seller relationships exist between South Australian companies and Japanese importers, quality of product is generally better than other sources, and the prices of the salt are competitive. Therefore, while Western Australia may offer some savings in freight to Japan over South Australia, the established and amiable relationships of the past should be of benefit to any new supplier from South Australia.

JAPANESE IMPORT POTENTIAL

Traditionally, Japan has imported between 75 and 80 percent of its salt requirements. While Japan produces domestically for both consumer and industrial goods processing, a higher proportion of its salt imports are for industrial

products. This proportion is expected to increase in the future. Table 5 summarizes the distribution of Japanese salt imports for the period 1961-65.

TABLE 5. JAPANESE IMPORTS OF SALT, 1961-65
(Thousands of Tons)

Year	Industrial	Food	Total
1961	2,600	227	2,827
1962	2,700	201	2,901
1963	2,037	334	3,371
1964	3,663	344	4,007
1965	3,417	441	3,858

Source: Australian Department of Trade and Industry, Japan Desk, International Trade Relations Division

A more detailed picture of Japan's imports for 1967 by general type and point of origin is shown in Table 6.

TABLE 6. JAPANESE IMPORTS OF SALT, 1967

Type	Source	Tons
Common salt (put up for resale)	West Germany	1
Common salt N.E.S.	Mexico	2,011,055
	Mainland China	1,083,539
	Taiwan	5,513
	Indonesia	18,891
	India	391,564
	Pakistan	95,979
	Aden	51,291
	Yemen	112,439
	Spain	34,467
	USSR	5,445
	Romania	25,823
	Turkey	7,497
	USA	481,796
	Venezuela	53,168

TABLE 6. (Continued)

Type	Source	Tons
	Chile	170,520
	Tunisia	35,875
	United Arab Republic	56,850
	Ethiopia	169,649
	Australia	74,649
TOTAL		4,886,010

Source: Japanese Trade Statistics.

While the Japanese Industrial Structure Research Council had forecast 4,350,000 tons of salt imports for 1967, the actual figure was 4,886,000. Therefore, the Council's forecasts through 1970 have been adjusted as shown in Table 7. Additional estimates have been included for 1975 and 1980.

TABLE 7. FORECASTS FOR JAPANESE SALT IMPORTS 1968-80

Year	Tons
1968	5,170,000
1969	5,440,000
1970	5,780,000
1975	6,230,000
1980	6,800,000

Source: Battelle estimates; Japanese Industrial Structure Research Council (M.I.T.I.)

Therefore, we come to a major point in the evaluation. Australia, up to now, has been exporting its excess supply of salt to Asian countries and contiguous islands. Japan, being the most industrialized country in this part of the world, has absorbed the major portion of these exports. The feasibility of initiating a new salt production unit in South Australia hinges on the demand/supply picture for Japan and other possible outlets in Asia plus any other countries

offering sufficient demand and for which South Australian producers can satisfactorily compete. An important element in this evaluation is the new supply that is expected to become available from Western Australia and other exporting areas.

Table 8 is a summary analysis of what the supply/demand relationship is projected to be through 1980 for Japan. While these figures indicate a surplus of supply, only two of the new companies are believed to have definite commitments of their production either through joint ownership or sale contracts with Japanese firms. Despite the fact that the production of these two firms along with I.C.I.A.N.Z. shipments (less domestic consumption increase) exceeds Japan's forecast requirements in 1969 by approximately 150,000 tons, with the small increase in those companies anticipated production during 1970, and possibly for the next couple of years, there will be a near parity during that period between the supply under contract and Japan's forecast requirements. In addition, the internal competition between Japanese trading companies must be considered. It is understood individual importing companies are assigned quotas by the Japanese Monopoly Corporation based on that organization's estimate of the demand requirements. Two companies, Marubeni Iida Co. Ltd. and Sumitomo Shoji Kaisha Ltd., have joint equity positions with Dampier Salt, Ltd., and Norseman Gold Mines N.L. Since it is believed neither of these companies will obtain export licenses from the W. A. Government, it is assumed these two Japanese import houses have quotas which they will be unable to fill except from either another Australian source or some other foreign source.

TABLE 8. JAPANESE SUPPLY/DEMAND FOR SALT, 1968-80
(Tons)

Year	Forecast Demand	Basic Supply (1967)	Forecast New Australian Supply*	Surplus Australian Supply
1968	5,170,000	4,886,000	320,000	36,000
1969	5,440,000	4,886,000	1,102,000	548,000
1970	5,780,000	4,886,000	1,304,000	410,000
*				
1975	6,230,000	4,886,000	2,354,000	1,010,000
1980	6,800,000	4,886,000	2,634,000	720,000

* Consider increase in domestic consumption.

Source: Battelle estimates; Japanese M.I.T.I.

Related to these deficiencies is the relative instability and lack of capacity of some of Japan's regular sources of salt supply. An example of this problem that occurred in previous years is when the stocks of Egyptian salt "ran out" after supplying 60,000 tons to the Japanese Monopoly Corporation. Similarly,

salt available from Taiwan was limited to 350,000 tons, which apparently was less than the volume originally anticipated.

Another tentative limitation to Japan fulfilling its salt requirements involves political factors. While Communist China was the second largest supplier to Japan in 1967, it is close to Japan, and its salt is very cheap, the possibility of this source of supply being cut off would be critical to Japan. In a similar vein, supplies from such countries as Aden, Yemen, and Rumania must be open to question.

On the other hand, with the development of Western Australian salt facilities, certain reaction can be expected from current suppliers to Japan. It has been indicated that Mexico, Japan's largest supplier, plans to increase its capacity. In addition, although Japanese experts have predicted Australian salt could be landed in Japan for less than from Mexico, that country can be expected to compete vigorously from the standpoint of price, since its product, although of somewhat lower quality, is essentially the same as that from Australia.

Therefore, although there appears to be an excess of supply, an opportunity may exist for additional companies to contract for export to Japan. This suggests that a potential new supplier should contact the two trading companies mentioned above and other importers also, in an effort to obtain a contract for sales. Due to the relative importance of the Japanese market, initial investment might be tied to the signing of a long-term contract to supply that market.

OTHER MARKET POTENTIALS

Because of the nebulous Japanese market potential, it is essential that Australian salt producers consider other outlets for their product. As a Japanese importing representative stated, "This business will become highly competitive and some companies will be seriously disappointed if they are depending only on the Japanese market. They could lose money."

Therefore, information has been obtained on the salt industries and consumption of most countries of the world. The usefulness of much of this information is limited, however, because of the relative value of salt and the high transportation costs. While there are isolated instances of long-distance shipping of salt, normally this involves refined salt shipped in less than bulk quantities and in packages. As a consequence, Australian producers must be primarily interested in other countries within reasonable shipping distances.

Table 9 describes the production, imports, exports, and apparent consumption of salt for selected countries that appear to offer some possibilities as markets for Australian salt. In each instance, the information on the sources of imports that is available is included.

Referring to the Asian countries, during 1964 India had the highest apparent consumption with 5,368,000 tons. However, this country is a major producer and also exported 283,000 tons during 1964. Since India imports relatively little salt and is an undeveloped economy, there seems to be little market potential for Australian salt.

TABLE 9. TRADE AND CONSUMPTION OF SALT IN SELECTED COUNTRIES
(Thousands of Metric Tons)

Country	Average Annual Production, 1964-66	Range of Imports, 1963-65	Range of Exports, 1963-65	Apparent Consumption, 1965	Sources of Imports
Asia					
Aden	75.4	--	65-70	7.5	--
Afghanistan	33.7	--	--	33.7	--
Burma	129.7	--	--	129.7	--
Cambodia	59.0 (1964)	--	--	N/A	--
Ceylon	64.7	33-40	--	118.0	All from India
Hong Kong	--	32-35	--	32.0	China (25), Thailand (3)
India	4,953.0	3.6 (1964)	195-283 (63 & 64)	5,368 (1964)	Pakistan (3.6)
Indonesia	250 (1965-66)	--	--	253.0	--
Iraq	49.0	--	--	60	--
Iran	257.0	--	2.5-3.4 (63 & 64)	225	--
Israel	47.7	--	--	55	--
Jordan	17.7	--	1.3-6.1	14	--
Korea, Republic of	482.7 (varies)	--	--	669	--
Kuwait	8.0 (1965)	1.135 (1965)	--	9.1 (1965)	Iran (.7), U.K. (.2) W. Germany (1)
Laos	3.4	4-1.0	--	3.0	Thailand (.4)
Lebanon	23.0	1.1-1.5 (63-64)	Neg.	24	Egypt (1.1) W. Germany (.3)
Malaysia (Singapore & Brunei)	--	83.1-87.5 (63-64)	--	80-85	Thailand (67.1)
Pakistan	467.7	2.0-2.6 (63-64)	--	495	--
Philippines	138.0 (varies)	--	--	225	--
Ryukyu Is.	4.3	--	--	3	--
Saudi Arabia	5.0	--	--	5	--
Syria	19.0	15.6-23.5	--	36.6	Egypt (9.0), Jordan (5.9)
Taiwan	524	--	283-399	258	--
Thailand	193	--	82-140	106	--
S. Vietnam	158	--	--	175	--
Yemen	78 (1963-66)	--	35-100	Neg.	--
Other Areas					
United Kingdom	7,034	38-180	363-405	6,655.0	W. Germany (35) Poland (10) Tunisia (60)
Canada	3,899	222.5-400.6	656.5-906.5	3,653.1	US (166.9) Mexico (172.4) Spain (31.3)
Brazil	1,089	12-250.0	.03	1,450.0	W. Germany (78.6) US (35.6) Tunisia (30.2)

Source: U.S. Bureau of Mines

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Most other countries of Asia with substantial requirements also appear to fill their needs through internal production. One exception is Ceylon which, although it produces 60,000 tons internally, also imports 30,000-40,000 tons, all of which originates in India. Another exception is Hong Kong, which must import all its salt requirements of 30,000-35,000 tons annually. Most of its imports come from Communist China and Thailand. The last exception is the area including Malaysia, Singapore and Brunei (combined in this data), which must import 83,000-87,000 tons each year. Australian producers already supply over 3,000 tons to this area, and most of the balance is imported from Thailand. However, due to the nearness of this market, the previous selling relationship, and the steady development of the area, especially Malaysia, there appears to be a possibility of exporting 10,000-25,000 additional tons annually to this area.

The only other countries that appear to offer significant exporting opportunities are quite distant. They include the United Kingdom, Canada, and Brazil. The only reasons they are included here are their quantities of imports and, for U.K. and Canada, the tariff advantages offered to Australian companies. Also in each instance, some of those countries' imports have been shipped considerable distances from Mexico, Tunisia, and Spain.

In summary, the market potential, outside of Japan, is relatively limited. While an Australian salt producer may make some penetration of those markets, most of them produce considerable internal quantities, additional sources of supply have been established, and those economies are mostly under-developed and the rate of growth is very slow.

FINAL REPORT

on

PHASE I - A STUDY OF THE FREE WORLD MARKETS FOR SALT

to

INTERNATIONAL TECHNICAL SERVICES LIMITED
(Geosurveys of Australia Pty. Ltd.)

from

BATTELLE MEMORIAL INSTITUTE
Columbus Laboratories

November 15, 1968

INTRODUCTION

Geosurveys of Australia Pty. Ltd. is considering the exploitation of a Yorke Peninsula brine discovery in the State of South Australia. Because of other extensive developments within the salt industry, particularly in Western Australia, Battelle was asked to conduct a study on the Free World Market for Salt.

This study consists of two phases. This report covers Phase I which is a general identification of apparent markets by virtue of current size or growth potentia Phase II would be concerned with the determination of the probable penetration that could be achieved by a new producer on the Yorke Peninsula in the selected markets.

CONCLUSIONS ON THE MARKET POTENTIAL FOR ADDITIONAL SALT FROM SOUTH AUSTRALIA

There has been considerable activity within Western Australia during the past two years to develop additional productive facilities for salt (NaCl). Successful operations will increase the production and supply of salt for domestic use and for export much above current levels. Since the Sponsor is anticipating the initiation of its own facilities in South Australia, there is concern about the ability of the market to absorb this great increase in supply.

While Australia's domestic consumption is expected to steadily increase, most of the new supply of salt probably will seek export markets, primarily in Japan. However, the Western Australian Government is concerned about the competition and price levels for the first newly established companies. Therefore, it is anticipated that only two or three of the six newly formed companies will be granted export licenses.

On the basis of Battelle's analysis of this increase in production and export supply of salt and the projected import requirements of Japan, it is expected that there will be a considerable excess available for export to that and other markets. While this surplus should not be excessive during 1969 and 1970, much greater quantities will be involved between 1970 and 1980. In addition, the potential for increased imports of salt into other countries in Asia and other nearby markets does not appear very promising. One exception may be Malaysia. While this country presently imports over 3,000 tons of salt annually from Australia, there is a possibility of increasing the amount to 10,000-25,000 tons annually over the next few years. The only other markets that offer reasonable potentials are the United Kingdom, Canada, and Brazil. However, the shipping distances to these markets form a major deterrent. Therefore, the feasibility of the Sponsor's establishing new production facilities in South Australia appears to hinge on the Japanese market.

Most of the new companies in Western Australia are either joint ventures or have sales contracts with Japanese importers. Since three or four of these companies may not receive export licenses to supply the Japanese market, there may be an opportunity for a company in South Australia. Therefore, it is suggested that several Japanese trading firms be contacted for the purpose of determining interest in long-term contracts for the supply of salt. This should be done immediately, pointing out the potential lack of supply from established suppliers due to insufficient capacity and to political reasons, the competitiveness of salt shipped from South Australia with most of Japan's current suppliers, and the long-standing trade relationships between South Australia and Japan in salt.

In summary, a review of the markets for salt in Asia and other selected countries, indicates that the Sponsor should initiate a capital investment program directed toward the production of salt only on the basis of firm contracts for export to Japan. In the absence of such an assured outlet for its production, the feasibility of entering the market would be extremely marginal.

TREND OF THE AUSTRALIAN SALT INDUSTRY

While Australia's production of salt has grown over 20 percent during the past five years, it still represented less than one percent of world production in 1966. As shown in Table 1, production of salt in Australia increased from 463,000 tons in 1960 to 644,500 tons in 1966. Imports of salt have been a minor and declining factor, with nearly all quantities originating in the United Kingdom. Exports have varied considerably from year to year, accounting for up to 20 percent of domestic production. Nearly all those shipments have been from South Australia to Japan and New Zealand, with small quantities to contiguous island economies. The inferred domestic consumption of salt in Australia has fluctuated between 1960 and 1966; however, there has been considerable growth during 1965 and 1966.

During the past couple of years, there has been extensive interest in a developing salt industry in Western Australia. This has progressed to the point of the government granting reserves to newly formed companies and preliminary investment in and development of productive facilities. Included in this group of companies have been the following:

(1) Shark Bay Pty., Ltd., Shark Bay, W.A., owned by Adelaide Steamship Company Ltd. (60 percent) and Garrick Agnew Pty., Ltd. (40 percent).

TABLE 1. AUSTRALIA SALT INDUSTRY
(Thousands of Tons)

Year	Domestic Production	Exports	Imports	Inferred Domestic Consumption
1966-1967*	644.5	93.4	6.8	557.9
1965-66	654.2	113.5	6.8	547.5
1964-65	545.5	116.6	8.0	436.8
1963-64	581.5	119.9	5.8	467.4
1962-63	536.0	74.5	7.7	468.2
1961-62	508.7	59.6	11.8	460.9
1960-61	463.3	18.3	19.4	464.4

* Fiscal year July 1, 1966 to June 30, 1967
Source: Australian Department of Trade and Industry

Contracted to sell to Mitsui Dussan Kaisha, Ltd., 1.6 million tons of salt over a seven-year period; first shipments made in 1968. The company plans to produce 500,000 tons annually of salt in 1969. Located near Useless Loop in Western Australia, the company has formed evaporating ponds by enclosing the inlet and has built shiploading facilities on an off-shore island.

(2) Leslie Salt Company of San Francisco, California, U.S.A. Biggest solar salt producer in the U.S.A. has contracted with Leslie Ishirjama, Inc., of San Francisco to supply the Japanese market through Tashoku, Ltd. Expects to begin exporting 475,000 tons annually in 1969 and increase this to 1,000,000 tons annually by 1975 if demand warrants. Has leased 40,000 acres of tidal salt marsh 30 miles East of Port Hedland, W.A. Seawater is to be circulated through eight ponds and brine pumped into a canal to flow 18 miles to a crystallizer pond adjoining Port Hedland Township.

(3) Dampier Salt, Ltd. Owned by Comalco Industries Pty., Ltd. (50 percent), Marubeni Iida Co. Ltd. and Nissho Co. Ltd. of Japan (32 percent combined), British Tobacco Ltd. (14 percent), and C.M.L. Society Ltd. (4 percent). To start construction on a salt plant near port of Dampier. Plans to produce 650,000 tons annually by 1970.

(4) Texada Mines, Ltd., of Texada, B.C., Canada. Agreement with W.A. government for two-year research program on the feasibility of a potash facility on Lake McLeod. To extract economical volume of potash, the company anticipates a by-product of 3,000,000 tons of salt annually.

(5) Norseman Gold Mines N.L. (51 percent) and Sumitomio Shoji Kaisha Ltd. (49 percent). A joint venture for exporting salt obtained from Lake Lefroy near Norseman to Japan through Port of Esperance. Feasibility of the project depends on construction of a railway to Esperance and lowering of the freight rate by the government of Western Australia. Company anticipates shipping 200,000 tons of salt by 1969, increasing to 500,000 tons annually over the next 5-10 years.

(6) Exmouth Salt Co., of Exmouth Gulf, Western Australia. Owned by group of individuals from Perth with interest in acquiring a Japanese equity. Anticipate getting into production for export in 1970 with goal of 1,500,000 annually in subsequent years.

These very ambitious plans would increase the total volume of salt production by 1970 nearly 400 percent over current levels. This is based on Battelle's estimates of production from current facilities and the volume expected to be forthcoming from the new facilities by 1970.

POTENTIAL AUSTRALIAN SALT PRODUCTION: 1970

	Tons
Current Facilities	700,000
New Facilities	
Shark Bay Pty. Ltd.	300,000
Leslie Salt Co.	500,000
Dampier Salt, Ltd.	100,000
Texada Mines, Ltd.	500,000
Norseman Gold Mines N.L.	500,000
Exmouth Salt Co.	100,000
TOTAL PRODUCTION	2,700,000

Source: Battelle estimates; Australian Mining Journal

Assuming a normal growth in domestic consumption to be estimated 600,000-630,000 tons in 1970, a little over 2,000,000 tons would be available for export.

However, it is possible the total amount of new salt production will not actually reach 2,000,000 tons. Much depends on the awarding of export licenses to the new companies. Although the W.A. Government is believed to favor foreign capital participation, and most of the new companies have either Japanese or U.S. equity, it also is very much concerned about competition in terms of total supply, price levels, and the availability of markets. It is understood that only Shark Bay, which has exported 120,000 tons during the first half of 1968, Leslie Salt, and Texada have prospects of getting export licenses in the future. These companies' exports have been limited in the past and they have been subjected to other stringent controls by the W.A. Government. However, the issuance of export licenses to the remaining companies should be considered as pending, but the probability of their receiving licenses and going into production is unknown. Therefore, until they actually receive their licenses or additional information is obtained, the analysis

will be limited to the three companies whose licenses seem most assured and the estimated quantitites they expect to export.

Considering the productive capacity of only three of the new companies, reduces the prospective volumes considerably during the next few years. A summary of the estimated production and quantities available for export between 1968 and 1980 are shown in Table 2.

It is believed that (a) production of salt in 1968 will be approximately 870,000 tons, (b) imports should increase to around 10,000 tons, and (c) domestic consumption will be about 594,000 tons. This leaves approximately 286,000 tons of salt to be exported. By 1969, production is expected to jump to 1,670,000 tons, and with normal growth in consumption, the amount of salt available for export should increase to 1,068,000 tons. Production is expected to reach 3,030,000 tons by 1975 with 2,320,000 tons available for export, and in 1980, production should increase to 3,330,000 tons with 2,600,000 tons for export.

These estimates and extrapolations are based on current trends and information available on the new companies' organizations, plans, and anticipated growth patterns. Comparing these data with production, consumption, and export figures of previous years, it is apparent that much larger export markets must be developed. However, as in the past, exports of the greater quantities of salt must be considered in relation to the production and exports of other countries.

AUSTRALIAN EXPORT POTENTIAL

The export markets for salt are very complex and illusive in nature. Nearly all countries produce some of their own salt. Even those that are net exporters may import varying amounts of their requirements. In some instances, countries with a considerable supply deficit also export to other countries. In other cases, some countries enjoy the advantage of being relatively near to large, fully industrialized markets and have developed long-standing trading relationships.

The primary world import markets for salt consist of the regions of North America, Europe, and Asia. The amounts of imports used by these regions and the other major regions of the world are as follows:

WORLD IMPORTS OF SALT, 1965

	Tons
Asia	3,650,000
Africa	283,000
Europe	2,950,000
South America	298,000
North and Central America	2,620,000
TOTAL	9,801,000

Source: U.S. Bureau of Mines

TABLE 2. ESTIMATED AUSTRALIAN SALT PRODUCTION
1968-1980 (Tons)

Company	Years				
	1968	1969	1970	1975	1980
I.C.I.A.N.Z.	550,000	600,000	650,000	1,000,000	1,250,000
Shark Bay	120,000	250,000	300,000	300,000	300,000
Leslie Salt	--	400,000	500,000	1,000,000	1,000,000
Texada Mines	50,000	250,000	250,000	500,000	500,000
B.H.P.-Whyalla	50,000	60,000	80,000	80,000	80,000
Others	100,000	110,000	110,000	150,000	200,000
Totals	870,000	1,670,000	1,890,000	3,030,000	3,330,000
Plus imports	10,000	10,000	10,000	10,000	10,000
Less inferred domestic consumption	594,000	612,000	630,000	720,000	740,000
Export supply	286,000	1,068,000	1,270,000	2,320,000	2,600,000

Source: ITS and BMI estimates.

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Based on a total world production of approximately 119,500,000 tons of salt in 1965, the 9,801,000 tons of imports represents about 8.2 percent of the total supply. With the expanding need for salt by industrialized countries and the growth of developing countries, the trend of world imports of salt related to total production through 1980 is estimated to be as follows:

WORLD TREND OF SALT IMPORTS
(Tons)

	Production	Imports	Percent
1965	119,500,000	9,801,000	8.2
1970	126,000,000	11,350,000	9.0
1975	146,000,000	14,600,000	10.0
1980	175,000,000	17,500,000	10.0

Source: Battelle estimates; U.S. Bureau of Mines

Australia's estimated share of world salt trade related to its supply of salt available for export would be as follows:

AUSTRALIA'S SHARE OF WORLD SALT IMPORTS
(Tons)

	Total World Imports	Australia Exports	Percent
1965	9,801,000	113,500	1.2
1970	11,350,000	1,270,000	11.2
1975	14,600,000	2,320,000	16.0
1980	17,500,000	2,600,000	14.8

Source: Battelle estimates

AUSTRALIAN SALT TRADE

Salt, especially industrial and rock salt, is a very low-value commodity. Consequently, there are definite limitations on the distances it can economically be transported, although there are several instances in world trade where it is shipped thousands of miles. Therefore, the existence of large industrialized countries within acceptable shipping distances of the exporting countries is of primary importance. In this respect, Australia is at a disadvantage due to its distance from the major industrial areas of Europe and North America.

Table 3 indicates Australia's exports for 1966-67 by general types of salt, destinations, quantities and approximate values per ton. Although these data may differ from those of other sources, there is general agreement, and any discrepancies are probably due to the exclusion of some minor markets.

The most significant aspects of Australia's exports are that (1) the major portions of shipments are made to Japan, New Zealand and Malaysia, and (2) the prices

TABLE 3. AUSTRALIAN SALT EXPORTS
1966-67 FISCAL YEAR

Type of Salt	Destination	Tons	Approximate F.O.B. Value $A /Ton
Table salt (in packages not exceeding 14 lb. net weight)	N/A	390	64.10
Other table salt	New Zealand	1,364	14.67
	Other countries	630	15.87
Common salt, N.E.I.	Brunei	500	34.00
	Fiji	897	15.60
	Japan	78,759	3.40
	Malaysia	3,325	3.90
	New Zealand	6,569	17.65
	Other countries	711	21.10
TOTAL EXPORTS		93,145	

Source: Australian Department of Trade and Industry.

for large quantities of refined salt range from $A 15.00 to $A 21.00 per ton, while industrial salt ranges from $A 3.40 to $A 3.90 per ton.

Another important factor is that well over 95 percent of Australia's exports during fiscal 1966-67 originated from South Australia. Table 4 details the destinations, quantities, and approximate values of those shipments. It will be noted that over 85 percent of South Australia's exports are to Japanese trading companies.

The data available for total Australian exports compared with those of South Australia above differ in the value per ton. Since considerably greater tonnages are shipped from South Australia, the $A3.30 per ton appears reasonable in relation to the $A 3.40 for all exports. Contracts with Japanese trading companies for larger annual and individual shipments could account for the differences in the values.

TABLE 4. SOUTH AUSTRALIAN SALT EXPORTS
1966-67 FISCAL YEAR

Destination	Tons	Approximate Value/Ton
Fiji	1,282	12.85
Gilbert & Ellice Is.	10	15.80
Japan	78,759	3.30
Malaysia	3,325	3.85
New Caledonia	13	22.15
New Hebrides	6	14.13
New Zealand	7,883	17.90
Papua/New Guinea	378	17.47
Samoa (American)	19	14.42
Tonga	42	15.09
Western Samoa	222	15.51
TOTAL	91,939	

Source: Australian Department of Trade and Industry.

It has been indicated that satisfactory buyer/seller relationships exist between South Australian companies and Japanese importers, quality of product is generally better than other sources, and the prices of the salt are competitive.

While salt shipped from South Australia has been valued at $A 3.30 per ton, the total delivered value in Japan has been in the range of $A 7.80 to $A 8.00 per ton. It is believed this includes transfer, storage, loading, and unloading costs at both the shipping and destination points. This implies a total shipping cost of approximately $A 4.50 to $A 4.70 per ton.

More recently, it has been indicated that some contracts for Australian exports to Japan have been within a range of $A 2.90 to $A 3.00 per ton. It is unlikely that transportation costs, especially shipping conference rates, have changed; therefore, the most recent delivered value of South Australian salt in Japan is believed to be approximately $A 7.40 to $A 7.70 per ton.

Other values of salt imported into Japan from other major suppliers during 1967 have been determined to be approximately as follows:

Mexico	$A 6.90
Mainland China	$A 7.20
United States	$A 8.70
India	$A 7.60

The variability in these data indicates the difficulty in estimating the future values of contracts for salt from specific sources. This is especially true when the values of contracts in 1967 for salt imported into Japan from Mexico were $A 6.90 while those from the United States were $A 8.70. While the water distance from each of those points is approximately the same, the value of salt imported from Mexico was $A 1.20 less than that imported from the United States. Much of the difference apparently is due to labor costs and, in some instances, due to different shipping conferences. However, other factors that are operative include specific contract negotiations and related circumstances such as size of contract, delivery times, and Japanese demand requirements for salt.

Although relatively little information is available on the initial and operating costs of current and potential salt exporters in Westerna Australia, the above data provide some guidance as to what to expect in terms of contracts with Japanese trading companies. Since most of the Western Australian companies are joint ventures with those trading firms, the costs and development problems are known to the Japanese companies.

It has been suggested the start-up expenses of these new companies will be somewhat higher than the Sponsor's initial costs. This is primarily due to requirements to provide housing, utilities, and other facilities at the remote locations. During the early phases of the companies operations, which would vary from 1968 to 1972 depending on the company involved, these higher costs would have to be allocated to limited production volumes resulting in higher costs per ton. In addition, some of the new companies have experienced difficulties, such as leaks in their evaporative beds, that add to initial costs and delay the initial production schedules.

However, most of these higher costs per ton for production, compared with the Sponsor's costs, would be off-set by lower shipping costs to Japan. While such costs apparently range from $A 4.50 to $A 4.70 from South Australia to Japan, based on available information, it is reasonable to expect these costs to be reduced to approximately $A 4.00 to $A 4.25 from Western Australia. However, the actual total shipping costs depend on each particular company's facilities, point of shipment, and tonnages being shipped. Similarly, the total delivered value of salt from Western Australia depends on the total production costs, total shipping costs, size of basic contracts and the time involved, and the internal accounting procedures of each company. Therefore, because of these variables, the actual export value of salt from Western Australia or the delivered value in Japan cannot be determined. Recognizing the equity positions of the Japanese trading firms in the new Western Australian facilities and the Japanese pragmatic and astute trading acumen, there is a reasonable basis for assuming the export value of Western Australian salt will be competitive with South Australian and other Japanese suppliers.

Based on this information, it is believed that the minimum delivered value of salt imported by Japan from Western Australia would fall in a range of $A 6.90 and $A 7.50 per ton. With a shipping cost ranging from $A 4.00 to $A 4.25 per ton, this would imply a minimum export value from Western Australia of from $A 2.90 to $A 3.25 per ton. To be competitive, this means the Sponsor probably would be required to establish an export value of $A 2.40 to $A 2.80 per ton during the period between 1968 and 1970.

This value range should remain firm until 1970 due to several factors. Normally, the contracts negotiated for salt by Japanese trading firms cover a period of from two to seven years. The total may vary in volume under any given contract from a few tens-of-thousands of tons of salt to over 1.5 million tons. Of course the larger volume contracts extend over the longer time periods. The large contract volumes limit suppliers of salt to Japan to Mexico and Mainland China. More recently, it has been indicated that Shark Bay Salt Pty., Ltd. has a contract with Japan for 1.6 million tons over a seven year period. However, the initial shipments by Shark Bay and the other Western Australian companies will be relatively limited. It is believed that the small quantities to be shipped under the initial contracts over the next two years will not upset the prevailing prices for salt.

The years following 1970 appear to represent a less favorable prospect. Two major factors that will be operative between 1970 and 1980 are the demand for salt by the Japanese economy and the relative supply available for import. A clue to what may occur is reflected in a recent contract for salt to be exported from Mexico. It has been indicated that under this contract the salt will be exported at a value of $A 2.10 per ton. While this is an isolated case, it suggests that with increased availability of salt the prices probably will decline.

JAPANESE IMPORT POTENTIAL

Traditionally, Japan has imported between 75 and 80 percent of its salt requirements. While Japan produces domestically for both consumer and industrial goods processing, a higher proportion of its salt imports are for industrial products. This proportion is expected to increase in the future. Table 5 summarizes the distribution of Japanese salt imports for the period 1961-65.

TABLE 5. JAPANESE IMPORTS OF SALT, 1961-65
(Thousands of Tons)

Year	Industrial	Food	Total
1961	2,600	227	2,827
1962	2,700	201	2,901
1963	2,037	334	3,371
1964	3,663	344	4,007
1965	3,417	441	3,858

Source: Australian Department of Trade and Industry, Japan Desk, International Trade Relations Division

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A more detailed picture of Japan's imports for 1967 by general type and point of origin is shown in Table 6.

TABLE 6. JAPANESE IMPORTS OF SALT, 1967

Type	Source	Tons
Common salt (put up for resale)	West Germany	1
Common salt N.E.S.	Mexico	2,011,055
	Mainland China	1,083,539
	Taiwan	5,513
	Indonesia	18,891
	India	391,564
	Pakistan	95,979
	Aden	51,291
	Yemen	112,439
	Spain	34,467
	USSR	5,445
	Rumania	25,823
	Turkey	7,497
	USA	481,796
	Venezuela	53,168
	Chile	170,520
	Tunisia	35,875
	United Arab Republic	56,850
	Ethiopia	169,649
	Australia	74,649
TOTAL		4,886,010

Source: Japanese Trade Statistics.

While the Japanese Industrial Structure Research Council had forecast 4,350,000 tons of salt imports for 1967, the actual figure was 4,886,000. Therefore, the Council's forecasts through 1970 have been adjusted as shown in Table 7. Additional estimates have been included for 1975 and 1980.

Therefore, we come to a major point in the evaluation. Australia, up to now, has been exporting its excess supply of salt to Asian countries and contiguous islands. Japan, being the most industrialized country in this part of the world, has absorbed the major portion of these exports. The feasibility of initiating a new salt production unit in South Australia hinges on the demand/supply picture for Japan and other possible outlets in Asia plus any other countries offering sufficient demand and for which South Australian producers can satisfactorily compete. An important element in this evaluation is the new supply that is expected to become available from Western Australia and other exporting areas.

TABLE 7. FORECASTS FOR JAPANESE SALT IMPORTS 1968-80

Year	Tons
1968	5,170,000
1969	5,440,000
1970	5,780,000
1975	6,230,000
1980	6,800,000

Source: Battelle estimates; Japanese Industrial Structure Research Council (M.I.T.I.)

Table 8 is a summary analysis of what the supply/demand relationship is projected to be through 1980 for Japan. While these figures indicate a surplus of supply, only two of the new companies are believed to have definite commitments of their production either through joint ownership or sale contracts with Japanese firms. Despite the fact that the production of these two firms along with I.C.I.A.N.Z. shipments (less domestic consumption increase) exceeds Japan's forecast requirements in 1969 by approximately 150,000 tons, with the small increase in those companies anticipated production during 1970, and possibly for the next couple of years, there will be a near parity during that period between the supply under contract and Japan's forecast requirements. In addition, the internal competition between Japanese trading companies must be considered. It is understood individual importing companies are assigned quotas by the Japanese Monopoly Corporation based on that organization's estimate of the demand requirements. Two companies, Marubeni Iida Co. Ltd. and Sumitomo Shoji Kaisha Ltd., have joint equity positions with Dampier Salt, Ltd., and Norseman Gold Mines N.L. Since it is believed neither of these companies will obtain export licenses from the W.A. Government, it is assumed these two Japanese import houses have quotas which they will be unable to fill except from either another Australian source or some other foreign source.

TABLE 8. JAPANESE SUPPLY/DEMAND FOR SALT, 1968-80
(Tons)

Year	Forecast Demand	Basic Supply (1967)	Forecast New Australian Supply*	Surplus Australian Supply
1968	5,170,000	4,886,000	320,000	36,000
1969	5,440,000	4,886,000	1,102,000	548,000
1970	5,780,000	4,886,000	1,304,000	410,000
*				
1975	6,230,000	4,886,000	2,354,000	1,010,000
1980	6,800,000	4,886,000	2,634,000	720,000

* Consider increase in domestic consumption.
Source: Battelle estimates; Japanese M.I.T.I.

Related to these deficiencies is the relative instability and lack of capacity of some of Japan's regular sources of salt supply. An example of this problem that occurred in previous years is when the stocks of Egyptian salt "ran out" after supplying 60,000 tons to the Japanese Monopoly Corporation. Similarly, salt available from Taiwan was limited to 350,000 tons, which apparently was less than the volume originally anticipated.

Another tentative limitation to Japan fulfilling its salt requirements involves political factors. While Communist China was the second largest supplier to Japan in 1967, it is close to Japan, and its salt is very cheap, the possibility of this source of supply being cut off would be critical to Japan. In a similar vein, supplies from such countries as Aden, Yemen, and Rumania must be open to question.

On the other hand, with the development of Western Australian salt facilities, certain reaction can be expected from current suppliers to Japan. It has been indicated that Mexico, Japan's largest supplier, plans to increase its capacity. It is believed that during the period of 1963-65 Mexico expanded its capacity at least by 1,000,000 tons. This is reflected in their growth in production from 1,225,000 tons in 1963 to 2,200,000 tons in 1965. During this period its exports increased from 1,004,000 tons to 1,601,000 tons. Subsequently, it has been indicated that the Mexican exporting firm of Exportadora de Sal (Mexican Salt Supplies) has a five year contract with the Japanese trading firm of Iwai and Company to supply 1,500,000 tons of salt annually between 1966 and 1970. This is 500,000 tons above Mexico's total exports of salt to Japan during the year 1965.

In addition, Mexico has been slowly increasing its exports to the United States. Information from The Salt Institute indicates the volume of such imports and the relatively low prices have been creating difficulties for U.S. domestic producers. As evidence of this trend, Mexico exported 332,000 tons to the U.S. in 1963, 477,000 tons in 1965, and in June of 1968, that one month's imports were 52,252 tons for an indicated annual rate of 625,000 tons.

These increases in contracts and actual exports from Mexico reflect an additional capacity of from 400,000 to 600,000 tons, at least, to handle the increase in exports. Reasonable estimates of future exports based on this trend would not preclude an expansion of capacity of up to an additional 250,000 tons between 1968 and 1970. Therefore, it is believed Mexico's salt capacity will have increased from around 1,250,000 in 1963 to 2,900,000 - 3,000,000 tons by 1970. This takes into account a steady increase in apparent consumption in Mexico from approximately 200,000 tons in 1963 to 600,000 tons in 1966 and an estimated 750,000 tons annually by 1968-1970.

With this increase in capacity, Mexico can be expected to compete vigorously, from the standpoint of price, with other suppliers to Japan. While Japanese traders have predicted Australian salt can be landed in Japan for less than from Mexico, considerable pressure will be applied on Australian suppliers to reduce their prices.

OTHER MARKET POTENTIALS

Because of the nebulous Japanese market potential, it is essential that Australian salt producers consider other outlets for their product. As a Japanese importing representative stated, "This business will become highly competitive and some companies will be seriously disappointed if they are depending only on the Japanese market. They could lose money".

Therefore, information has been obtained on the salt industries and consumption of most countries of the world. The usefulness of much of this information is limited, however, because of the relative value of salt and the high transportation costs. While there are isolated instances of long-distance shipping of salt, normally

this involves refined salt shipped in less than bulk quantities and in packages. As a consequence, Australian producers must be primarily interested in other countries within reasonable shipping distances.

Table 9 describes the production, imports, exports, and apparent consumption of salt for selected countries that appear to offer some possibilities as markets for Australian salt. In each instance, the information available on the sources of imports is included.

Referring to the Asian countries, during 1964 India had the highest apparent consumption with 5,368,000 tons. However, this country is a major producer and also exported 283,000 tons during 1964. Since India imports relatively little salt and is an undeveloped economy, there seems to be little market potential for Australian salt.

Most other countries of Asia with substantial requirements also appear to fill their needs through internal production. One exception is Ceylon which, although it produces 60,000 tons internally, also imports 30,000-40,000 tons, all of which originates in India. Another exception is Hong Kong, which must import all its salt requirements of 30,000-35,000 tons annually. Most of its imports come from Communist China and Thailand. The last exception is the area including Malaysia, Singapore and Brunei (combined in this data), which must import 83,000-87,000 tons each year. Australian producers already supply over 3,000 tons to this area, and most of the balance is imported from Thailand. However, due to the nearness of this market, the previous selling relationship, and the steady development of the area, especially Malaysia, there appears to be a possibility of exporting 10,000-25,000 additional tons annually to this area.

The only other countries that appear to offer significant exporting opportunities are quite distant. They include the United Kingdom, Canada, and Brazil. The only reasons they are included here are their quantities of imports and, for U.K. and Canada, the tariff advantages offered to Australian companies. Also in each instance, some of those countries' imports have been shipped considerable distances from Mexico, Tunisia, and Spain.

TABLE 9. TRADE AND CONSUMPTION OF SALT IN SELECTED COUNTRIES
(Thousands of Metric Tons)

Country	Average Annual Production, 1964-66	Range of Imports, 1963-65	Range of Exports, 1963-65	Apparent Consumption, 1965	Sources of Imports
Asia					
Aden	75.4	--	65-70	7.5	--
Afghanistan	33.7	--	--	33.7	--
Burma	129.7	--	--	129.7	--
Cambodia	59.0 (1964)	--	--	N/A	--
Ceylon	64.7	33-40	--	118.0	All from India
Hong Kong	--	32-35	--	32.0	China (25), Thailand (3)
India	4,953.0	3.6 (1964)	195-283 (63 & 64)	5,368 (1964)	Pakistan (3.6)
Indonesia	250 (1965-66)	--	--	253.0	--
Iraq	49.0	--	--	60	--
Iran	257.0	--	2.5-3.4 (63 & 64)	225	--
Israel	47.7	--	--	55	--
Jordan	17.7	--	1.3-6.1	14	--
Korea, Republic of	482.7 (varies)	--	--	669	--
Kuwait	8.0 (1965)	1.135 (1965)	--	9.1 (1965)	Iran (.7), U.K. (.2) W. Germany (1)
Laos	3.4	4-1.0	--	3.0	Thailand (.4)
Lebanon	23.0	1.1-1.5 (63-64)	Neg.	24	Egypt (1.1) W. Germany (.3)
Malaysia (Singapore & Brunei)	--	83.1-87.5 (63-64)	--	80-85	Thailand (67.1)
Pakistan	467.7	2.0-2.6 (63-64)	--	495	--
Philippines	138.0 (varies)	--	--	225	--
Ryukyu Is.	4.3	--	--	3	--
Saudi Arabia	5.0	--	--	5	--
Syria	19.0	15.6-23.5	--	36.6	Egypt (9.0), Jordan (5.9)
Taiwan	524	--	283-399	258	--
Thailand	193	--	82-140	106	--
S. Vietnam	158	--	--	175	--
Yemen	78 (1963-66)	--	35-100	Neg.	--
Other Areas					
United Kingdom	7,034	38-180	363-405	6,655.0	W. Germany (35) Poland (10) Tunisia (60)
Canada	3,899	222.5-400.6	656.5-906.5	3,653.1	US (166.9) Mexico (172.4) Spain (31.3)
Brazil	1,089	12-250.0	.03	1,450.0	W. Germany (78.6) US (35.6) Tunisia (30.2)

Source: U.S. Bureau of Mines

THE DETECTION OF POTASH MINERALS IN DRILLING OPERATIONS

by R. A. Laws

GEOSURVEYS OF AUSTRALIA PTY. LTD.

April 1968.

1968/3

SUMMARY

Most of the worlds potash resources occur in deeply bedded saline deposits in Germany (Permian), Saskatchewan (Middle Devonian), and the Delaware Basin of Texas and New Mexico (Permian). Potash minerals are difficult to identify by using the normal mineral identification methods of hardness, lustre, cleavage, etc. Radiation logging methods have proved valuable in identification and quantitative analysis of potash minerals within bore holes.

ORIGIN AND MODE OF OCCURRENCE OF POTASH

It has been estimated that 3.11% of the earth's crust is composed of potash, mostly concentrated in minerals which have no economic value. The most usable form is the mineral sylvite and associated minerals formed by the evaporation of sea water under complex and not fully understood conditions.

Deposition of a salt from sea water requires that the concentration be increased until the solubility product of the salt is exceeded. On a large scale in nature this can be accomplished only by evaporation in areas where restrictions to free circulation exist, and under arid conditions where evaporation exceeds precipitation plus runoff for considerable periods of time.

In a barred or silled basin, under arid conditions, a slope of the water surface develops causing a basinward surface flow of sea water due to hydrostatic pressure. At depth,oppositely directed currents flow from high to low salinity regions due to density distribution (see fig. 1); when high concentrations are developed, a strong horizontal salinity gradient exists which produces lateral segregation of different salts during precipitation. The order of precipitation of salts from sea water is listed below, together with the approximate limiting density and salinity values within which various salts precipitate from solution.

TABLE I.

Salt	Lower Limit		Upper Limit	
	Density	Salinity (parts per thousand)	Density	Salinity (parts per thousand)
Calcium Carbonate	1.0500	72	1.1264	199
Calcium Sulphate	1.1264	199	1.2015	332
Calcium sulphate & Sodium Chloride	1.2138	353	1.2570	427
Sodium Chloride	1.2778	457	1.3069	523
Magnesium Sulphate	1.2138	353	1.3069	523

Iron oxide (not shown in table) is deposited first, and the potassium salts deposited towards the close of sodium chloride deposition.

Circumstances under which only one salt (such as halite or gypsum) are deposited over wide areas and to considerable thicknesses while not being associated with less soluble salts, are not yet fully understood.

Potash bearing rocks are commonly restricted to quite thin seams within halite. Rythmic layering is common.

The largest known reserves of potash are found in the Middle Devonian Prairie Evaporites of Saskatchewan. The evaporites (predominantly halite) are up to 700 feet thick, but potash mineralisation in the form of sylvenite and carnallite, only occurs in three distinct zones within the top 300 feet. The best mining intervals contain from 22% to 28% K_2O equivalent over intervals from 11 to 16 feet thick.

In the U.S.A. the reserves are concentrated in the Texas-New Mexico Delaware Basin. The salt series is of Permian age and from 1,000 to 2,600 feet thick. Repeated sequences of clay, anhydrite, polyhalite, halite and sylvite are common. Mining is mainly concentrated on the bottom sylvite zone at Carlsbad where a bed from 5 to 12 feet thick of halite and sylvite averages 26% K_2O. The potash is mined at depths down to 1,000 feet. The best known deposits occur in the Zechstein salt series of Permian age covering an area of 77,000 square miles in north-western Germany. The beds are intensely folded and vary widely in thickness.

Mining is concentrated in areas where salt diapirs have brought the potash rich beds close to ground level. The deposits are mined by underground methods reaching to depths of 2,000 feet.

Other important potash deposits are known from the Oligocene of Alsace and northern Spain, and within the Perm basin of the U.S.S.R.

PROPERTIES OF POTASH MINERALS

The properties of potash minerals of commercial importance are summarized below (Table II). The term potash applies to the theoretical equivalent in potassium oxide (K_2O), a compound never found in nature or manufactured in commerce but generally used for comparison of potassium compounds. For agricultural purposes, as long as the potash is in soluble form, the composition of the salt is immaterial.

As the potash minerals of prime importance are those found in bedded deposits associated with other evaporites, a second Table (Table III) is given, comparing the properties of evaporite minerals. It will be noted that in the field the only way to distinguish sylvite (the most important potash mineral) from halite is by taste and hardness. Sylvite has a quicker or sharper taste and a cooling effect on the tongue. After tasting several pieces however, it is difficult to distinguish by this method. As sylvite usually occurs admixed with halite some considerable experience is necessary in determining the percentage of sylvite by taste alone. When tested with a steel probe or knife, sylvite has a softer or smoother cut, somewhat like soapstone, while halite feels hard and brittle.

TABLE III - SOME PHYSICAL PROPERTIES OF EVAPORITE MINERALS

Mineral	Hardness	Specific Gravity	Colour etc.	Crystal class	Fracture & Cleavage	Other
Sylvite	2.2	1.98	clear, white, to red, vitreous	Isometric	cubical	taste as for halite but sharper
Langbeinite	4.2	2.82	white to red, vitreous	Isometric	massive, conchoidal fracture	tasteless
Polyhalite	2.5 - 3.5	2.77	white - brick red, dull	triclinic	conchoidal fracture, distinct cleavage	tasteless
Carnallite	2.7	1.60	clear - white - redbrown, vitreous	orthorhombic	none, conchoidal fracture	sharp bitter taste
Kainite	3.0	2.13	white - dark red			usually granular
Halite	2.5	2.16	colourless - white vitreous	isometric	perfect cubic (100)	salty taste
Anhydrite	3.0 - 3.5	2.89 - 2.98	white, often with blue-red tint, pearly lustre	orthorhombic	(001) perf. (010) perf. (100) distinct	
Gypsum	1.5 - 2.0	2.3	white - colourless or stained pearly lustre	monoclinic	(010) perf. (100) distinct - poor (T11) distinct - poor	

TABLE II - PROPERTIES OF COMMERCIALLY IMPORTANT POTASH MINERALS

Mineral	Formula	Percentage K_2O	Crystal class	Hardness	S.G.	Lustre	Cleavage	Colour	Taste	Other
Sylvite	KCl	63.2	Isometric	2.2	1.98	vitreous	cubical	clear white to red	as halite but sharper	very plastic under pressure
Langbeinite	$2\ MgSO_4.K_2SO_4$	27.7	Isometric	4.2	2.82	vitreous	massive	white to red	tasteless	conchoidal fracture
Polyhalite	$K_2SO_4.MgSO_4.2CaSO_4.2H_2O$	15.6	triclinic	2.5 - 3.6	2.77	dull	distinct	white to brick red	tasteless	conchoidal fracture
Carnallite	$KCl.MgCl_2.6H_2O$	16.9	orthor-hombic	2.7	1.60	vitreous	none	clear to white to red-brown	sharp bitter	conchoidal fracture
Kainite	$MgSO_4.KCl.3H_2O$	18.9	monoclinic	3	2.13			white to dark red		usually granular
Alunite	$KAl_3(SO_4)_2$	11.4	Ditrig.	4	2.6 - 2.8		Poor (0001)	colourless grey, white, pink, etc.		hydrothermal & lake deposits
Nitre	KNO_3	46.5								cave, caliche or playa deposits
Orthoclase	$K_2OAl_2O_36SiO_2$	16.9	Monoclinic	6	2.57	Pearly, vitreous	ex.(001) good(010)	white, flesh, grey.	none	magmatic deposits
Leucite	$KAl(SiO_3)_2$	21.5	Pseudo-isometric	$5\frac{1}{2}$ to 6	2.47	vitreous to dull	none uneven fracture	white to grey	none	lava deposits conchoidal fracture
Glauconite	Fe & K hydrous silicate of variable composition			2	2.5 - 2.8	various	scaly	green & dark grey-green		shallow marine deposits
Sylvinite	Miners term for a mechanical mixture of halite and sylvite									
Hartsalz	A mixture of sylvinite and kieserite ($MgSO_4.4H_2O$)									

NOTE: The underlined minerals are formed by evaporation of brines. Sylvite is the most useable and easily available form.

THE DETECTION OF POTASH MINERALS DURING DRILLING OPERATIONS

The detection of potash bearing formations whilst drilling is in progress can only be achieved by an examination of the cuttings. To obtain cuttings from such formations, salt saturated or oil emulsion sands must be used. Alternatively air or gas may be used as the circulating fluid in favourable instances.

If a normal fresh water - bentonite mud is used, the potassium salts together with the associated halite, will dissolve and cause flocculation of the drilling mud. In this case the detection of potash salts dissolved in the drilling mud, either qualitatively or quantitatively is virtually impossible. Due to the extremely complicated nature and diverse composition of drilling fluids, the detection of potassium ions as separate from sodium ions is a difficult analytical problem. The presence of metals such as calcium, and barium (in barytes); "pipe dope" contamination etc.; the presence of a background of potassium from the impure caustic soda used and from other sources, together with many other ions present in the drilling mud, prevents any but the most complicated analytical procedures in determining an increase in potassium content. However, when it is anticipated that any water soluble minerals such as halite, sylvite etc. are to be encountered during drilling, the mud system is altered so that flocculation, gauge and sloughing problems are overcome. In these cases, cuttings are obtained and the presence of potash minerals can be detected by a careful and continuous monitoring of the returns.

THE USE OF RADIOACTIVE LOGS

Natural potassium contains 0.012% of the radioactive isotope K40, which has a half life of 1400 million years. This isotope emits intense gamma rays, making it relatively simple to distinguish potassium rich formations.

In the U.S.A. and Canada, the standard gamma ray tool, which measures the natural radioactivity of formations has been run in many of the wells drilled through the potash units primarily as a correlation tool. Most of these wells were drilled in the search for oil, and special radioactive logs specifically designed to evaluate potash rich minerals have rarely been run.

However a fair quantitative measurement can be made with the standard gamma ray tool. The radioactivity reading, corrected for bore hole effect (diameter, temperature, mud weight, etc.) is practically proportional to the K_2O content, approximately 15API units for 1% of K_2O. One difficulty is that the connecting circuit has a time lag in building up to the full value of the count. As the potash bearing beds are thin, and due to the speed with which the tool is run in most wells, only approximately 60% of true reading will be reached for a 5 foot bed, and 90% for a 10 foot bed.

If potash bearing cores are available from the well, a correlation of counts per second with the analysed potash percentage can be made, enabling other potash rich zones to be estimated accurately.

Czubek et al (1962?) have derived formulae and nomograms useful in the quantitative analysis of gamma logs for potassium. They estimate an error of about ± 10% in estimation of percentage of potash due to the following causes:

1. The statistical character of the measurements.
2. The inaccuracy of the background estimation.
3. The sensitivity of the recording milliammeter.
4. The statistical error in the estimation of the thickness from the gamma ray log.

One more important factor as mentioned before, is the speed of the tool in the hole as against the thickness of the units being measured.

The gamma-gamma, (or formation density log) is occassionally run in wells drilled in oil search. This tool measures the density of formation by bombarding the formation with gamma rays and measuring the proportion of gammas absorbed over a set distance. The ratio of gammas emitted to gammas absorbed is proportional to the density. The natural radioactivity of the formation has no influence and so the presence or absence of K40 does not influence the readings. However, knowing that K_2O is present from the gamma ray log, and knowing the evaporitic anture of the section being drilled, the formation density log can differentiate between the various evaporite minerals by density (see Table IV below). A neutron log must also be available to determine the water of crystallization. In practice the problems of bed thickness and mineral mixtures complicates the interpretation.

TABLE IV

Mineral	Equiv. % K_2O	ØN	P^B (FDL)	P^B (TRUE)
Anhydrite	0	0	2.98	2.96
Langbeinite	22.6	0	2.82	2.83
Polyhalite	15.5	15	2.79	2.78
Gypsum	0	49	2.35	2.32
Kainite	18.9	45	2.12	2.13
Halite	0	0	2.03	2.16
Sylvite	63.0	0	1.86	1.98
Carnallite	17.0	65	1.57	1.61

ϕN = Porosity derived from the neutron log
$P^B(FDL)$ = Density measured by formation density log
$P^B(TRUE)$ = True density

Carnallite rock (carnallite plus halite) having a density of from 1.60 to 2.17 g./cm^3, can also be differentiated from sylvinite having a density of from 1.98 to 2.17 g./cm.^{3} Figure 3 below illustrates this concept.

By full use of radioactive logs it should be possible to obtain fairly accurate quantitative information to distinguish between sylvite and carnallite; differentiate between clay salts and poor carnallite, and to detect some non-radioactive salts such as kieserite ($MgSO4.4H_2O$) and anhydrite.

SOME ECONOMIC CONSIDERATIONS

Whether or not a potash deposit is economically workable depends on the mutual relationship of grade, thickness, depth and extent of the deposit. As the potash minerals are the end product of highly concentrated solutions, deposits occur only in thin zones, usually layered with halite. Any workable zone so far discovered is always a combination of several thin beds of high grade potash ore, alternating with beds of low concentration, grading down to halite.

In Saskatchewan, less than 25% sylvite in the ore is economically unattractive. However in other areas mined at shallower depths, much lower grades are worked.

It has generally been found that the potash rich zones are enriched lenticular zones of potash salts in halite. Due to this lenticular nature of the commercially workable are, usually considerable drilling must often be done to define the economic limits of a deposit.

In the financial year 1964-65, 109,024 tons of potassium fertilizers were imported into Australia, having a value of $3,441,000 f.o.b. The demand for potash is increasing rapidly, the world demand doubling every 5 to 7 years.

In New Mexico natural gas is used for power and heating in refining the crude salts by fractional crystallization.

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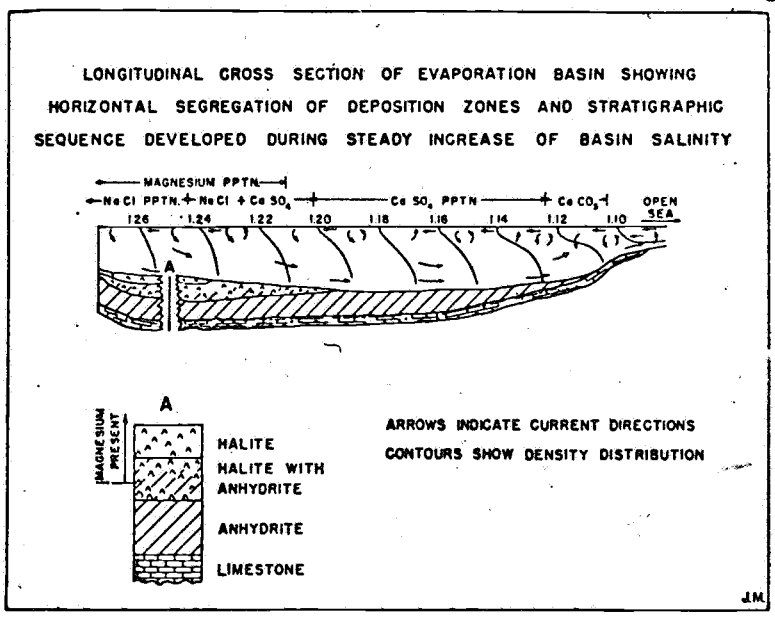


Fig 1 After Scruton (1953)

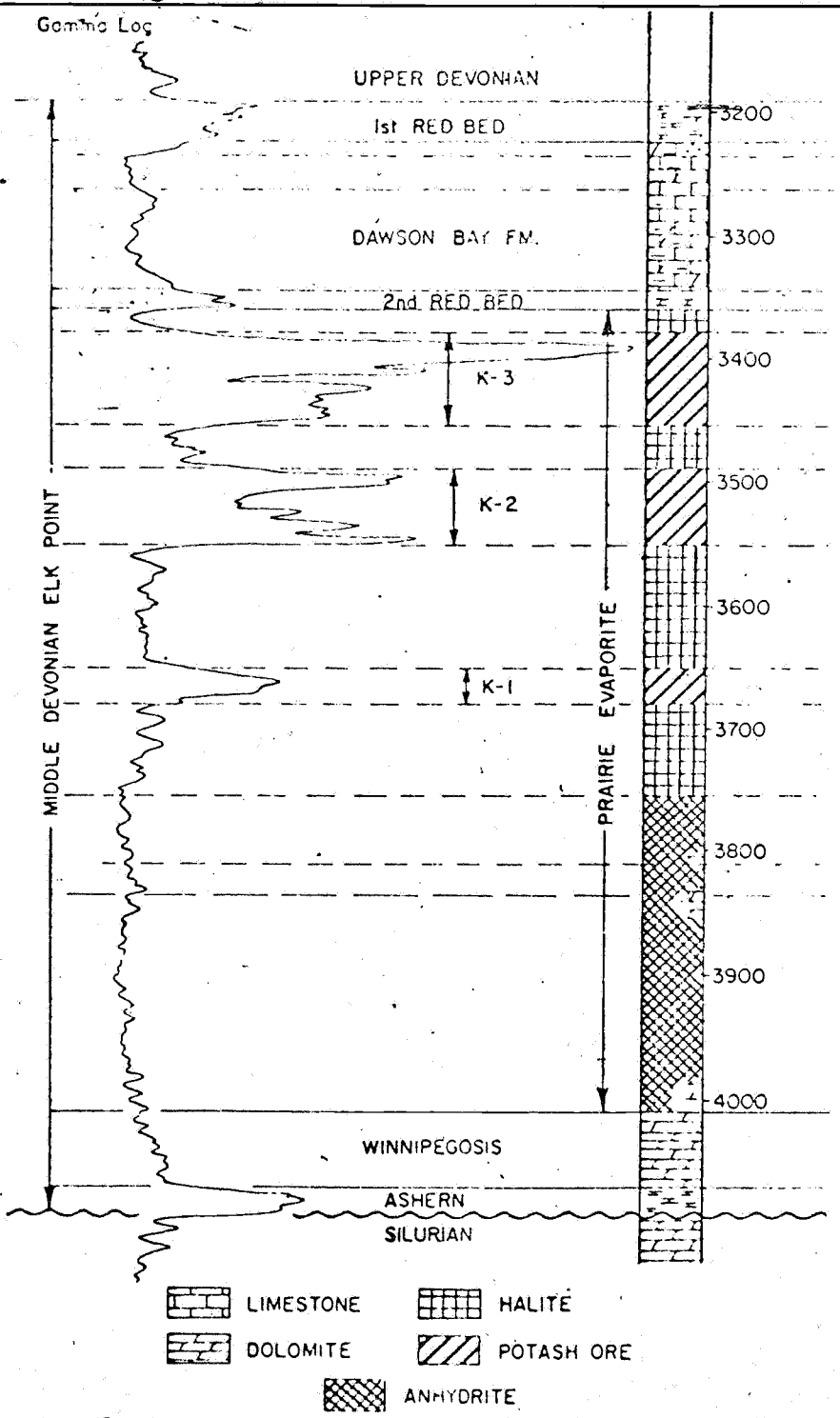


FIG. 2.—Well profile, Sohio Standard Plunkett 2, 15-20-33 25W2. (Saskatchewan) After Klingspor (1966)

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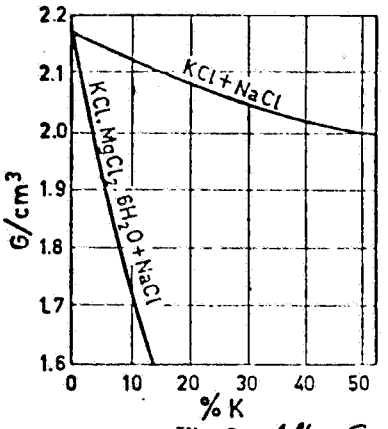


Fig. 3 After Czubek et al (1962?)

Theoretical dependence of the density of carnallite and sylvinite rocks on their potassium content

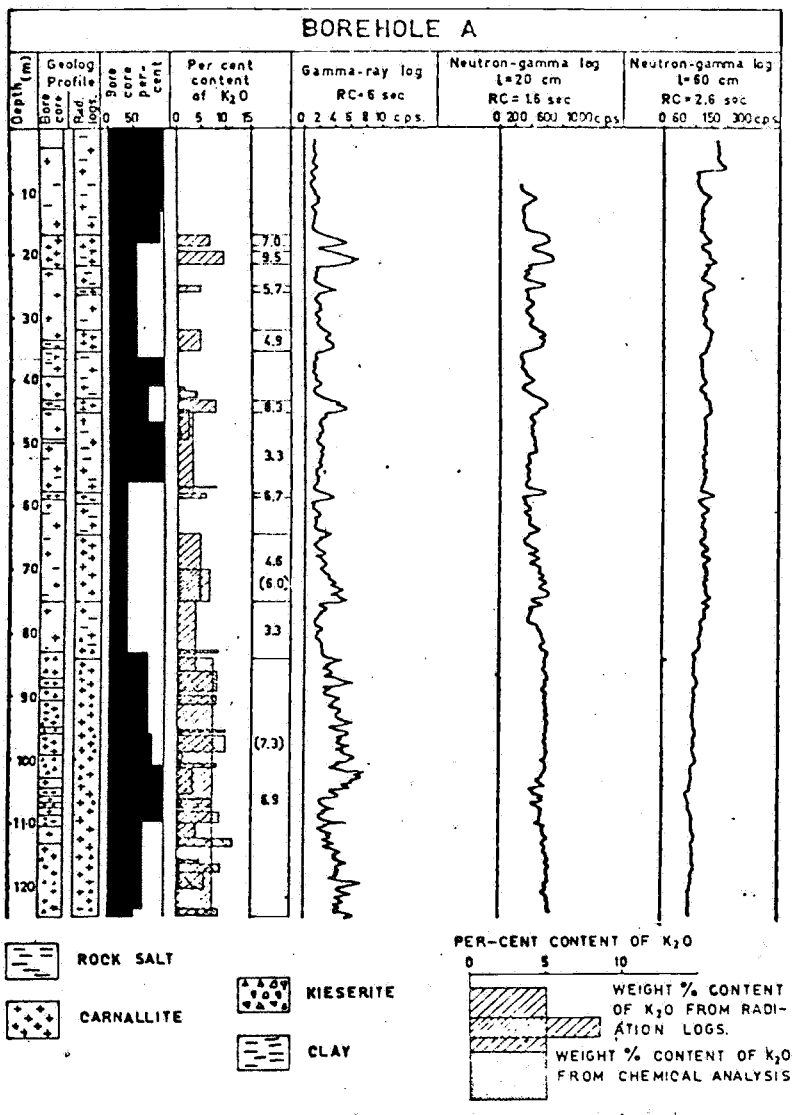
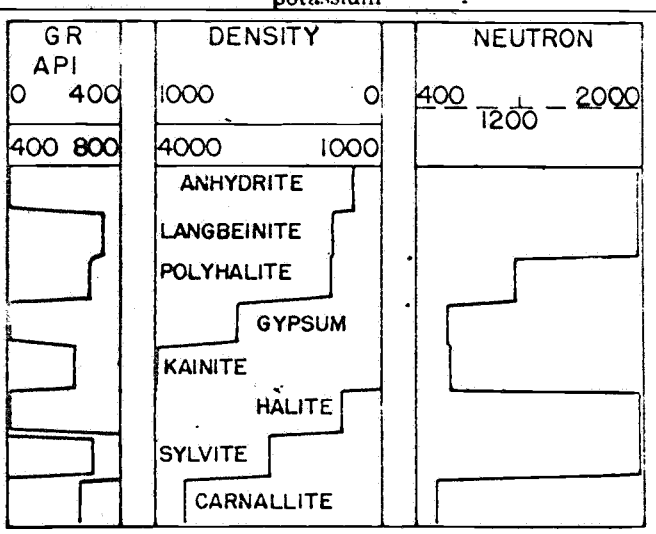


Fig. 4 After Czubek et al (1962?)

Results comparing the chemical and radiation methods of quantitative analyses of potassium

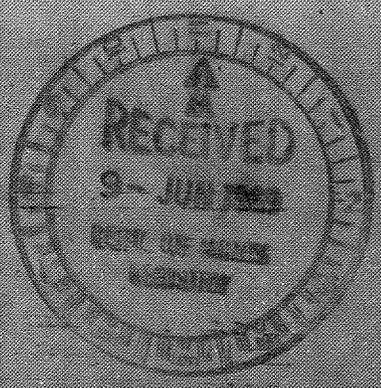


RADIOACTIVITY RESPONSES FOR EVAPORITE MINERALS (Idealised)

Fig 5. After Alger et al (1962)

BP420/2.

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Proposed Study Programme on Technical and Economic Feasibility of Establishing Salt Production based on Stansbury Brines

for

GEOSURVEYS OF AUSTRALIA PTY. LIMITED

by

INTERNATIONAL TECHNICAL SERVICES LIMITED
202 East Terrace, Adelaide, South Australia, 5000.

28th June, 1968.

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PROPOSED STUDY PROGRAMME

on the

TECHNICAL AND ECONOMIC FEASIBILITY OF ESTABLISHING SALT PRODUCTION BASED ON STANSBURY BRINES

INTRODUCTION.

During the drilling of the Stansbury No. 4 Well by Beach Petroleum N.L., a large reservoir of concentrated sodium chloride brine was intersected at depth. This occurs in a porous Kulpara Dolomite believed to cover several hundred square miles, and is greater than 1,000 feet in thickness.

Because of the indicated size and quality of the brine reservoir, Geosurveys of Australia Pty. Limited conducted a preliminary appraisal of the possibilities of exploitation. The naturally occurring impermeable clay-surfaced evaporating ponds in the immediate vicinity; the closeness to a deep sea port facility; the availability of labour close to hand ; the presence of existing power, water and road services, all favour an economic venture. Following a brief report describing these attractive features, the Board authorised a more detailed investigation of the project.

Accordingly, Geosurveys of Australia Pty. Ltd. invited International Technical Services Limited to carry out a feasibility study to evaluate the possible establishment of a Salt Industry based on this resource. The proposal which follows gives the suggested Programme of Study for phase I of this investigation.

STUDY PLAN

It is recommended that the study should be carried out in two phases to limit the sponsor's financial involvement until the degree of risk and economic attractiveness of the project become clearer.

PHASE I This will be a preliminary study of the project in sufficient detail to form a basis for broad planning decisions. All major facets will be examined, including engineering, marketing, economic and financial aspects. Limited experimentation will be necessary, but the well itself will not be opened. As a result of the study a broad plan of development will be formulated.

PHASE II This will concentrate on detailed examination of each major aspect of the project. It will provide detailed market information, provide fully detailed layout drawings sufficient for tendering purposes, recommend equipment, and suggest the best operating procedure. Pilot experimentation and well-testing programmes will be carried out.

Phase II is intended to form the basis for the actual implementation and financial commitment decisions by the Board.

If the results of Phase I are encouraging, the decision can be taken to proceed with Phase II, open the well for draw-down tests and commence pilot operations.

Some details of a possible Phase II programme are described briefly in Appendix A, but do not form part of this proposal, which is specifically for Phase I only.

It is assumed in this proposal that certain geological, surveying and other site work will be carried out separately by Geosurveys or other consultants, and that data from these investigations will be made available to the I.T.S. study team. More specifically, the following assumptions are made :-

1. The evaluation of the size and production capability of the brine reservoir, together with the well head pumping and storage tank installation design, are not included in this proposal.

2. The necessary site survey data will be made available to the study team.

3. Permeability data on the evaporating pan clays will be made available, and will be of sufficient detail and accuracy that seepage rates can be assessed. This is a fundamental design factor.

PROPOSED STUDY PROGRAMME - PHASE I

OBJECTIVES

The principal objectives of this study are as follows:-

1. To carry out a preliminary survey of world markets for salt.

2. To investigate relevant chemical engineering problems and to develop a conceptual design of the evaporating and crystallising system.

3. To examine the general engineering work required to produce sketch plans and estimates of cost.

4. To carry out an economic analysis to assess the profitability, size and development stages that might be recommended.

These objectives are more fully discussed under their respective headings below.

1. Market Survey

Considerable development of salt production is taking place in this country, and some six or seven major projects

costing over $36 million have been announced, or are under construction. All of these producers are looking to the Japanese market, where about 4.5 million tons of salt per year is being imported. However, the planned capacity of these ventures will approach 6 million tons, and a situation of serious over-supply seems likely to develop. Because of this, some curtailment of these ventures was recently recommended by the West Australian Government.

This market situation could result in considerable price cutting, and calls for a broader market base than the sole Japanese market. The close look at the world supply-demand situation for salt is therefore necessary so that a price expectation through to the year 1980 can be evaluated.

The market study will include the following steps :-

(i) A search of available data on salt importing countries will be made including sources such as the U.S. Bureau of Mines, the U.S. Agency for International Development, the United Nations, and various departments of Trade and Commerce in the U.S.A., Canada, Europe and Japan. This will be done by letter contact and confined mainly to those countries which are importers of salt.

(ii) Identify those markets which, by virtue of their present size or growth potential, appear capable of supporting large volume shipments from South Australia. Annual consumption in excess of 100,000 tons appears most likely to yield market penetrations resulting in yearly deliveries of 10,000-25,000 tons, and this will be adopted as a preliminary criterion.

(iii) Promising importing countries will be classified by broad geographical areas relating to shipping distance from South Australia and other major salt exporting nations.

(iv) These data will be examined for consumption patterns by end-use categories for preliminary evaluation of purity levels required.

(v) Transportation requirements and an indicative price pattern through to the year 1980, both for crude and refined salt, will be evaluated.

(vi) The most favourable markets will be selected for detailed further investigation in Phase II of the study.

The Phase I market survey is intended primarily to be a "paper" study based on documentation which is readily available. By contrast, a Phase II market survey, if carried out would be essentially a field study involving personal contacts in importing countries.

2. Chemical Engineering

In normal sea water evaporation, the limit to the recovery of salt which can be achieved is set by the presence of magnesium chloride. As evaporation proceeds the amount of magnesium appearing in the crystalline salt product is quite low until approximately 70% of the salt is recovered. Beyond this point the magnesium content of the product increases sharply and determines the yield of salt which can be achieved for a given magnesium content. The Stansbury brines contain less magnesium in proportion than sea water but considerably more calcium chloride. No published data is available to indicate what effect this will have. The only way in which the yield can be determined is by experiment, but this need not involve either a long or an expensive programme.

For a given specification of purity of the salt, the evaporating and crystallising cycles can be produced. From this information, together with seepage loss and evaporation rate calculations, the necessary design criteria can be developed.

The procedure for Phase I of the Chemical Engineering studies will be as follows :-

2.1 Laboratory Work:

(i) An experimental quantity of synthesized brine will be prepared based on available analyses of previous brine samples.

(ii) The salt point, i.e. the point at which salt begins to crystallise, will be determined. This is one of the factors used to establish the areas of concentrating pans in which the unwanted brine constituents will be removed prior to salt deposition.

(iii) The end point, i.e. the point at which crystallization must be stopped to produce salt of the required quality, will be found. This will be required in order to fix the yield of salt, the area of crystallizing pans and the composition of the bittern.

The data obtained from this work is an essential prerequisite to design the evaporating and crystallizing system.

2.2 Collection and Analysis of Meteorological Data :

Data on rainfall, on evaporation rates and on wind direction and velocity throughout the year will be required. In addition, the probable incidence of dust, particularly in late summer, is important.

Information from weather recording stations on Yorke Peninsula and, to a lesser extent, from Eyre Peninsula and the Adelaide area will be collected, collated and extrapolated where required to provide the basic data for the proposed site. The nature of the terrain in the area will be examined to establish the likelihood of any anomalous local effects. Finally, the data will be used to establish as closely as possible :

(i) The rainfall for each month of the year, both in terms of the long-term average and of the variability which can be expected.

(ii) The gross and net evaporation, expressed similarly.

(iii) The probability of dust presenting problems in the operation.

2.3 Conceptual Design :

Using the information available from 2.1 and 2.2, the areas and preferred configuration of the evaporating, crystallizing and service sections will be established.

The operating sequence of the individual process units will be established, and the output of both harvested salt and bittern determined for average seasons. Estimates of the variability in the pattern within seasons and between seasons will be made.

3. General Engineering

It is considered that the preliminary design and estimation of the engineering works as required for Phase I of the study would encompass the following aspects.

3.1 Primary Works.

(a) Evaporating System

Investigation of most economic layout of concentrator basins, crystallizers and bittern ponds.

Preliminary design and sketches of civil works required for the banks, basins and ponds of the evaporating system.

(b) Conduits, pipelines, etc.

Layout and preliminary design of the liquid handling facilities.

Sketch design of sluices, valves and metering devices.

(c) Pumping (excluding well-head pumping)

Estimation of pumping requirements, if this is in fact found to be necessary.

Preliminary selection of pumps and sketch design of pump houses.

(d) Roads and Fences

Layout and preliminary design of service roads and location of fences.

Primary Works (Contd.)

(e) Services

Sketch design of electricity and water supply service runs.

3.2 Harvesting Facilities

(a) Salt transportation

Investigation and sketch design of salt transport system from crystallizer pans to storage areas.

e.g. Rail system including small robust trucks and portable track for laying on pans.

(b) Storage and Handling

Selection of stockpile area. Preliminary design of handling equipment. Selection of washing area if necessary, and sketch design of facilities.

(c) Buildings

Sketch design of buildings required for general office, weighbridge, amenities and toilet accommodation.

3.3 Outloading

(a) Examination of existing ship loading facilities at Port Giles.

(b) Sketch design of modifications and/or extensions to the present facilities.

(c) Preliminary design of ancilliary buildings (if required).

(d) Sketch design of buffer storage and handling facilities.

3.4Estimates

Cost estimates for all the above works would be carried out progressively with the sketch designs.

3.5 Vital Aspects

There are a number of engineering matters which are vital to the technical feasibility and economic success of this project, and these will have to be given careful consideration during the preliminary studies :-

(a) Investigation of the relative economics of alternative arrangements of concentrators, crystallizers, washers and bittern ponds. This involves examination of costs of conduits, pipelines, roads and banks.

(b) The location of storages and handling facilities in relation to crystallizer ponds.

(c) Prevention of water movement through and below the banks enclosing the pans.

This could involve a thorough investigation of alternate types of cut-offs for use in the banks. (e.g. clay cores, concrete wells, plastic sheeting).

(d) Minimisation of the cost of bank construction. This involves studies of -

(1) types of construction.
(2) overall layout of the ponds,in order to minimise total length of banks.
(3) methods of construction.

(e) Other matters to be looked at very carefully include -

(1) Stabilisation of the banks against the action of small waves in the region of the liquid surface level.

(2) Corrosion of materials used in construction of all works.

4. Economic Analysis

The economic analysis will incorporate the following items :-

(a) A transportation investigation for the delivery of salt from the storage areas near the ponds to the loading facility at Port Giles. (This aspect has an obvious interdependence with the General Engineering work outlined above).

(b) An analysis of data obtained from the market study to determine product quality and other factors bearing directly on the technological design criteria as indicated above.

(c) Estimates of capital and operating costs will be prepared.

(d) Recommendations on the stages of development of the venture will be made, taking into account the markets, developmental costs and cash flow. A discounted cash flow analysis will be done to reveal the prospective rates of return during each major developmental stage of the project.

(e) The cash flow results will be tested for sensitivity to factors likely to influence the rate of return. In this way the more risky aspects of the project will be identified.

REPORTING

A fully detailed final written reportwill be submitted to the sponsor at the conclusion of the study. The document will contain our findings and recommendations, and will list all relevant data which is discovered.

Although it is not anticipated that regular progress reports will be needed, close liaison with the sponsor will be maintained and conferences called when and if appropriate.

TIME AND COST ESTIMATES

It is anticipated that the study can be commenced within four weeks of the acceptance of this proposal. The overseas market studies, chemical engineering work, and general engineering investigations will require careful co-ordination in view of the close interdependence if the overall time is to be kept to a minimum. It is expected that 4-5 months will be required to complete this study. The estimated total cost for Phase I will be $23,500. This figure includes all of the work outlined in this proposal as well as travelling expenses and production of the final written report. The method of settlement proposed is four equal monthly progress payments of $5,000 with the outstanding balance payable in full upon receipt by the sponsor of the final written report. Terms will be nett cash seven days from date of invoice.

TEAM CAPABILITY

For this study I.T.S. will be assisted and supported by the extensive technical and economic resources of the Battelle Memorial Institute of the U.S.A. for the market study; the Australian Mineral Development Laboratories for chemical engineering know-how; and the engineering skills of Kinnaird, Hill, deRohan and Young. I.T.S. will coordinate the various sections of the study and also actively contribute to the market and economic assessments.

All organisations are well experienced to carry out their respective parts of the study, and descriptions of their capabilities are appended. Résumés of the staff members who will be involved in the study are also included.

VALIDITY

This proposal will remain valid for a period of three months from the date it is received by the sponsor, and thereafter will be subject to confirmation by International Technical Services Limited.

CONFIDENCE

The sponsor's name will not be revealed to anyone outside those immediately involved with the project. No findings will be divulged in any way without the sponsor's permission in writing. All data collected, experimental results and final written report become the property of the sponsor.

For and on behalf of INTERNATIONAL TECHNICAL SERVICES LIMITED

R. H. Hannaford
General Manager

APPENDIX A

OUTLINE OF PHASE II PROGRAMME

APPENDIX A

OUTLINE OF PHASE II PROGRAMME

The following is a brief summary of a Phase II study to produce more reliable and accurate information than will be obtainable from the Phase I programme.

1. MARKET STUDY

This phase will be concerned with determination of the probable penetration that could be achieved by Yorke Peninsula salt from a new producer in the selected markets. It will involve considerations such as :

(a) Current and projected demand (to 1980) by grades.

(b) Specifications (chemical, physical, and packaging) for various grades.

(c) Number of consumers or primary outlets for various grades and approximate annual consumption of major consumers.

(d) Current and projected supply, both domestic and imported, and estimated prices.

(e) Internal marketing methods and import channels, including import procedures and restrictions.

(f) Transportation costs from South Australia and important current supplying countries, usual routing.

(g) Accepted commercial arrangements regarding credit, discounts, contracts, and exchange currency.

Evolution of the current situation (1966/67 fiscal year or 1967 calendar year basis) will be based on historical data for the past five years and projections will be made for 1970, 1975 and 1980.

The resulting analysis will interpret demand and supply trends, indicate the marketing strategies appropriate for a new supplier, and forecast the sales

potential (by quantity and value) for Yorke Peninsula salt, establish firm sales targets to 1980.

2. GEOLOGICAL ASPECTS

The list of steps shown below should be taken in Phase II. The list is not exhaustive and the sponsor may wish to add to it.

(a) Set up a small meteorological station on site, perhaps by furnishing the necessary equipment to a local resident and pay a small remuneration.

(b) Open the well, set up experimental pumps, obtain a quantity of brine for further tests.

(c) Carry out adequate draw-down tests to assess the recovery performance of the well, maximum pumping rate and pumping horsepower.

3. CHEMICAL ENGINEERING

(a) Commence pilot operations using a small nearby pond which can be divided into miniature evaporation and crystallizing pans using the embankment techniques suggested in the Phase I study.

(b) Carry out a programme of site tests to determine nett evaporation, the salt point, the end point, seepage rates, inter-pond leakage rates, effect of dust and product quality.

(c) Test methods of bittern disposal.

(d) Finalise figures on the pan areas required.

(e) Formulate a tentative operating procedure and programme for obtaining production control data.

4. GENERAL ENGINEERING

(a) Prepare final pan layouts using the more accurate figures on evaporation areas required.

(b) Produce final drawings suitable for tendering purposes.

(c) Prepare draft equipment and installation specifications for calling tenders.

(d) Prepare up-to-date capital cost estimates.

5. ECONOMIC ANALYSIS

The analysis carried out in Phase I would be repeated, using the more accurate technical and economic data obtained from the Phase II investigations.

APPENDIX B

I.T.S. PROJECT PERSONNEL AND EXPERIENCE

APPENDIX B

I.T.S. PROJECT PERSONNEL AND EXPERIENCE

International Technical Services Limited is a not-for-profit contract research company formed last year to provide technical-economic consulting services to industry. We are sponsored and supported by three wellknown organisations:-

The Battelle Memorial Institute
The Australian Mineral Industries Research Association (Amira)
The Australian Mineral Development Laboratories (Amdel)

Amdel's laboratories, and their staff of over 200 scientists and technicians are located here in Adelaide. The Battelle Memorial Institute of Columbus, Ohio, is the largest contract research organisation in the world with over 7,000 staff and major branches in Richland, Washington, Frankfurt and Geneva.

We are able to draw on the extensive technical-economic resources and know-how of these supporting institutions on a project-by-project basis to supplement our own staff of engineers and economists. I.T.S. can thus put together research teams to handle a wide assortment of investigations involving many disciplines. Our company is receiving wide acceptance in Australia and we have already completed such projects as :-

1. A market study for natural gas.
2. Two feasibility studies for mineral/metallurgical industries.
3. A technical/economic solution to a by-product disposal problem.
4. A world market study for a mineral.
5. An Australia-wide market study into mineral, metallurgical and chemical equipment contracting.
6. A market study for glass containers.
7. A major chemical fertiliser investigation.

Several projects of a similar nature are in hand at the present time.

The I.T.S. consultant who would be assigned the task of overall coordination of this project is Mr. Donald W. Saunders. He would also carry out the Australian

market study for salt and undertake the economic analysis. He would be assisted, where necessary, by our chief economist, Mr. John W. Lawler.

DONALD W. SAUNDERS

Consultant - International Technical Services Ltd.
B.A.Sc. Electrical Engineering (1961), The
University of British Columbia.

Mr. Saunders joined the staff of I.T.S. early in 1968. To date he has worked on a market study for glass containers and is now completing a technical-economic study of a waste disposal problem occurring in a major metallurgical processing plant.

Before joining I.T.S. he was the secretary of a public manufacturing company in Adelaide and, prior to this, worked for a consulting engineering practice with branches in all states. Mr. Saunders' first post-graduate appointment was at the Weapons Research Establishment working on the design, construction and installation of automatic control systems.

Mr. Saunders will shortly complete his Bachelor of Economics Degree at the University of Adelaide. He is a corporate member of the Institution of Engineers Australia.

APPENDIX C

AMDEL PROJECT PERSONNEL AND EXPERIENCE

APPENDIX C

AMDEL PROJECT PERSONNEL AND EXPERIENCE

EXPERIENCE

Production of salt by solar evaporation of sea water is a well established large-scale industry in South Australia, and both Amdel and its forebears have been closely associated with the industry.

A number of relevant projects have been carried out in recent years within Amdel, and these include :

(a) An involvement in commissioning of a large salt plant in Western Australia. An Amdel engineer worked on site during the first season and was concerned with development of operating procedures. This particular operation was beset with seepage problems and the key to the solution of these difficulties was provided by an Amdel contact with a similar operation in another country.

(b) Extensive experimental work on crystallization from brines under conditions simulating solar evaporation has been carried out. These studies have been aimed at modification of the normal operation in an effort to increase the yield of salable product.

(c) The recovery of by-products from bittern has been studied at length. This has included a number of approaches to recovery of potash by both physical and chemical methods. Recovery of magnesium has been investigated, and a completely new process for bromine recovery has been developed and patented.

(d) Studies of the use of solar energy have been carried out. These have been related principally to distillation of water, which is the basis of salt production, but regarding water rather than salt as the product.

In addition to involvement in these areas directly connected with salt manufacture, Amdel personnel are continuously involved in process evaluation studies and are well oriented in the application of chemical and chemical engineering principles to projects such as that proposed.

PERSONNEL

J. D. MELBOURNE

Mr. Melbourne graduated from the University of Adelaide with an Honours Degree in Chemical Engineering in March, 1964.

Since graduation he has been attached to the Industrial Chemistry Section of Amdel and was involved initially in development of a novel technique for calcination of limestone. He was then associated for a period with solar salt produotion, and spent a season at a Western Australian plant during its commissioning.

For the past three years he has been working principally on desalination of water and has been Leader of the Water Research Group for 1½ years. Apart from work in ion exchange and reverse osmosis, he has prepared for the South Australian Department of Mines a comprehensive review of desalination processes, including solar distillation. His publications are in the field of water desalination.

Mr. Melbourne is a Graduate Member of the Institute of Chemical Engineers (London).

W. M. WALKER

Mr. Walker graduated from Glasgow University with a B.Sc. degree in Chemical Engineering in 1959 and has recently joined Amdel.

Previous relevant experience includes three years with Babcock & Wilcox Ltd. as a Senior Research Engineer engaged on various aspects of boiling heat transfer. For the past three years he has been with I.C.I. Ltd. doing chemical plant design work.

He has co-authored a paper entitled " Sub-cooled Boiling during the flow through horizontal and vertical Heated Pipes and Annuli" presented to the Institute of Mechanical

W. M. WALKER (Contd.)

Engineers at a Boiling Heat Transfer Symposium, Manchester, England, 1965. He also co-authored a paper entitled "Flow-Induced Vibrations in Crossflow Heat Exchangers" to be published soon in "Chemical and Process Engineering".

J. D. HAYTON

Mr. Hayton graduated from the University of Western Australia with a B.Sc. in Chemistry in 1938.

For the past 10 years he has been a senior officer in the Chemistry and Industrial Chemistry Sections of Amdel and its parent organisation. He is currently assistant to the Officer in Charge of the Section. During this period he has either carried out personally, or has supervised, extensive experimental work on salt production by solar evaporation. Most of this work was sponsored by the South Australian Department of Mines and was aimed both at improving salt yield and at recovery of by-products from bittern.

R. E. WILMSHURST

Mr. Wilmshurst graduated from the University of Adelaide with a B. Tech. degree in Chemical Technology in 1959, having obtained the Associate Diploma in Industrial Chemistry of the South Australian School of Mines in 1948.

He is presently Officer in Charge of the Industrial Chemistry Section of Amdel.

Apart from supervising projects in the solar salt field, he is the inventor of a patented process for recovery of bromine as a by-product of solar salt manufacture.

Mr. Wilmshurst is an Associate Member of the Royal Australian Chemical Institute and has served both on the S.A. Branch Committee and as Branch Secretary of that body.

APPENDIX D.

THE BATTELLE MEMORIAL INSTITUTE - PROJECT PERSONNEL AND EXPERIENCE.

APPENDIX D.

THE BATTELLE MEMORIAL INSTITUTE - PROJECT PERSONNEL AND EXPERIENCE.

For more than 20 years Battelle has maintained a group of technical economists to investigate the commercial and economic problems faced by industrial managements. Staffed by technically trained personnel with extensive experience in management, this group is particularly competent in relating market and marketing data and changing technological patterns to business goals. In particular, a part of this group, now known as the Metals and Minerals Economics Division, has performed studies involving virtually all the commercial industrial minerals, both nonmetallic and metallic, with emphasis varying from local to world-wide markets. These investigations have provided the Division with broad acquaintance with industrial development trends - and concurrently industrial mineral requirements - in evolving economies as well as in the highly developed economies.

As appropriate, the Battelle group charged with primary responsibility for a study calls on the specialized experience of other Battelle groups, such as chemical processing technology, food processing technology, or transportation economics. This team approach assures a sound logical interpretation of the frequently complex interelationships affecting management decisions regarding investment in new businesses. Battelle's record of successfully completed studies in many diverse mineral commodities attests to its competence to perform this study.

It is expected that several professional persons and technical assistants would contribute to this study within the Metals and Minerals Economics Division of Battelle - Columbus. It is not proposed to list their particulars and qualifications here beyond emphasizing the wealth of experience and record of outstanding successes earned by this Division. A few representative studies, extracted from the dozens of similar research programmes already carried out are:-

1. Evaluation of titanium markets and technology.

2. Appraisal of influences on present and future markets for brass and bronze castings.

3. Projection of position of the sulphur industry world wide.

4. Determination of production costs and potential markets for producer gas and industrial hydrogen.

The Chief of the Metals and Minerals Economics Division, Mr. Raymond W. Hale, will be responsible for the overall co-ordination and supervision of the world market study from Battelle - Columbus.

APPENDIX E

KINNAIRD, HILL, deROHAN AND YOUNG
PROJECT PERSONNEL AND EXPERIENCE

APPENDIX E

KINNAIRD, HILL, deROHAN AND YOUNG PROJECT PERSONNEL AND EXPERIENCE

EXPERIENCE

Representative Projects

The following list summarises the major assignments carried out by the firm which are relevant to the fields embraced by this project. The list is not exhaustive but it has been selected to indicate the firm's capabilities in relation to this proposed study.

Augusta Salt

Engineering studies for a large solar salt field at Port Augusta, S.A., in association with Leslie Salt Company of San Francisco.

Estimated cost of project $6 million.

Flinders University of S.A.

Engineering studies for roads, services and site facilities and all design and supervision of civil engineering works.

Approximate cost $1 million.

Irrigation Projects

Planning, conceptual and detailed design, hydraulics, documentation and project administration for pumped irrigation schemes located in the Murray Valley Region of South Australia. Total area developed is in excess of eight thousand acres.

Total cost approximately $4 million.

Belconnen College of Advanced Education, Canberra, A.C.T.

Planning, design and supervision of all site works and design of all structural work associated with phase one of the development.

Approximate cost $3 million.

Land Reclamation Scheme, South Australia

Engineering studies and preliminary designs for a scheme to reclaim 1,600 acres of land and establish inland waterways in South Australia.

Estimated cost $15 million.

PERSONNEL

The team would comprise :-

Function	Staff Member
Overall Supervision	Partner in Charge
Project Management	Senior Engineer
Civil Engineering	Senior Consultant
Design and Estimates	Engineer
Drawings, Sketches	Draughtsmen

The actual staff allocated to this project will, of course, depend on commencement dates and prior commitments but the following are the principal members anticipated to be involved.

Partner in Charge	M. A. Kinnaird
Project Manager	J. G. Martin
Senior Civil Engineering Consultant	R. G. Perry
Engineer	A. L. Read
Draughtsmen	Two to be allocated as required during the study.

The total staff of Kinnaird, Hill, deRohan and Young is approximately 70 of whom about half are graduates. The modern facilities of the firm's head office in Adelaide would be used by the operating team.

The IBM 1130 computer housed in the firm's Melbourne office would be used where applicable for routine calculations and analysis of technical problems. Rapid and easy communication to and from Melbourne is available by direct telex linkage.

EXPERIENCE OF KEY PERSONNEL

J. G. Martin, B.E., A.M.I.E. Aust.
Project Manager.

Mr. Martin graduated in civil engineering in 1954 and worked for a Government instrumentality and two nationally known firms of consulting engineers before joining Kinnaird, Hill, deRohan and Young. His experience has included the co-ordination of design teams working on projects involving civil, structural, mechanical and electrical engineering.

EXPERIENCE OF KEY PERSONNEL (Contd.)

J. G. Martin (Contd)

The fields in which Mr. Martin has operated include :-

Civil Engineering
- Roads
- Drainage
- Silos

Materials Handling
- Ship Loaders
- Iron Ore
- Grain, Cement, Fertiliser

Structural Engineering
- Industrial buildings and plant
- Parking stations
- Multi storey office buildings

Feasibility studies.

Prior to his present appointment Mr. Martin held the following positions

Manager, South Australia - Crooks, Michell, Peacock and Stewart, Consulting Engineers.

Associate - P. G. Pak Poy and Associates, Consulting Engineers and Planners.

R. G. Perry, B.E., M. Eng. Sc. (Highway Engineering)
Senior Consultant.

Before joining Kinnaird, Hill, deRohan and Young, Mr. Perry had obtained wide experience in the civil engineering fields. During a number of years with the Department of Works he held positions as structural design engineer, engineer in charge of a concrete testing laboratory, design engineer, roads and aerodromes and engineer in charge of the soil testing laboratory. In 1960 he completed a Master of Engineering Science Degree in Highway Engineering at the University of New South Wales.

EXPERIENCE OF KEY PERSONNEL (Contd.)

R. G. Perry (contd)

Mr. Perry has been engaged on projects in the following fields :-

Multi storey buildings
Roads
Siteworks
Airfields
Foundations
Concrete mix design

The firm's soil engineering division is under the control of Mr. Perry.

A. L. Read, B.E., A.M. A.S.C.E.
Senior Engineer.

Since graduation Mr. Read has had seven years experience in the design and supervision of civil and structural engineering works. This has included two years with the Bechtel Corporation in U.S.A. working on civil, hydraulic and structural design associated with hydro-electric schemes.

Mr. Read has been with our firm for the last four years engaged on design, preparation of contract documents, calling tenders and supervision of major works including -

Flinders University site works
State Government Office Block, Victoria Square, Adelaide.
Irrigation Projects, Murray Valley, S.A.
Major sub-divisions, Metropolitan, Adelaide.

His main fields of activity have been -

Bulk earthworks
Roads
Drainage
Hydraulics
Services (Water, Sewer, Gas, Telephone)

038

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GEOSURVEYS OF AUSTRALIA PTY. LIMITED

PRELIMINARY REPORT

on

SALINE MINERALS

in

AUSTRALIA

by R. C. Sprigg

31-3-69

GEOSURVEYS OF AUSTRALIA PTY. LTD.

039

PRELIMINARY REPORT ON SALINE MINERALS IN AUSTRALIA.

Aspects of geological history and a present day arid climate offer Australia a big future in the exploitation of evaporite minerals. An increasingly favourable political climate for export of minerals, coupled with potential new benefits under the Research and Development Act underscore new seriousness which "Geosurveys" should direct to this field.

It is my belief that an extensive suite of saline minerals will eventually be discovered in central and western Australia. The existence of extensive evaporite basins has already been established in several regions of direct interest to Beach Petroleum and the possibilities for discovering economic accumulations in these is improving as more drilling is undertaken. By Saline Minerals I include principally:-

a. Salt and brines
b. Potash and associated minerals
c. Gypsum
d. Sedimentary (biochemical) sulphur
e. Alunite

1. KNOWN EVAPORITE BASINS

Quite apart from extensive salt, gypsum and alunite deposits occurring extensively throughout surficial Australia, petroleum exploration drilling has uncovered a number of fossil deposits that are of wider potential interest.

Briefly these are as follows:-

a. Canning - Kidson Basin W.A. (Thick salt and gypsum)
b. Woolnough Hills area W.A. (gypsum)
c. Eucla Basin S.A.-W.A. (anhydrite)
d. Amadeus Basin N.T. (Salt and gypsum)
e. Southern Yorke Peninsula S.A. (anhydrite, gypsum, and brine)
f. Boree, Q. (Thick salt beds)

and there are others. None of the foregoing deposits have yet disclosed any mineral of even remote commercial interest at this stage, but the geological implications are quite clear.

2. THE AUSTRALIAN SCENE

The following extracts from the "Industrial Review and Mining Year Book of Australia" for 1968 are informative:

Page 19: "SALT... Production Will Become A Major Industry.

Salt production by solar evaporation of seawater and by harvesting naturally occurring brines from inland salt lakes will become a major industry in W.A. during the next three years.

One solar salt producer, Shark Bay Salt Pty. Ltd., began exporting salt to Japan in large tonnages this year from a salt plant costing nearly $4 million at Useless Loop.

Another, Leslie Salt Co. of San Francisco, is well advanced with the construction of a $7 million salt plant at Port Hedland, and expects to begin exporting to Japan next year.

In addition to these projects four other companies are in various stages of preparing major salt industries which will produce salt for the export market or for use in local chemical industries.

If all six projects proceed a sum approaching $40m. could be invested in the next five years to make Western Australia one of the leading exporters of industrial salt in the world.

By the mid 1970s the total tonnage of salt exported from the State each year could exceed the present tonnage of wheat being exported.

The salt projects now under construction or in the planning or investigation stages in W.A. are:

(1) Shark Bay Pty. Ltd., owned by the Adelaide Steamship Co. Ltd., (60%) and Garrick Agnew Pty. Ltd. (40%) which has contracted to sell Mitsui & Co. 1.6 million tons of salt over seven years. The first salt was exported this year and the company plans to extend its plant to produce 500,000 tons of salt a year by 1969. Part of the Useless Loop inlet has been enclosed by earthworks to form evaporating ponds and a shiploading facility has been built at an island offshore.

(2) At Port Hedland work is in progress on a solar salt plant with ancillary facilities for the Leslie Salt Co. of San Francisco.

Leslie Salt is the biggest solar salt producer in the U.S.A. selling more than 320 salt products and derivatives produced from a plant on

the shores of San Francisco Bay. It has contracted in association with Leslie Ishiyama Inc. also of San Francisco to supply Japanese users with salt through Toshoku Ltd.

Exports are expected to begin next year at an initial rate of 475,000 tons rising to 1,000,000 tons a year when the plant is operating at full capacity. If the demand is sufficient the plant may be expanded to produce 2,000,000 tons a year by 1975.

The company has leased 40,000 acres of previously useless tidal salt marsh from the West Australian government for the project about 30 miles east of Port Hedland. Eight 2000 acre evaporating ponds have been formed. Seawater will be pumped into the No. 1 pond and allowed to circulate in succession through the ponds to the No. 8 pond, by which time the salt content will have risen from 3½ percent to 25 percent. The brine will be pumped into a canal to flow 18 miles to a crystalliser pond on a tidal salt marsh adjoining Port Hedland township.

(3) Dampier Salt Ltd., owned by aluminium producer Comalco Industries Pty. Ltd. (50%) Marubeni Iida Co. Ltd. and Nissho Co. Ltd. of Japan (32% between them) British Tobacco Ltd. (14%) and the C.M.L. Society Ltd. 4%.

The company plans to start construction immediately on a salt plant on tidal swamps adjoining the port at Dampier. It aims to produce 650,000 tons of salt annually by 1970. It has leased 28,600 acres of salt flats behind Dampier and has an option to lease another 9000 acres.

(4) Texada Mines Ltd. of Texada B.C. Canada, reached agreement with the West Australian government in February to undertake a two year research programme studying the possibility of establishing a potash extraction industry on Lake McLeod, an 800 square mile salt lake north of Carnarvon.

The company, which has developed a potash extraction process in Peru, estimates that it will have to harvest 3,000,000 tons of salt a year to extract a desired minimum of 200,000 tons of potash a year.

It may also produce magnesium bromide, boron and other chemicals from the salt brines. It has undertaken to invest at least $300,000 in establishing a pilot plant for research during the proving phase.

If the project is feasible it will spend at least $13,000,000 on plant and construction including a loading wharf at a point to be determined, dredging if necessary and 150 houses for employees at Carnarvon.

(5) Norseman Gold Mines N.L. has reached agreement with Sumitomo Shoji Kaisha Ltd. on a joint venture to investigate the possibility of harvesting salt from Lake Lefroy near Norseman on the Eastern Goldfields for export to Japan through Esperance. (The Kambalda nickel strike is on the western shore of Lake Lefroy.)

Norseman Gold Mines, which is to hold a 51 percent interest in the venture, has been granted a 300-square mile reserve over the lake. The success of the project will be governed by transport costs because the salt must be railed from Lake Lefroy to Esperance, a distance of 170 miles.

(6) Exmouth Salt Co. owned by a group of Perth people including the wives of consulting engineers L. Halpern, L. Glick and J.G. Lewis is planning to develop a salt field at Exmouth Gulf with an eventual capacity to produce 1.5 million tons of salt a year. A Japanese equity is planned in the project."

On p. 174. The reviewer discussed Salt production at Pt. Alma in Queensland. Here underground brines (which I understand are about 7% Nacl) are to be pumped from 140 feet depth and flowed nine miles to 450 acres of crystallizing pond. Production eventually is expected to rise to 450,000 tons per annum.

a. <u>Profit Potential</u>

A marketing report has now been obtained from the Department of Trade and Industry reference "Export of Crude Solar Salt".

Prices negotiated vary greatly.

e.g. Singapore $A 10.50 per ton

Canada $A 15.00 per short ton.
(Note Australian Salt is imported duty free into Canada whereas 3 cent tariff is levied on salt from U.S. A. & Mexico)

Japan - imports about 3 million metric tons annually, rising. The average price paid is $A 8.75. High quality (96% Nacl) Salt averaged $A 9.90 M/T c.i.f. It is noted here that Australian salt is favoured as being particularly reliable in quality.

Australian exports for 1966/7 were as follows.

N.S.W.	259	tons (long)	$ 15,857
	649	"	25,061
	65	"	3,349
	91,939	"	442,678
	6	"	238
	92,918		$ 490,183

Obviously when the W.A. operations come into production this figure will be multiplied by a factor of four or more.

Some observations by the A/g Regional Director of the Department of Trade and Industry, in a report made for Science Aids Pty. Ltd. recently are interesting. (February 14th, 1968) "Regarding tonnages which form marketable parcels, you have no doubt noted that progressively larger vessels are being commissioned to carry other bulk commodities such as coal, iron ore and bauxite from Australia to Japan. As you know, this enables large economies to be achieved in freight rates per ton. You might therefore have to consider offering parcels up to the maximum size vessels which will be able to load at Port Giles, in which case your annual harvest might be cleared in, say, two shipments."

"Regarding prices you may be able to obtain some indications from the statistics attached (summarised above.....R.C.S.). Again it should be kept in mind that new contracts for shipment ex. W.A. to Japan are far larger than anything previously negotiated from Australia. It therefore seems likely that prices will be trimmed accordingly. It therefore also appears possible that to be competitive, your company might need to offer F.O.B. prices slightly below W.A. prices because of larger haul. On the other hand Japanese policy has traditionally been to source supplies of raw materials from a number of locations in order to ensure continuity of supply."

In another report (Japan Market Survey: Salt dated November, 1965) it is stated:

(1) Japanese companies have an agreement with mainland China to buy 750,000 tons of crude salt in 1965.

(2) An agreement to buy 600,000 tons of salt from India at 22/- per ton F.O.B. over two years began in July, 1964.

(3) A contract has been negotiated between Iwai and Co. (Importer) and Exportadora de Sal (Mexican Salt Supplies) for long-terming purchases of Mexican salt by Japan. Amounts under consideration are:

1,000,000 tons in 1965.

1.5 million tons yearly average 1966/70.

Price negotiated was £1.1.0 per long ton F.O.B. ($2.10).

In the foregoing prices the grade is not stated, and this could be lower than traditional supplied from Australia. However, it does seem probable that a price on board at Pt. Giles would need be in the $2-4 range per ton, despite considerably higher Australian export prices currently being negotiated.

It would appear then that an output of one quarter of a million tons annually should be a serious target. This to give an income of say $500,000. From this must be deducted over say 5 years the amortization of say 3 wells costing $250,000 (viz. $50,000 per annum), plus interest, plus maintenance; pipe and pipe laying developments of crystallizers, scraping, handling,

crushing, and transport (to Pt. Giles approximately 8.5 miles) in bulk carriers at 5 cents per mile.

3. SOUTHERN YORKE PENINSULA BRINES

Yorke Peninsula because of its dry climate (Summer drought) has been a centre of salt industry since early pioneer days. Evaporation over precipitation ranges in the south from about 40 inches per annum to 50 or more in the north. Impervious clay bottomed lagoons, and low run-off have provided particularly favourable features in the establishment of the industry. At Port Price, in the north, an estuarine arm of the sea adjacent to the slightly concentrated northern St. Vincent Gulf Waters, has added a more stable element to the local industry. The I.C.I. interests about St. Kilda provide the basis of a major industry nearer Adelaide.

The newest and possibly most significant fillip to the industry can be expected to accrue with the development of Yorke Peninsula's first deep sea port at Point Giles, near Edithburgh. With the advent of bulk carriers from Japan requiring minimum 40,000 ton cargoes, the potential for expanding the local salt industry, if prices remain reasonable, seems bright.

A. Cambrian Brines

The Kulpara dolomite is basically a magnesium-metasomatised limestone in which the conversion to dolomite has been accompanied by (about 16%) loss in volume, thereby resulting in extensive increase in porosity, both pin-point and vughular. Flow testing the Stansbury and Edithburgh wells indicated that fault-fracturing gave added porosity-permeability potential.

Without going into great detail at this stage, the thick (1,000 - 2,000 feet) Kulpara dolomites, might appear to average 8% porosity, distributed rather irregularly, and possess at least locally good to extreme permeability. By opening much or all of the limestone to flow, large volumes of brine could presumably be extracted rapidly.

B. Brine Reserves Estimations

The area of Kulpara Dolomite in depth beneath southern Yorke Peninsula conservatively 300 to 400 square miles and the limestone extends seaward to east and south and much greater areas. Sea water replenishment and pressure potential must be assumed to be maintained via a variety of updip subcrop intake areas and fault fracture zones over relatively wide areas.

For the purpose of this exercise let us assume 150 square miles of useful dolomite reservoir area viz. 100,000 acres. Also conservatively assume only 1,000 feet of dolomite section averaging 5% effective porosity. i.e. an equivalent 50 feet deep body of fluid.

1 acre foot = 43,560 cubic feet

= 272,250 gallons

100,000 acre feet = 272,000,000,000 gallons
(i.e. 0.27 trillion gallons)

Just how much of this enormous volume (conservatively estimated) is available for commercial recovery under sea level water drive is a major geological and engineering problem. However, it is safe to assume that anything up to 100 million gallons withdrawal per year would be rapidly replenished from the sea and other sources without serious loss of head. Further, it would seem geologically certain that withdrawal of over 1,000 million gallons per annum from the aquifer could do absolutely no permanent damage to this type of hard rock reservoir. Local "drawdown" would then remain the main engineering problem as this would effect pumping costs, and necessitate operation of a number of withdrawal wells spaced probably at intervals of at least one mile.

C. Stansbury West No. 1 Well: Interstitial Brines in Kulpara Dolomite.

The Kulpara Dolomite was encountered from 4226 to 5375 feet and revealed good porosity and permeability throughout. Macro-vugular and fracture porosity was especially effective.

Porosity values computed from electric logs were:

4226 - 4480 feet	5 - 10% occasionally up to 20%
4480 - 4910 "	5 - 15% occasionally up to 25%
4910 - 5230 "	Generally less than 10% with streaks of higher porosity.
5230 - 5375 "	5 - 15% but streaky

Of D.S.T.s 4, 5, 6 and 7 in this zone all but No. 4 revealed good permeabilities.

Brine recovered from D.S.T. No. 6 was typical of the zone and the assumed composition of salts was as follows.

Sodium chloride	157,451 p.p.m.
Calcium chloride	2,628 "
Calcium sulphate	1,100 "
Magnesium chloride	826
Calcium bicarbonate	205
	162,210

Specific gravity of the brine averages 1.12 i.e. one gallon would weigh 11.2 lbs.

of which $\frac{157,451}{1,000,000} \times \frac{11.2}{100}$ = 1.76 lbs. is salt.

Despite Formation fluid pressures indicating "above gradient" reservoir pressures, the high density brines encountered would stabilise at possibly 400 feet below the local surface level. Upon sustained pumping drawn down could well stabilise at 800 to 1000 feet, requiring possible 70 Horse Power to maintain output at the surface.

D. Available Evaporating Pans

Several large salt lakes that annually evaporate to dryness occur on southern Yorke Peninsula, along with a host of smaller ones. The total area of salt lagoons available as evaporation pans totals approximately 14 square miles.

Lake Fowler covers approximately 2,000 acres

Weavers Lagoon: 560 acres.

Taking the Stansbury West No. 1 well as a starting point, Weavers Lagoon offers a valuable basis for evaluation of the potential for brine-salt production.

Net evaporation over precipitation in this area approximates 42 inches per annum (assume 3 feet).

1 acre foot = 272,250 gallons

3 feet evaporation over 550 acre feet of Salt lagoon

i.e. approx. 450 million gallons.

Stansbury West brines average 16-17 Nacl, in water of Density 1.12. That is 1.75 lbs. salt per gallon.

i.e. 1.75 x 450 million lbs. salt per annum.
= 350,000 tons salt per annum.

That is, 450 million gallons of 16-17% brine could (theoretically) be evaporated to dryness annually on Weavers Lagoon for recovery of 350,000 tons of salt annually. In actual practice a proportion of this evaporation potential would be lost by reason that at least one quarter of the acreage would be "out" of evaporation much of the year for salt harvesting (scraping), and a lower efficiency factor due to the higher solar reflectivity of brines. Hence a maximum safe goal would likely be 250,000 tons per annum, necessitating production of about 350 million gallons of brine per year (viz. one million gallons per day)

One million g.p.d. = 40,000 per hour production rate.

In the first instance it would be more rational to develop only one existing well (Stansbury West) opening this for prolonged draw-down and production testing, then extending to trial exploitation by piping 2 to 3 miles to Weavers Lagoon if promising. At 14,000 g.p.h. pumping this would provide about 100,000 tons of salt per annum. Additional wells nearer the lagoon could treble the output as the scheme demanded.

E. Areas of Research (With a view to attracting R. & D. Subsidy)

Extensive R. and D. would be required on production potential, possible damage to aquifers, replenishment (as by artificial sea water drive studies), stimulation of flow, increased evaporation (by dyes) and so forth.

Considerable engineering would be required as to the most efficient (costwise) diameters of additional wells, methods of drilling (e.g. airdrilling), stimulation of aquifers, installations and type of pumps, marketing, etc. The design of the company should make due allowance for these under the R. & D. Act.

Addition of Organic dyes to the brine with the object of entrapping all the incoming radiation. The dye most commonly used is 2-Naphthol Green type. It is most effective in higher concentrations of brines, and in experiments at St. Kilda (I.C.I.) dyed ponds showed an encrease in performance, salt thickness and yield 15-20% over undyed ones.

In view of the considerable lifts involved in expected large draw-downs, particular attention must be paid to advances in pumping, as by compressed air etc.

F. Preliminary Costing for a 250,000 tons per annum Project

(i) Capital Costs

		$
1.	Cleaning and assessing Stansbury West No. 1, assessing flow rates and potential (Note 50% of this could be recoverable under R. & D.).	70,000
2.	Two new development wells	200,000
3.	Casing and production tubing ($5 per ft. 8000ft.)	40,000
4.	Pumps - 3 at $5000	15,000
5.	Three miles of collector pipe line or lined channel for gravity flow to Weavers Lagoon.	45,000
6.	Construction of evaporite pans	5,000
7.	Roller crushers: Storage areas	15,000
8.	Scrapers, F/E loaders, tippers, etc: vehicles	30,000
9.	Buildings (sheds and office): workshop	10,000
10.	Purchase of land, Rights of Way etc. (Weavers, Pt. Giles and well sites: pipe lines)	20,000
		450,000

Say capitalization $450,000 to be amortised over 5 years viz. $90,000 / annum.

(ii) Operating Expenses per Annum

		$
1.	Permanent Staff and administration: Salaries, Manager, foreman, clerk	10,000
	Equipment operators permanently on site	15,000
2.	Operation of wells, pans: Scraping etc.	50,000
3.	Power and fuel (exclusive of trucking to sea port)	15,000
4.	Contract cartage and loading Pt. Giles (8.5 miles at 4 cents per ton mile, loading etc. i.e. 250,000 tons at 40 cents)	100,000
5.	General maintenance, repairs	20,000
6.	Contingencies	30,000
		240,000

8.5 × 4 = 34 + 6 = 40

Shark Piling + loading + wharf ?? 6 cents

(iii) Profitability Summary

(a) Annual Costs

1.	Amortization of Capitalization p.a.	$90,000
2.	Operational expenses (Note: in first year, and declining subsequently, R. & D. provisions could reduce costs by perhaps 10%)	240,000
	Estimated cost per 250,000 tons = viz. 1.32 per ton.	330,000

(b) Income:

Assume price received F.O.B. Pt. Giles to be a minimal $2.10 per ton in bulk.

Then 250,000 tons would bring $525,000.

i.e. profitability per ton $0.74.

Overall annual profitability thence $185,000

Rate of return on investment of $500,000 would be approximately 27%.

FURTHER REPORT.

by

049

R. C. Sprigg

S T A N S B U R Y B R I N E S

March, 1969.

Gollin's telegraphed indication that their first talks with Kashima Denka were encouraging make it necessary for early company decisions relating to the Stansbury Brines proposal.

Japanese requirements would call for 400,000 tons of salt to be delivered annually via Port Giles, with definite loading stipulations which pose problems additional to those outstanding in relation to production of the original salt.

As of this time, it appears reasonably assured that 98% purity salt can be produced upon direct crystallisation of 80% of the original brine. Also, current indications are that the average annual quantity of salt that can be reasonably assured from Weaver's Lagoon alone is of the order of 158,000 tons, being less than half of that required.

A study of available lagoon surfaces within eight miles of Port Giles indicates that there is something of the order of 1,320 acres available in the Weaver's Lagoon vicinity, in ponds greater than 50acres in area. There are, of course, many larger lakes to the south-west which could be used were it economical to pump and pipe the brines to these distances, or develop brine supplies in their vicinity. For example, Lake Fowler, situated nine miles from Port Giles, is approximately 2,000 acres in extent and, if suitable quality brines were developed nearby, this lake could handle much of the undertaking. The Australian Salt Company already operates salt leases on part of this lake and possibly could be encouraged into a joint venture.

Recommendations:

1. Geosurveys to set up a brine project to develop and production test Stansbury West No. 1 Well.

2. Engage a consultant to undertake a study of the reservoir characteristics of the Kulpara limestone.

3. Prepare a Consultant's report on underground evaporite mineral potential in Australia.

4. Prepare full reports on the brine production potential, and related evaporite possibilities in Southern Yorke Peninsula. The reports to treat fully with the economic possibilities, and include an overall assessment by a consultant.

5. Special Mining leases and Salt leases to be applied for expeditiously.

R. C. SPRIGG

Geosurveys is now faced with a major decision as to whether it should extend its researches as to the economic possibilities of the Stansbury Brines, having in mind the increased tonnages required, the still outstanding uncertainties as to the overall brine composition, and production potential of the brines available, as well as the fragmentation of the project if additional lagoons must be developed.

Several companies have indicated interest in the project, some of them have extensive field experience in salt production, and it is becoming abundantly clear, as a result also of visits to major port installations by Messrs. R. C. Sprigg and D. H. A. von Sanden, that considerable investment will be required to raise Port Giles to the delivery rate necessary for efficient and economical loading of 400,000 tons annually. (The present limits of belts in use in South Australia approximate 800 tons per hour, against the indicated Japanese requirement of 2,000 tons per hour).

At this time, the Premier has indicated that the best his Government can offer for Port Giles is for a loading cost across the wharf of 40 cents per ton, to which must be added a shipping charge amounting in this case to approximately 3 cents to 3.5 cents per ton. This total figure of 43 cents per ton is greatly in excess of 13 cents to 17 cents sought by Gollin's. It would mean our revised estimates afoer re-costing many of the items involved would be as follows:-

CAPITAL COSTS

1.	Six Wells ($75,000 each)	$ 450,000
2.	Casing and production tubing each $63,000 (Special acid resisting)	240,000 ? (6 x 63,000 = 378,000)
3.	Pumps	50,000
4.	Harvesting machines, vehicles, materials handling equipment, buildings	75,000
5.	Land acquisition, buildings, etc.	50,000
6.	Port Loading Facilities, including land acquisition	100,000
7.	Construction of ponds, dykes, pumps and inter-lagoon pipeline	600,000
8.	Contingencies	50,000
		$1,615,000

OPERATING EXPENSES

(1)	Annual depreciation (on 10 year period) approx.	160,000
(2)	Interest on investment (in initial year) (47%)	12,000
(3)	Overheads (approx. 10% on operating costs)	60,000
(4)	Pumping from six deep Wells (each 400,000 gpd)	140,000
(5)	Scraping and transfer at lake (15c per ton)	60,000
(6)	Transport to Port Giles (3.5 cent/ton mile: av. 9 miles) 3½ cent	126,000
(7)	Maintenance and Pond Control	75,000
(8)	Stacking at Port Giles (5 cents/ton)	20,000
(9)	Loading across wharf, plus shipping charges (43.5 cents/ton)	174,000
		$827,000

operating cost Pumping 140,000
Scraping 60,000
Pond control + maint 75,000
Stacking at PG 20,000
295,000

Transport contractor

POTENTIAL PROFITABILITY

Annual operating expenses as outlined and can be expected to increase at a rate of about 3% per annum over the 10 year period, but this presumably would be offset by reduced interest on depreciated capital.

Assuming the lower limit of price range potential indicated by Gollin's (viz. $3.00 to 3.50 per ton) and a price review at the end of 5 years downwards to $2.80 per ton, then the potential profitability would appear to be:-

1970	400,000 tons at $3.00 per ton	$1,200,000
	Less operating costs	827,000
	Profitability	$ 370,000
1975	400,000 tons at $2.80 per ton	$1,120,000
	Less operating costs	830,000
	Profitability	$ 290,000

CONCLUSIONS

A likely return on investment as of 1970/1 of $370,000 reducing by 1975 probably to $290,000 is indicated. While reasonable safety factors are included in the various cost estimates along the line, major uncertainties remain unresolved relative to brine potential, brine composition and capital costing of expanded evaporation pan layout.

It is my opinion that the interest of an existing local salt producer be solicited in an attempt to develop the most practical approach within the limits of our information and the sales potential now in sight. At least one South Australian salt producer has indicated that it may welcome an opportunity to break into the Japanese market, and several other companies have also made approaches re the Stansbury Brines project.

Several of these prospects are in sight if indeed the Japanese offers could be made firm for say development by Summer 1970/1. This relates to the much shallower brines in the Peesey Swamp area, 20 miles from Port Giles, and the prospects of further oil exploration drilling by Beach in the Edithburgh area where additional evaporite potential exists.

REG. C. SPRIGG

31st March, 1969

copy only

056

30 Greenwood Grove,
Urrbrae.....S.A. 5064.

21st January, 1969.

Messrs. Geosurveys of Aust. Pty. Ltd.,
G.P.O. Box 1479-L,
ADELAIDE, S.A. 5001

Attention: Mr. Sprigg

Dear Sirs,

S T A N S B U R Y B R I N E S

I have read the files and reports on the above subject handed to me and make these comments.

Report by Cundill, Meyers & Associates:

1. Reservoir properties of dolomite, probable brine reserves and maximum pumping rate.

I am not competent to critically comment on the examination by this group of Consultants, and note an extended testing programme of Stansbury West No. 1 Well is recommended to evaluate the reservoir potential.

I consider this essential and that it should follow the engineering study if this shows the prospect to be worthwhile.

2. A.M.D.L. Report:

Laboratory evaporation tests on a synthetic brine made up to represent what might be recovered from bores indicate that something like 80% of the sodium chloride might be recovered by solar evaporation, at a commercial grade of 98% Nacl.

The major contaminants are $CaSO_4$ and $CaHCO_3$ and the percentages are such that they will need careful checking against buyers requirements.

The laboratory work will need checking by site pilot plant work before a final decision on large scale production is made.

3. Markets:

I agree with the thoughts expressed in Messrs. International Technical Services Ltd. Report of 5th December, 1968, that the only outlet for salt from the proposed Stansbury Project would be the Japanese market. A market survey I had made 2 years ago came up with this conclusion, and the bulk of the production from the Company concerned is so marketed.

The Australian market is much more attractive but it is small and well covered by present suppliers.

4. Price:

I agree also that with the large future increase in output from Western Australia there will be pressure on prices.

Batelle on page 10 of the Report states - "It has been indicated that some contracts for Australian exports to Japan have been within the range of $2.90 to $3.00."

Unfortunately, the source of this information is not given so its value cannot be assessed. If Australia refers to Western Australian contracts then because of the freight differential the best that could be expected in South Australia would be $2.40 to $2.50.

On the other hand, if it refers to South Australian contracts then West Australia might expect $3.40 - $3.50.

By comparison with landed prices in Japan from other exporting countries e.g. Mexico, China, India but excluding U.S.A. (whose landed cost is $1.10 to $1.80 higher) they have come up with a figure for the year 1968-1970 of $2.90 - $3.25 Western Australia and $2.40 - $2.80 from South Australia. After 1970 they indicate the price could fall and point out that Mexico will be selling as low as $2.10.

I have no information as to the quality of salt from Mexico, China and India but have been told that salt exported to Japan from some sources is poor by Australian standards.

Coming now to the South Australian scene and with figures with which I am personally familiar, the ruling price for exports to Japan some 2 years ago was $3.40 F.O.B.

In the case of the major supplier I know that this has now fallen to $2.80 a ton.

It seems to me, therefore, for estimating purposes we should assume two prices viz: $2.50 and $2.10 F.O.B.

If the actual Western Australian contract figures were available the picture would be clearer. I will be visiting Port Hedland soon and will try and get a clue as to price.

5. Quality:

There is no doubt in my mind that you will have to ship at a minimum 98% Nacl.

South Australian contracts with Japan are written on this basis and salt from the Company with which I was previously associated outturned at 98% plus and as high as 98.3%.

From discussions some time ago with the consultant for Leslie salt at Port Hedland, I learned that they propose to make a grade of 99% Nacl.

He admitted this was higher than normal, but indicated that to sell one million tons a year they had set out to produce a grade better than the norm. (They are washing).

International Technical services in their letter of 6th December raise 3 points:

(1) Are capital costs likely to exceed the $500,000 originally assumed? I think they will be higher but cannot say this with assurance until the preliminary engineering study (layout and capital cost phase 1 of I.T.S. proposal) is carried out.

(2) Could salt be produced and loaded at F.O.B. cost Port Giles $1.00 - $1.30 per ton. This is a low figure and from experience previously gained from evaporation of sea water, I doubt if it can be achieved.

(3) Could satifactory long term supply contracts be arranged with Japanese, Malaysian or other overseas countries?

On the assumption that large quantities of concentrated brine will be available at low cost and because of -

a. the availability of suitable evaporating areas.

b. proximity to a shipping port.

c. relatively cheap road transport to the port.

d. recovery of 80% of the salt at a commercial grade.

There are good reasons for believing salt could be produced at a reasonable price.

However, because of the low price of this product for industrial purposes - (and the probable pressure on future prices) - the proposal could turn out to be marginal or unattractive, but until an engineering study is done the economic feasibility of the project will not be known.

It is my recommendation that the engineering study proceed and that at the same time you start discussions with Japanese trading houses regarding a sales contract.

If you wish it, I would be prepared to work in conjunction with the Consultants nominated by Messrs. International Technical Services - Messrs. Kinnaird, Hill, De Rohan & Young, on the engineering and cost study.

Yours faithfully,

(signed) K.M. Bennett.

Env 1063

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YORKE PENINSULA SALT FEASIBILITY STUDY

FINAL REPORT

for

GEOSURVEYS OF AUSTRALIA PTY. LTD.

prepared by

INTERNATIONAL TECHNICAL SERVICES LIMITED

in conjunction with

THE BATTELLE MEMORIAL INSTITUTE
THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES
KINNAIRD, HILL, deROHAN AND YOUNG, CONSULTING ENGINEERS.

I N T E R N A T I O N A L T E C H N I C A L S E R V I C E S L T D .

202 East Terrace, Adelaide, South Australia. 5000.

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YORKE PENINSULA SALT FEASIBILITY STUDY

SUMMARY

Early in 1968 preliminary work by the sponsor indicated that salt production at Weaver's Lagoon appeared to offer several potentially important advantages. The highly concentrated underground brine, naturally occurring clay pans, a nearby bulk-loading port facility, and availability of housing, labour, water and electricity, promised to more than offset South Australia's transport cost disadvantage to the principal Japanese bulk salt market. The preliminary evaluation also indicated that an economically viable salt production venture could possibly be established which would yield an attractive rate of return on capital. For this reason, Geosurveys of Australia Pty. Limited engaged International Technical Services Limited to carry out a detailed feasibility study of the project, concentrating initially on the relatively unfavourable market prospects which were apparent.

Following a meeting with the sponsor on December 17th, 1968, it was decided to stop work on this study and discontinue the project. This decision was prompted by several unfavourable technical and economic factors which had come to light :-

1. The world market survey report indicates generally poor prospects.

2. Prices will be forced down by over-supply conditions which are likely to prevail during the next decade.

3. Satisfactory local markets do not exist.

4. The brine crystallisation behaviour is perverse, in that sufficient contained impurities deposit during evaporation to either jeopardise product quality or necessitate excessive NaCl wastage.

5. The prospective output tonnage is much lower than anticipated.

6. The capital costs are likely to be much higher than were assumed during the preliminary stage.

As it was originally planned, the feasibility study would have included world and Australian market surveys, chemical and civil engineering investigations and an economic analysis. The world market survey was completed in full and preliminary field visits were made to the major salt users in Australia. The chemical engineering studies were limited to determining the brine evaporation behaviour and the approximate output tonnage which could be expected from Weaver's Lagoon.

Virtually no work was carried out on the civil engineering investigations. A thorough economic analysis was ruled out because accurate cost data were not available without completing the chemical and civil engineering work. A hypothetical economic model has been analysed, however, to illustrate why sound business judgement was sufficient to reject the project.

During Battelle's work on the world market survey it was apparent that the Western Australian Government might officially discourage several of the announced salt projects. Since completion of the market report, however, Texada Mines have received the go ahead to export 200,000 tons of potash per year and a limited quantity of the salt by-product. Norseman Gold Mines and Dampier Salt Limited have confidently announced their intentions to proceed, although it is not completely clear what support they will receive from the W.A. Government.

These events alter the significance of several points raised in Battelle's analysis, including the figures shown in Table 2, but will not change the overall conclusion. Indeed, the market situation will become even worse if all the announced W.A. projects are allowed to proceed unchecked.

This report includes Battelle's world market survey findings, the chemical engineering results to date, and analyses carried out by I.T.S. Much of this information was submitted to the sponsor during the course of the study.

MARKETS

1. WORLD MARKET SURVEY.

CONCLUSIONS ON THE MARKET POTENTIAL FOR ADDITIONAL SALT FROM SOUTH AUSTRALIA

There has been considerable activity within Western Australia during the past two years to develop additional productive facilities for salt (NaCl). Successful operations will increase the production and supply of salt for domestic use and for export much above current levels. Since the Sponsor is anticipating the initiation of its own facilities in South Australia, there is concern about the ability of the market to absorb this great increase in supply.

While Australia's domestic consumption is expected to steadily increase, most of the new supply of salt probably will seek export markets, primarily in Japan. However, the Western Australian Government is concerned about the competition and price levels for the first newly established companies. Therefore, it is anticipated that only two or three of the six newly formed companies will be granted export licences.

On the basis of Battelle's analysis of this increase in production and export supply of salt and the projected import requirements of Japan, it is expected that there will be a considerable excess available for export to that and other markets. While this surplus should not be excessive during 1969 and 1970, much greater quantities will be involved between 1970 and 1980. In addition, the potential for increased imports of salt into other countries in Asia and other nearby markets does not appear very promising.

One exception may be Malaysia. While this country presently imports over 3,000 tons of salt annually from Australia, there is a possibility of increasing the amount to 10,000 - 25,000 tons annually over the next few years. The only other markets that offer reasonable potentials are the United Kingdom, Canada, and Brazil. However, the shipping distances to these markets form a major deterrent. Therefore, the feasibility of the Sponsor's establishing new production facilities in South Australia appears to hinge on the Japanese market.

Most of the new companies in Western Australia are either joint ventures or have sales contracts with Japanese importers. Since three or four of these companies may not receive export licences to supply the Japanese market, there may be an opportunity for a company in South Australia. Therefore, it is suggested that several Japanese trading firms be contacted for the purpose of determining interest in long-term contracts for the supply of salt. This should be done immediately, pointing out the potential lack of supply from established suppliers due to insufficient capacity and to political reasons, the competitiveness of salt shipped from South Australia with most of Japan's current suppliers, and the long-standing trade relationships between South Australia and Japan in salt.

In summary, a review of the markets for salt in Asia and other selected countries, indicates that the Sponsor should initiate a capital investment programme directed toward the production of salt only on the basis of firm contracts for export to Japan. In the absence of such an assured outlet for its production, the feasibility of entering the market would be extremely marginal.

TREND OF THE AUSTRALIAN SALT INDUSTRY

While Australia's production of salt has grown over 20 percent during the past five years, it still represented less than one percent of world production in 1966. As shown in Table 1, production of salt in Australia increased from 463,000 tons in 1960 to 644,500 tons in 1966. Imports of salt have been a minor and declining factor, with nearly all quantities originating in the United Kingdom. Exports have varied considerably from year to year, accounting for up to 20 percent of domestic production.

Nearly all those shipments have been from South Australia to Japan and New Zealand, with small quantities to contiguous island economies. The inferred domestic consumption of salt in Australia has fluctuated between 1960 and 1966; however, there has been considerable growth during 1965 and 1966.

TABLE 1. AUSTRALIAN SALT INDUSTRY

(Thousands of Tons)

Year	Domestic Production	Exports	Imports	Inferred Domestic Consumption
1966-1967*	644.5	93.4	6.8	557.9
1965-66	654.2	113.5	6.8	547.5
1964-65	545.5	116.6	8.0	436.8
1963-64	581.5	119.9	5.8	467.4
1962-63	536.0	74.5	7.7	468.2
1961-62	508.7	59.6	11.8	460.9
1960-61	463.3	18.3	19.4	464.4

*. Fiscal year July 1, 1966 to June 30, 1967

Source : Australian Department of Trade and Industry

During the past couple of years, there has been extensive interest in a developing salt industry in Western Australia. This has progressed to the point of the government granting reserves to newly formed companies and preliminary investment in and development of productive facilities. Included in this group of companies have been the following :

(1) Shark Bay Pty. Ltd., Shark Bay, W.A., owned by Adelaide Steamship Company Ltd. (60 percent) and Garrick Agnew Pty. Limited (40 percent).

Contracted to sell to Mitsui Dussan Kaisha Ltd., 1.6 million tons of salt over a seven-year period; first shipments made in 1968. The company plans to produce 500,000 tons annually of salt in 1969.

Located near Useless Loop in Western Australia, the company has formed evaporating ponds by enclosing the inlet and has built shiploading facilities on an off-shore island.

(2) Leslie Salt Company of San Francisco, California, U.S.A. Biggest solar salt producer in the U.S.A. has contracted with Leslie Ishirjama Inc., of San Francisco to supply the Japanese market through Tashoku Ltd. Expects to begin exporting 475,000 tons annually in 1969 and increase this to 1,000,000 tons annually by 1975 if demand warrants. Has leased 40,000 acres of tidal salt marsh 30 miles East of Port Hedland, W.A. Seawater is to be circulated through eight ponds and brine pumped into a canal to flow 18 miles to a crystalliser pond adjoining Port Hedland Township.

(3) Dampier Salt Ltd. Owned by Comalco Industries Pty. Ltd. (50 percent), Marubeni Iida Co. Ltd. and Nissho Co. Ltd. of Japan (32 percent combined), British Tobacco Ltd. (14 percent), and C.M.L. Society Ltd. (4 percent). To start construction on a salt plant near port of Dampier. Plans to produce 650,000 tons annually by 1970.

(4) Texada Mines Ltd., of Texada, B.C., Canada. Agreement with W.A. government for two-year research programme on the feasibility of a potash facility on Lake McLeod. To extract economical volume of potash, the company anticipates a by-product of 3,000,000 tons of salt annually.

(5) Norseman Gold Mines N.L. (51 percent) and Sumitomio Shoji Kaisha Ltd. (49 percent). A joint venture for exporting salt obtained from Lake Lefroy near Norseman to Japan through Port of Esperance. Feasibility of the project may depend on transportation assistance by the government of Western Australia. Company anticipates shipping 200,000 tons of salt by 1969, increasing to 500,000 tons annually over the next 5 - 10 years.

(6) Exmouth Salt Co., of Exmouth Gulf, Western Australia. Owned by group of individuals from Perth with interest in acquiring a Japanese equity. Anticipate getting into production for export in 1970 with goal of 1,500,000 annually in subsequent years.

These very ambitious plans would increase the total volume of salt production by 1970 nearly 400 percent over current levels. This is based on Battelle's estimates of production from current facilities and the volume expected to be forthcoming from the new facilities by 1970.

POTENTIAL AUSTRALIAN SALT PRODUCTION : 1970

	Tons
Current Facilities	700,000
New Facilities	
Shark Bay Pty. Ltd.	300,000
Leslie Salt Co.	500,000
Dampier Salt Ltd.	100,000
Texada Mines Ltd.	500,000
Norseman Gold Mines N.L.	500,000
Exmouth Salt Co.	100,000
TOTAL PRODUCTION	2,700,000

Source : Battelle estimates; Australian Mining Journal.

Assuming a normal growth in domestic consumption to be estimated 600,000 - 630,000 tons in 1970, a little over 2,000,000 tons would be available for export.

However, it is possible the total amount of new salt production will not actually reach 2,000,000 tons. Much depends on the awarding of export licences to the new companies. Although the W.A. Government is believed to favour foreign capital participation, and most of the new companies have either Japanese or U.S. equity, it also is very much concerned about competition in terms of total supply, price levels, and the availability of markets. It is understood that only Shark Bay, which has exported 120,000 tons during the first half of 1968, Leslie Salt, and Texada have prospects of getting export licences in the future. These companies' exports have been limited in the past and they have been subjected to other stringent controls by the W.A. Government. However, the issuance of export licences to the remaining companies should be considered as pending, but the probability of their receiving licences and going into production is unknown. Therefore, until they actually receive their licences or additional information is obtained, the analysis will be limited to the three companies whose licences seem most assured and the estimated quantities they expect to export.

This assumption is that Shark Bay as W.A. are [illegible] likely to limit their exports to allow S.A. to produce

Considering the productive capacity of only three of the new companies, reduces the prospective volumes considerably during the next few years. A summary of the estimated production and quantities available for export between 1968 and 1980 are shown in Table 2, on page 10.

It is believed that (a) production of salt in 1968 will be approximately 870,000 tons, (b) imports should increase to around 10,000 tons, and (c) domestic consumption will be about 594,000 tons. This leaves approximately 286,000 tons of salt to be exported. By 1969, production is expected to jump to 1,670,000 tons, and with normal growth in consumption, the amount of salt available for export should increase to 1,068,000 tons. Production is expected to reach 3,030,000 tons by 1975 with 2,320,000 tons available for export, and in 1980, production should increase to 3,330,000 tons with 2,600,000 tons for export.

These estimates and extrapolations are based on current trends and information available on the new companies' organisations, plans, and anticipated growth patterns. Comparing these data with production, consumption, and export figures of previous years, it is apparent that much larger export markets must be developed. However, as in the past, exports of the greater quantities of salt must be considered in relation to the production and exports of other countries.

AUSTRALIAN EXPORT POTENTIAL

The export markets for salt are very complex and illusive in nature. Nearly all countries produce some of their own salt. Even those that are net exporters may import varying amounts of their requirements. In some instances, countries with a considerable supply deficit also export to other countries. In other cases, some countries enjoy the advantage of being relatively near to large, fully industrialized markets and have developed long-standing trading relationships.

The primary world import markets for salt consist of the regions of North America, Europe, and Asia. The amount of imports used by these regions and the other major regions of the world are as follows :

WORLD IMPORTS OF SALT, 1965

	Tons
Asia	3,650,000
Africa	283,000
Europe	2,950,000
South America	298,000
North and Central America	2,620,000
TOTAL	9,801,000

Source : U.S. Bureau of Mines.

TABLE 2. ESTIMATED AUSTRALIAN SALT PRODUCTION 1968 - 1980 (Tons)

Company	Years				
	1968	1969	1970	1975	1980
I.C.I.A.N.Z.	550,000	600,000	650,000	1,000,000	1,250,000
Shark Bay	120,000	250,000	300,000	300,000	300,000
Leslie Salt (Pt. Hedland)	-	400,000	500,000	1,000,000	1,000,000
Texada Mines (Lake McLeod)	50,000	250,000	250,000	500,000	500,000
B.H.P. - Whyalla	50,000	60,000	80,000	80,000	80,000
Others	100,000	110,000	110,000	150,000	200,000
Totals	870,000	1,670,000	1,890,000	3,030,000	3,330,000
Plus imports	10,000	10,000	10,000	10,000	10,000
Less inferred domestic consumption	594,000	612,000	630,000	720,000	740,000
Export Supply	286,000	1,068,000	1,270,000	2,320,000	2,600,000

Source : ITS and BMI estimates.

Based on a total world production of approximately 119,500,000 tons of salt in 1965, the 9,801,000 tons of imports represents about 8.2 percent of the total supply. With the expanding need for salt by industrialized countries and the growth of developing countries, the trend of world imports of salt related to total production through 1980 is estimated to be as follows :

WORLD TREND OF SALT IMPORTS
(Tons)

	Production	Imports	Percent
1965	119,500,000	9,801,000	8.2
1970	126,000,000	11,350,000	9.0
1975	146,000,000	14,600,000	10.0
1980	175,000,000	17,500,000	10.0

Source : Battelle estimates : U.S. Bureau of Mines

Australia's estimated share of world salt trade related to its supply of salt available for export would be as follows :

AUSTRALIA'S SHARE OF WORLD SALT IMPORTS
(Tons)

	Total World Imports	Australia Exports	Percent
1965	9,801,000	113,500	1.2
1970	11,350,000	1,270,000	11.2
1975	14,600,000	2,320,000	16.0
1980	17,500,000	2,600,000	14.8

Source : Battelle estimates

AUSTRALIAN SALT TRADE

Salt, especially industrial and rock salt, is a very low-value commodity. Consequently, there are definite limitations on the distances it can economically be transported, although there are several instances in world trade where it is shipped thousands of miles. Therefore, the existence of large industrialized countries within acceptable shipping distances of the exporting countries is of primary importance. In this respect, Australia is at a disadvantage due to its distance from the major industrial areas of Europe and North America.

Table 3 indicates Australia's exports for 1966-67 by general types of salt, destinations, quantities and approximate values per ton. Although these data may differ from those of other sources, there is general agreement, and any discrepancies are probably due to the exclusion of some minor markets.

The most significant aspects of Australia's exports are that (1) the major portions of shipments are made to Japan, New Zealand and Malaysia, and (2) the prices for large quantities of refined salt range from $A15.00 to $A21.00 per ton, while industrial salt ranges from $A3.40 to $A3.90 per ton.

TABLE 3. AUSTRALIAN SALT EXPORTS
1966 - 67 FISCAL YEAR

Type of Salt	Destination	Tons	Approximate F.O.B. Value $A /Ton
Table salt (in packages not exceeding 14 lb. net weight)	N/A	390	64.10
Other table salt	New Zealand	1,364	14.67
	Other countries	630	15.87
Common salt, N.E.I.	Brunei	500	34.00
	Fiji	897	15.60
	Japan	78,759	3.40
	Malaysia	3,325	3.90
	New Zealand	6,569	17.65
	Other countries	711	21.10
TOTAL EXPORTS		93,145	

Source : Australian Department of Trade and Industry.

Another important factor is that well over 95 percent of Australia's exports during fiscal 1966-67 originated from South Australia. Table 4 details the destinations, quantities, and approximate values of those shipments. It will be noted that over 85 percent of South Australia's exports are to Japanese trading companies.

The data available for total Australian exports compared with those of South Australia above differ in the value per ton. Since considerably greater tonnages are shipped from South Australia, the $A3.30 per ton appears reasonable in relation to the $A3.40 for all exports. Contracts with Japanese trading companies for larger annual and individual shipments could account for the differences in the values.

TABLE 4. SOUTH AUSTRALIAN SALT EXPORTS
1966 - 67 FISCAL YEAR

Destination	Tons	Approximate Value/Ton
Fiji	1,282	12.85
Gilbert & Ellice Is.	10	15.80
Japan	78,759	3.30
Malaysia	3,325	3.85
New Caledonia	13	22.15
New Hebrides	6	14.13
New Zealand	7,883	17.90
Papua/New Guinea	378	17.47
Samoa (American)	19	14.42
Tonga	42	15.09
Western Samoa	222	15.51
TOTAL	91,939	

Source : Australian Department of Trade and Industry.

It has been indicated that satisfactory buyer/seller relationships exist between South Australian companies and Japanese importers, quality of product is generally better than other sources, and the prices of the salt are competitive.

While salt shipped from South Australia has been valued at $A3.30 per ton, the total delivered value in Japan has been in the range of $A7.80 to $A8.00 per ton. It is believed this includes transfer,storage, loading, and unloading costs at both the shipping and destination points. This implies a total shipping cost of approximately $A4.50 to $A4.70 per ton.

More recently, it has been indicated that some contracts for Australian exports to Japan have been within a range of $A2.90 to $A3.00 per ton. It is unlikely that transportation costs, especially shipping conference rates, have changed; therefore, the most recent delivered value of South Australian salt in Japan is believed to be approximately $A7.40 to $A7.70 per ton.

Other values of salt imported into Japan from other major suppliers during 1967 have been determined to be approximately as follows :

Mexico	$A 6.90
Mainland China	$A 7.20
United States	$A 8.70
India	$A 7.60

The variability in these data indicates the difficulty in estimating the future values of contracts for salt from specific sources. This is especially true when the values of contracts in 1967 for salt imported into Japan from Mexico were $A6.90 while those from the United States were $A8.70. While the water distance from each of those points is approximately the same, the value of salt imported from Mexico was $A1.20 less than that imported from the United States. Much of the difference apparently is due to labour costs and, in some instances, due to different shipping conferences. However, other factors that are operative include specific contract negotiations and related circumstances such as size of contract, delivery times, and Japanese demand requirements for salt.

Although relatively little information is available on the initial and operating costs of current and potential salt exporters in Western Australia, the above data provides some guidance as to what to expect in terms of contracts with Japanese trading companies. Since most of the Western Australian companies are joint ventures with those trading firms, the costs and development problems are known to the Japanese companies.

It has been suggested the start-up expenses of these new companies will be somewhat higher than the Sponsor's initial costs.

This is primarily due to requirements to provide housing, utilities, and other facilities at the remote locations. During the early phases of the companies' operations, which would vary from 1968 to 1972 depending on the company involved, these higher costs would have to be allocated to limited production volumes resulting in higher costs per ton. In addition, some of the new companies have experienced difficulties, such as leaks in their evaporative beds, that add to initial costs and delay the initial production schedules.

However, most of these higher costs per ton for production, compared with the Sponsor's costs, would be off-set by lower shipping costs to Japan. While such costs apparently range from $A4.50 to $A4.70 from South Australia to Japan, based on available information, it is reasonable to expect these costs to be reduced to approximately $A4.00 to $A4.25 from Western Australia. However, the actual total shipping costs depend on each particular company's facilities, point of shipment, and tonnages being shipped. Similarly, the total delivered value of salt from Western Australia depends on the total production costs, total shipping costs, size of basic contracts and the time involved, and the internal accounting procedures of each company. Therefore, because of these variables, the actual export value of salt from Western Australia or the delivered value in Japan cannot be determined. Recognizing the equity positions of the Japanese trading firms in the new Western Australian facilities and the Japanese pragmatic and astute trading acumen, there is a reasonable basis for assuming the export value of Western Australian salt will be competitive with South Australian and other Japanese suppliers.

Based on this information, it is believed that the minimum delivered value of salt imported by Japan from Western Australia would fall in a range of $A6.90 and $A7.50 per ton. With a shipping cost ranging from $A4.00 to $A4.25 per ton, this would imply a minimum export value from Western Australia of from $A2.90 to $A3.25 per ton. To be competitive, this means the Sponsor probably would be required to establish an export value of $A2.40 to $A2.80 per ton during the period between 1968 and 1970.

This value range should remain firm until 1970 due to several factors. Normally, the contracts negotiated for salt by Japanese trading firms cover a period of from two to seven years. The total may vary in volume under any given contract from a few tens-of-thousands of tons of salt to over 1.5 million tons.

Of course the larger volume contracts extend over the longer time periods. The large contract volumes limit suppliers of salt to Japan to Mexico and Mainland China. More recently, it has been indicated that Shark Bay Salt Pty. Limited, has a contract with Japan for 1.6 million tons over a seven year period. However, the initial shipments by Shark Bay and the other Western Australian companies will be relatively limited. It is believed that the small quantities to be shipped under the initial contracts over the next two years will not upset the prevailing prices for salt.

The years following 1970 appear to represent a less favourable prospect. Two major factors that will be operative between 1970 and 1980 are the demand for salt by the Japanese economy and the relative supply available for import. A clue to what may occur is reflected in a recent contract for salt to be exported from Mexico. It has been indicated that under this contract the salt will be exported at a value of $A2.10 per ton. While this is an isolated case, it suggests that with increased availability of salt the prices probably will decline.

JAPANESE IMPORT POTENTIAL

Traditionally, Japan has imported between 75 and 80 percent of its salt requirements. While Japan produced domestically for both consumer and industrial goods processing, a higher proportion of its salt imports are for industrial products. This proportion is expected to increase in the future. Table 5 summarizes the distribution of Japanese salt imports for the period 1961 - 65.

TABLE 5. JAPANESE IMPORTS OF SALT, 1961-65
(Thousands of Tons)

Year	Industrial	Food	Total
1961	2,600	227	2,827
1962	2,700	201	2,901
1963	2,037	334	3,371
1964	3,663	344	4,007
1965	3,417	441	3,858

Source : Australian Department of Trade and Industry, Japan Desk, International Trade Relations Division

A more detailed picture of Japan's imports for 1967 by general type and point of origin is shown in Table 6.

TABLE 6. JAPANESE IMPORTS OF SALT, 1967

Type	Source	Tons
Common salt (put up for resale)	West Germany	1
Common salt N.E.S.	Mexico	2,011,055
	Mainland China	1,083,539
	Taiwan	5,513
	Indonesia	18,891
	India	391,564
	Pakistan	95,979
	Aden	51,291
	Yemen	112,439
	Spain	34,467
	USSR	5,445
	Rumania	25,823
	Turkey	7,497
	USA	481,796
	Venezuela	53,168
	Chile	170,520
	Tunisia	35,875
	United Arab Republic	56,850
	Ethiopia	169,649
	Australia	74,649
TOTAL		4,886,010

Source : Japanese Trade Statistics.

While the Japanese Industrial Structure Research Council had forecast 4,350,000 tons of salt imports for 1967, the actual figure was 4,886,000. Therefore, the Council's forecasts through 1970 have been adjusted as shown in Table 7. Additional estimates have been included for 1975 and 1980.

Therefore, we come to a major point in the evaluation. Australia, up to now, has been exporting its excess supply of salt to Asian countries and contiguous islands. Japan, being the most industrialized country in this part of the world, has absorbed the major portion of these exports. The feasibility of initiating a new salt production unit in South Australia hinges on the demand/supply picture for Japan and other possible outlets in Asia plus any other countries offering sufficient demand and for which South Australian producers can satisfactorily compete. An important element in this evaluation is the new supply that is expected to become available from Western Australia and other exporting areas.

TABLE 7. FORECASTS FOR JAPANESE SALT IMPORTS
1968 - 80

Year	Tons
1968	5,170,000
1969	5,440,000
1970	5,780,000
1975	6,230,000
1980	6,800,000

Source : Battelle estimates; Japanese Industrial Structure Research Council (M.I.T.I.)

Table 8 is a summary analysis of what the supply/demand relationship is projected to be through 1980 for Japan. While these figures indicate a surplus of supply, only two of the new companies are believed to have definite commitments of their production either through joint ownership or sale contracts with Japanese firms. Despite the fact that the production of these two firms along with I.C.I.A.N.Z. shipments (less domestic consumption increase) exceeds Japan's forecast requirements in 1969 by approximately 150,000 tons, with the small increase in those companies anticipated production during 1970, and possibly for the next couple of years, there will be a near parity during that period between the supply under contract and Japan's forecast requirements. In addition, the internal competition between Japanese trading companies must be considered.

It is understood individual importing companies are assigned quotas by the Japanese Monopoly Corporation based on that organizations's estimate of the demand requirements. Two companies, Marubeni Iida Co. Ltd. and Sumitomo Shoji Kaisha Ltd. have joint equity positions with Dampier Salt Limited, and Norseman Gold Mines N.L. Since it is believed neither of these companies will obtain export licences from the W.A. Government, it is assumed these two Japanese import houses have quotas which they will be unable to fill except from either another Australian source or some other foreign source.

TABLE 8. JAPANESE SUPPLY/DEMAND FOR SALT, 1968-80
(Tons)

Year	Forecast Demand	Basic Supply (1967)	Forecast New Australian Supply*	Surplus Australian Supply
1968	5,170,000	4,886,000	320,000	36,000
1969	5,440,000	4,886,000	1,102,000	548,000
1970	5,780,000	4,886,000	1,304,000	410,000
*				
1975	6,230,000	4,886,000	2,354,000	1,010,000
1980	6,800,000	4,886,000	2,634,000	720,000

* Consider increase in domestic consumption.

Source : Battelle estimates; Japanese M.I.T.I.

Related to these deficiencies is the relative instability and lack of capacity of some of Japan's regular sources of salt supply. An example of this problem that occurred in previous years is when the stocks of Egyptian salt "ran out" after supplying 60,000 tons to the Japanese Monopoly Corporation. Similarly, salt available from Taiwan was limited to 350,000 tons, which apparently was less than the volume originally anticipated.

Another tentative limitation to Japan fulfilling its salt requirements involves political factors. While Communist China was the second largest supplier to Japan in 1967, it is close to Japan, and its salt is very cheap, the possibility of this source of supply being cut off would be critical to Japan. In a similar vein, supplies from such countries as Aden, Yemen, and Rumania must be open to question.

On the other hand, with the development of Western Australian salt facilities, certain reaction can be expected from current suppliers to Japan. It has been indicated that Mexico, Japan's largest supplier, plans to increase its capacity. It is believed that during the period of 1963 - 65 Mexico expanded its capacity at least by 1,000,000 tons. This reflected in their growth in production from 1,225,000 tons in 1963 to 2,200,000 tons in 1965. During this period its exports increased from 1,004,000 tons to 1,601,000 tons. Subsequently, it has been indicated that the Mexican exporting firm of Exportadora de Sal (Mexican Salt Supplies) has a five year contract with the Japanese trading firm of Iwai and Company to supply 1,500,000 tons of salt annually between 1966 and 1970. This is 500,000 tons above Mexico's total exports of salt to Japan during the year 1965.

In addition, Mexico has been slowly increasing its exports to the United States. Information from The Salt Institute indicates the volume of such imports and the relatively low prices have been creating difficulties for U.S. domestic producers. As evidence of this trend, Mexico exported 332,000 tons to the U.S. in 1963, 477,000 tons in 1965, and in June of 1968, that one month's imports were 52,252 tons for an indicated annual rate of 625,000 tons.

These increases in contracts and actual exports from Mexico reflect an additional capacity of from 400,000 to 600,000 tons, at least, to handle the increase in exports. Reasonable estimates of future exports based on this trend would not preclude an expansion of capacity of up to an additional 250,000 tons between 1968 and 1970. Therefore, it is believed Mexico's salt capacity will have increased from around 1,250,000 in 1963 to 2,900,000 - 3,000,000 tons by 1970. This takes into account a steady increase in apparent consumption in Mexico from approximately 200,000 tons in 1963 to 600,000 tons in 1966 and an estimated 750,000 tons annually by 1968 -1970.

With this increase in capacity, Mexico can be expected to compete vigorously, from the standpoint of price, with other suppliers to Japan. While Japanese traders have predicted Australian salt can be landed in Japan for less than from Mexico, considerable pressure will be applied on Australian suppliers to reduce their prices.

OTHER MARKET POTENTIALS

Because of the nebulous Japanese market potential, it is essential that Australian salt producers consider other outlets for their product. As a Japanese importing representative stated, "This business will become highly competitive and some companies will be seriously disappointed if they are depending only on the Japanese market. They could lose money".

Therefore, information has been obtained on the salt industries and consumption of most countries of the world. The usefulness of much of this information is limited, however, because of the relative value of salt and the high transportation costs. While there are isolated instances of long-distance shipping of salt, normally this involves refined salt shipped in less than bulk quantities and in packages. As a consequence, Australian producers must be primarily interested in other countries within reasonable shipping distances.

Table 9 describes the production, imports, exports, and apparent consumption of salt for selected countries that appear to offer some possibilities as markets for Australian salt. In each instance, the information available on the sources of imports is included.

Referring to the Asian countries, during 1964 India had the highest apparent consumption with 5,368,000 tons. However, this country is a major producer and also exported 283,000 tons during 1964. Since India imports relatively little salt and is an undeveloped economy, there seems to be little market potential for Australian salt.

Most other countries of Asia with substantial requirements also appear to fill their needs through internal production. One exception is Ceylon which, although it produces 60,000 tons internally, also imports 30,000 - 40,000 tons, all of which originates in India. Another exception is Hong Kong, which must import all its salt requirements of 30,000 - 35,000 tons annually. Most of its imports come from Communist China and Thailand. The last exception is the area including Malaysia, Singapore and Brunei (combined in this data), which must import 83,000 - 87,000 tons each year. Australian producers already supply over 3,000 tons to this area, and most of the balance is imported from Thailand.

However, due to the nearness of this market, the previous selling relationship, and the steady development of the area, especially Malaysia, there appears to be a possibility of exporting 10,000 - 25,000 additional tons annually to this area.

The only other countries that appear to offer significant exporting opportunities are quite distant. They include the United Kingdom, Canada, and Brazil. The only reasons they are included here are their quantities of imports and, for U.K. and Canada, the tariff advantages offered to Australian companies. Also in each instance, some of those countries' imports have been shipped considerable distances from Mexico, Tunisia, and Spain.

TABLE 9. TRADE AND CONSUMPTION OF SALT IN SELECTED COUNTRIES
(Thousands of Metric Tons)

Country	Average Annual Production, 1964-66	Range of Imports, 1963-65	Range of Exports, 1963-65	Apparent Consumption, 1965	Source of Imports
Asia					
Aden	75.4	-	65-70	7.5	-
Afghanistan	33.7	-	-	33.7	-
Burma	129.7	-	-	129.7	-
Cambodia	59.0 (1964)	-	-	N/A	-
Ceylon	64.7	33-40	-	118.0	All from India
Hong Kong	-	32-35	-	32.0	China (25), Thailand (3)
India	4,953.0	3.6 (1964)	195-283 (63 & 64)	5,368 (1964)	Pakistan (3.6)
Indonesia	250 (1965-66)	-	-	253.0	-
Iraq	49.0	-	-	60	-
Iran	257.0	-	2.5-3.4 (63 & 64)	225	-
Israel	47.7	-	-	55	-
Jordan	17.7	-	1.3-6.1	14	-
Korea, Republic of	482.7 (varies)	-	-	669	-
Kuwait	8.0 (1965)	1.135 (1965)	-	9.1 (1965)	Iran (.7), U.K. (.3) W. Germany (1)
Laos	3.4	4-1.0	-	3.0	Thailand (.4)
Lebanon	23.0	1.1-1.5 (63-64)	Neg.	24	Egypt (1.1), W. Germany (.3)
Malaysia (Singapore & Brunei)	-	83.1-87.5 (63-64)	-	80-85	Thailand (67.1)
Pakistan	467.7	2.0-2.6 (63-64)	-	495	-
Philippines	138.0 (varies)	-	-	225	-

TABLE 9. TRADE AND CONSUMPTION OF SALT IN SELECTED COUNTRIES (Cont'd.)
(Thousands of Metric Tons)

Country	Average Annual Production, 1964-66	Range of Imports, 1963-65	Range of Exports, 1963-65	Apparent Consumption, 1965	Source of Imports
Ryukyu Is.	4.3	-	-	3	-
Saudi Arabia	5.0	-	-	5	-
Syria	19.0	15.6-23.5	-	36.6	Egypt (9.0), Jordan (5.9)
Taiwan	524	-	283-399	258	-
Thailand	193	-	82-140	106	-
S. Vietnam	158	-	-	175	-
Yemen	78 (1963-66)	-	35-100	Neg.	-
Other Areas					
United Kingdom	7,034	38-180	363-405	6,655.0	W. Germany (35), Poland (10), Tunisia (60)
Canada	3,899	222.5-400.6	656.5-906.5	3,653.1	US (166.9), Mexico (172.4), Spain(31.1
Brazil	1,089	12-250.0	.03	1,450.0	W. Germany (78.6), US (35.6), Tunisia (30.2)

Source : U.S. Bureau of Mines

2. THE AUSTRALIAN MARKET

The Australian market survey was not completed, since the project's feasibility depended mainly upon obtaining satisfactory export markets. However, preliminary contacts were made with I.C.I.A.N.Z. at Osborne, SouthAustralia, and at their head office in Melbourne. The information obtained from these contacts is summarised below.

(a) The company's policy is to become self-sufficient in salt. Their Port Alma, Queensland, fields will supply the Botany chlorine plant and the Dry Creek field will furnish salt for the Osborne soda ash works. They operate a chlorine plant in Melbourne which purchases approximately 20,000 tons of salt per year, largely from the Victorian Mallee and Dry Creek surplus.

(b) The Dry Creek fields have consistently produced surpluses which have been sold to the Botany plant or exported. This is a critical year for Dry Creek because of the unusually high rainfall. If, despite this, no shortage occurs at the Osborne works, then outside salt purchases will probably be unnecessary for at least 5 years. I.C.I.A.N.Z. have secured plenty of spare land for future expansion at both Dry Creek and Port Alma.

(c) The company's total salt demand will be influenced by overseas suppliers of soda ash, caustic soda and chlorine. The first two are subject to very heavy import pressure. The demand for chlorine is buoyant but its product cost, and hence its ability to withstand import competition, is influenced by the unfavourable price at which the caustic soda co-product can be sold.

(d) Summarising, I.C.I.A.N.Z. will not purchase large quantities of salt unless their Port Alma project fails or the demand for their products increases dramatically. In view of I.C.I's experience with salt production, and the import pressure on soda

ash and caustic soda, neither prospect is very likely to occur.

A second South Australian salt market could perhaps arise if the Port Pirie uranium treatment plant is used to extract rare earth elements as planned. The processing requires both caustic soda and hydrochloric acid. However, this project does not seem to be advancing with vigour, and may not proceed in accordance with announced plans. The total prospective demand for salt is unknown but is unlikely to be sufficient to solely support a salt works.

sulphuric acid

CHEMICAL ENGINEERING.

1. Brine Evaporation Behaviour

After consultation with the sponsor the composition of brine from DST 5 (4720-4832 ft.) was selected as typical of that likely to be available. The brine for evaporation tests was made up according to the analysis given for DST 5 (omitting lithium - 3ppm.). Forty litres of brine were prepared

Component	ppm.
Cl	98,300
SO_4	1,187
HCO_3	93
Na	62,100
K	828
Ca	1,178
Mg	190

Assumed Composition	ppm.
$CaHCO_3$	124
$CaSO_4$	1,682
$CaCl_2$	1,806
$MgCl_2$	744
NaCl	157,926
KCl	1,579

The specific gravity of the brine was 1.113 at 20° C and the initial pH was 7.0.

Two separate tests were conducted :-

(a) Direct Evaporation

A 500-ml portion of brine was evaporated under an infra-red lamp until almost dry. The salt/brine mixture was filtered under suction until the salt was as dry as possible. The salt was then washed on the filter with exactly 50 ml of saturated sodium chloride and again sucked dry. The amount of liquid " hold up" in the solid was determined by weighing the salt, drying at 100°C and re-weighing. The solid product, the initial filtrate (bitterns) and wash liquor were analysed separately and the distribution of the components was calculated after combining the results for the filtrate and wash.

Results

	Distribution of Components, %					
	NaCl	KCl	$CaCl_2$	$CaSO_4$	$MgCl_2$	$CaHCO_3$
Solid product	87	3	3	70	3	85
Filtrate(bitterns)	13	97	97	30	97	15

The total volume of bitterns was 40 ml including 5.5 ml of "Hold up" liquor.

Approximate composition of Solid Product

	%
NaCl	99.0
$CaSO_4$	0.7
$CaHCO_3$ (as $CaCO_3$)	0.1
KCl	0.03
MgCl	0.03
$CaCl_2$	0.03

(b) Stagewise Evaporation

Most of the brine (39 litres) was evaporated by infra-red heating under simulated natural conditions. An oscillating fan provided a constant air stream over the brine surface. The brine temperature reached 35 to 40°C during the day but was allowed to fall to approximately 20°C at night. Salt commenced to crystallise at a brine specific gravity of 1.210; the specific gravity then remained constant until approximately 80% of the salt had been crystallised, but

then rose gradually to 1.220 after 94% had been crystallised.

Solid products were removed at intervals by filtration under suction and then washed by displacement with approximately 500 ml of water. The wash water was returned to the evaporation bath with the filtrate. The final product obtained at a brine specific gravity of 1.220 was not washed after filtration, but the "hold-up" volume was determined and an adjustment was made in the composition of the solid to allow for the bitterns remaining in it.

The solid products and bitterns were analysed to enable distribution of the components to be determined. Some difficulties were experienced in obtaining material balances for some of the components, but the figures given in Table 10 are regarded as reliable indications of the compositions of the various fractions. Some of the figures have been "rounded off" for the purpose of evaluating the results.

From the results of the two tests the conclusion is reached that a salt product containing 99% NaCl could be obtained only in the earlier stages of evaporation (up to 40% of the total NaCl), but that at least 80% of the NaCl could be obtained as a 98% product (assuming no contamination with foreign materials). Most of the bicarbonate and sulphate in the brine are precipitated during the middle stages of evaporation, so there is little likelihood of reducing the level of contamination by these components except by limiting the extent of evaporation.

TABLE 10 COMPOSITION OF SALT PRODUCTS

Fraction	NaCl		KCl		$CaSO_4$		$MgCl_2$		$CaHCO_3$		$CaCl_2$	
	%	Dist. %	%	dist. %	%	dist. %	%	dist. %	%	dist. %	%	dist. %
1	99.8	31	<0.01	0.1	<0.1	2.1	<0.01	0.3	0.06	21	<0.01	0.1
2	99.5	12	<0.01	0.1	0.4	6.1	<0.01	0.3	0.08	13	<0.01	0.1
3	98.3	22	0.01	0.3	1.6	45.6	0.02	1.0	0.10	32	0.01	0.2
4	98.8	14	0.02	0.4	1.2	22.0	0.03	1.0	0.10	17	0.02	0.5
5	97.7	15	0.15	2.4	1.2	22.0	0.10	1.4	0.08	13	0.40	6.1
Bittern	-	6	-	96.7	-	2.2	-	96.0	-	4	-	93.0

CHEMICAL ENGINEERING (Contd.)

2. Evaporation System - Conceptual Design

Review of Progress

The meteorological data for Adelaide and Stansbury have been collected and assessed, and projections made to arrive at data which could be assumed to apply to Weaver's Lagoon.

The evaporation rates at the site have been estimated for each month of the year and for brines of various concentrations.

In the absence of a specified salt product quality and soil permeability data from the engineering and geological studies, a salt quality of 98% NaCl and a permeability of 10^{-6} cm/sec have been assumed in these initial calculations.

The relative areas of concentrator and crystalliser have been calculated and an overall scheme for layout of the available area has been prepared.

Salt production is estimated to be 158,000 short tons in an average year, with upper and lower limits (based on recorded meteorological data) of 280,000 tons and 75,000 tons. There is a 90% probability of exceeding 107,000 tons in any year.

An absence of run-off from surrounding areas into the lagoon has been assumed, and although bittern disposal will be required, no study of this problem has been carried out.

Evaporation Rates and Meteorological Data

The rate of salt production for a given area is a function of the nett evaporation (i.e. evaporation minus rainfall). The rate of evaporation varies with change of season, but also decreases with increasing salinity, so that at any given time the evaporation rate is different at different points in an evaporating system. Evaporation rates can be quantitatively predicted using the method of Bonython (1,2), based on the theory of natural evaporation developed by Penman (3) and Ferguson (4), as follows :-

$$E = \frac{2h}{L}(p_w - p_a) \qquad .....(1)$$

$$2p_w + \theta_w\left(1+\frac{r}{h}\right) = \frac{Q_a}{h} + 2p_a + \theta_a\left(1+\frac{r}{h}\right) \qquad .....(2)$$

where E = evaporation rate

Q_a = net gain of radiant energy

θ_a = air temperature

θ_w = liquid temperature

P_a = partial pressure of water vapour in the air

P_w = vapour pressure at the water surface

r = emission coefficient of long wave radiation

h = coefficient of heat transfer between air and water

L = latent heat of vaporisation of water

$r = 14400\,\sigma\,(273 + \theta_a)^3$ from ref. 4

where σ = Boltzmann's constant

$h = 0.1\,u$ cal/cm^2/hr/$^\circ$C from ref. 5

where u = mean wind speed in mph at the $8\frac{1}{2}$ ft. level

If the climatic variables are fixed, then solutions of equation (2) may be plotted as straight lines on a graph of p_w versus θ_w. If on the same graph be plotted the vapour pressure-temperature curves of various density brines, then the intersection of the lines of equation (2) and any curve represents the solution of the surface vapour pressure and temperature of liquid evaporating under these conditions. The evaporation rate may then be calculated from equation 1. Vapour pressure-temperature curves for various density brines are given in Figure 1 (from ref. 1).

The procedure outlined above was followed using the relevant meteorological data given in Table 11, and monthly evaporation rates were calculated for various density brines. These are given in Table 12. It can be seen that excellent agreement is achieved between the calculated and measured evaporation rates for water.

The evaporation data is presented graphically in Figure 2, where the variation of evaporation ratio (the ratio of brine evaporation to water evaporation) with brine density is shown, and in Figure 3, where the effective monthly nett evaporation is shown. The above data are based on average values of the climatic variables. In order to better appreciate the output of a solar evaporation system we must look at the deviations from these average values. Whilst deviation values are not available for Stansbury, they are readily available

for Adelaide. For the purposes of this exercise, variations in annual evaporation and rainfall for Stansbury have been calculated by proportioning the Adelaide data, and these are given in Table 13.

Brine Composition

The underground brine will be pumped to the concentrating ponds where evaporation takes place; the concentration of the brine increasing until it reaches the salting point i.e. is saturated with NaCl. Brine at this concentration, known as pickle, is then transferred to the crystallising ponds. Further evaporation causes the deposition of salt. When the brine reaches such a concentration of other salts as to cause these to be precipitated, thus lowering the quality of the product, it is run to waste over a weir. The waste brine is commonly known as bitterns.

During the evaporation of sea water, gypsum is normally deposited in the concentrating ponds, precipitating when the brine density reaches 1.12. The salting point is reached at brine specific gravity of about 1.215. It is normal to control the bitterns density to 1.25 to prevent the precipitation of the remaining solutes, mainly magnesium and potassium salts.

TABLE 11 : METEOROLOGICAL DATA FOR STANSBURY

	Q_a Cal/cm^2/hr.	θ_a °C	P_a mmHg	U mph	Mean Rainfall inches	Mean Evaporation inches	Net Evaporation inches
Jan.	24.8	20.5	9.1	8.9	0.59	8.0	7.4
Feb.	22.5	20.9	9.6	7.9	0.64	6.0	5.4
Mar.	18.0	17.5	9.2	7.5	0.65	5.0	4.3
Apr.	12.9	16.4	9.1	7.1	1.25	3.5	2.2
May	9.6	13.6	8.7	7.2	1.94	2.2	0.3
June	7.5	11.4	8.2	7.3	2.29	1.5	-0.8
July	8.5	10.5	8.0	7.6	2.18	1.7	-0.5
Aug.	11.2	11.5	7.9	8.3	2.06	2.3	0.2
Sept.	15.4	12.6	8.1	8.3	1.72	3.1	1.4
Oct.	18.8	14.8	8.1	8.8	1.49	4.6	3.1
Nov.	23.0	16.1	8.2	8.9	0.90	5.0	4.1
Dec.	24.6	19.1	9.0	8.9	0.68	6.8	6.1
Total					16.39	49.7	33.3

Source of Data 33.

Q_a - taken from charts of average monthly total radiation issued by the Commonwealth Bureau of Meteorology.

Q_a - from 6 year average for Warooka, issued by the Bureau of Meteorology, Adelaide.

P_a - taken as 10% greater than data for Adelaide from the 1960 Year Book.

U - taken as 10% less than data for Adelaide from the 1960 Year Book.

Mean rainfall - 85 year average for Stansbury, issued by the Bureau of Meteorology, Adelaide.

Mean evaporation - interpolated from map, Bureau of Meteorology, Adelaide.

TABLE 12 : CALCULATED EVAPORATION RATES AT STANSBURY

Data expressed in inches of water

Brine Density (gm/ml)	1	1.1	1.15	1.20	1.25
January	7.47	6.8	6.5	5.9	5.3
February	5.76	5.3	4.8	4.5	3.9
March	4.14	4.0	3.7	3.1	2.7
April	3.24	2.7	2.4	2.0	1.7
May	2.16	1.9	1.5	1.1	0.7
June	1.62	1.2	1.0	0.6	0.3
July	1.62	1.2	1.0	0.6	0.2
August	2.70	2.4	2.2	1.7	1.2
September	3.24	2.9	2.6	2.1	1.6
October	5.04	4.3	4.0	3.4	3.0
November	5.76	5.4	5.1	4.5	3.9
December	6.93	6.5	6.2	5.3	5.0
Total	49.68	44.6	41.0	34.8	29.5
Net Evaporation, total	33.3	28.2	24.6	18.4	13.1

TABLE 13 : YEARLY VARIATION IN NET EVAPORATION RATES

Data expressed in inches of water

Chance	Evaporation		Rainfall		Net Evaporation	
	Adelaide	Stansbury	Adelaide	Stansbury	Adelaide	Stansbury
100% better than	46.7	41.2	31.0	24.3	15.7	16.9
90%	50.0	43.7	26.7	21.2	23.3	22.5
80%	53.0	45.7	24.6	19.5	28.4	26.2
70%	55.0	47.7	23.1	18.2	31.9	29.5
60%	56.5	48.7	21.9	17.4	34.6	31.3
50% (Mean)	57.5	49.7	20.9	16.4	36.6	33.3
40%	58.5	50.7	19.5	15.4	39.0	35.3
30%	60.0	51.6	18.1	14.4	41.9	37.2
20%	62.0	53.6	17.1	13.6	44.9	40.0
10%	65.0	56.2	15.3	12.0	49.7	44.2
0	68.9	59.5	10.1	7.9	58.8	51.6

Evaporating an artificial brine of SG = 1.113 equivalent in salts content to the Stansbury brine, no salts are precipitated until the salting point at SG = 1.21 is reached. Pure salt is then deposited firstly, followed, as the density increases, by salt containing gypsum. Indications are that the bitterns should be rejected at SG = 1.22. In order to make a first assessment of the likely production from Weavers Lagoon, the data indicated above have been adopted, i.e.

Inlet brine,	SG = 1.113,	14.2%	by weight NaCl
		0.55%	other salts
		85.25%	water.
Pickle,	SG = 1.21,	26.7%	NaCl
		1.0%	other salts
		72.3%	water.
Bitterns,	SG = 1.22,	24.6%	NaCl
		7.1%	other salts
		68.3%	water.

Rejecting bitterns of this density should provide a product essentially 98% NaCl.

Seepage Rates

For the purposes of this exercise, a seepage rate for a normal lake has been assumed for the concentrating ponds, i.e. a permeability of 10^{-6} cm/sec. Over a 4 month evaporating season, this gives a seepage of 525 tons/acre. A seepage of one half of this has been accepted for the crystallising ponds. These rates are almost equivalent to 10% of the feed rate to the two sections and for the purposes of drawing up a mass balance over the system, 10% has been accepted. If on examination of Weavers Lagoon, much greater permeabilities are found, then consideration must be given to lining the ponds.

Crystalliser

Assuming that brine enters the crystalliser at its salting point and leaves as bitterns of SG 1.22, and assuming that evaporation takes place, depositing salts, from brine of average density we can find the yearly production per 1" evaporation per acre of crystalliser.

1 acre inch of brine of average composition weighs

$$\frac{3630 \times 62.3 \times 1.215}{2000} = 137.5 \text{ S. tons}$$

and is composed of
$0.256 \times 137.5 = 35.4$ S. tons salt
$0.041 \times 137.5 = 5.6$ S. tons other salts
$0.703 \times 137.5 = 96.6$ S. tons water.

Hence 1" nett evaporation will deposit 35.4 S. tons salt per acre of crystalliser.

On the basis of 1" nett evaporation per acre, and considering a seepage rate of 10% of the feed rate of pickle to the crystalliser, the seepage being taken as average composition, we can draw up a mass balance over the crystalliser as follows :

$$P = E_{cry} + B + L_{cry} + S$$
$$0.267P = 0.246B + S + 0.256\, L_{cry}$$
$$0.10P = 0.071B + 0.041\, L_{cry}$$
$$0.763P = 0.683B + E_{cry} + 0.703\, L_{cry}$$

Solving these equations we find

P, the mass flow of pickle	=	162.p S. tons
E_{cry}, the nett evaporation	=	96.6 "
B, the mass flow of bitterns	=	13.7 "
L_{cry}, the seepage flow	=	16.2 "
S, the salt production	=	35.4

Concentrator

If we assume near-ideal conditions in the concentrator, i.e. assume each particle of brine that enters proceeds steadily through the system, becoming progressively more saline owing to evaporation, until the concentrated brine reaches the salting point and leaves as pickle for the crystalliser, and that turbulence causes mixing over the vertical cross section but no mixing in the forwards or backwards direction, then on the basis of 1" nett evaporation per acre of crystalliser, and considering a seepage rate of 10% of the brine feed rate, the seepage being taken as average composition, we can draw up a mass balance over the concentrator as follows :

$$F = E_{conc} + P + L_{con}$$

$$0.142F = p.267P + 0.205\ L_{conc}$$

$$0.0055F = 0.01P + 0.0077\ L_{conc}$$

$$0.8525F = 0.723P + E_{conc} + 0.808\ L_{conc}$$

Solving these equations we find

P, the mass flow of pickle	= 162.0 S. tons
E_{conc}, the nett evaporation	= 160.2 "
F, the mass flow of inlet brine	= 358 "
L_{conc}, the seepage flow	= 35.8 "

The area of concentrator per acre of Crystalliser will be :—

Weight of 1 acre inch of brine in the concentrator

$$= \frac{3630 \times 62.3 \times 1.161}{2000}$$

$$= 131.5 \text{ S. tons}$$

and is composed of (at average density)

0.205 x 131.5	=	27.0 S. tons	salt
0.007 x 131.5	=	0.9 "	other salts
0.788 x 131.5	=	103.5 "	water.

Considering the yearly total nett evaporation from various brine densities we find from Figure 2,

concentrator, average density = 1.161, evaporation ratio = 0.695
crystalliser, " ratio = 1.215, " " = 0.49
i.e. evaporation ratio crystalliser/concentrator = 0.705

on theoretical basis should the ratio be calculated on gross evap figures + gross evaporation figures obtained + then rainfall figures deducted? JMA

Considering 1" nett evaporation from crystalliser :

1" from crystalliser = $\frac{1}{0.705}$ inches from concentrator

Hence evaporation = $\frac{103.5}{0.705}$ = 147 S. tons per acre concentrator.

The required evaporation from the concentrator = 160.2 S. tons
Hence area of concentrator per acre of crystalliser = 1.09 acres.

It should be noted that the relative areas required by the crystalliser and concentrator are influenced by the evaporation ratio between the crystalliser and the concentrator, and this in turn is dependent upon the assumed density of the bitterns. Taking, for example, a bitterns density of 1.25 which is the normal for sea water evaporation, we find for the average crystalliser density of 1.23, an evaporation ratio of 0.44.

i.e. evaporation ratio crystalliser/concentrator = 0.633

Hence per 1" nett evaporation from crystalliser, the evaporation per acre of concentrator = 103.5/0.633 = 164 S, tons

Hence area of concentrator per acre of crystalliser = 0.977 acres.

Although evaporating to a higher density bitterns requires more area of crystalliser for a given total, i.e. concentrator and crystalliser area, it does not necessarily produce more salt because of the lower nett evaporation. The salt production is proportional to the area and to the evaporation rate. So we find that :

$$\frac{\text{Salt production with bitterns SG 1.22}}{\text{Salt production with bitterns SG 1.25}} = \frac{0.49 \times 1.977}{2.209 \times 0.44} = 1.05$$

It should also be understood that the relative evaporation rates between crystalliser and concentrator also vary with season (see Figure 2), and so the relative areas for optimum output also vary with season. We find :

Summer : relative evaporation = 0.875, area of conc. = 1.35 acres/acre cry.

Spring & Autumn ; " " = 0.778, " " " = 1.20 "

Winter : " " = 0.54 " " " = 0.83 "

Yearly total: " " = 0.705 " " " = 1.09 "

If the area is split according to the yearly total ratios, then during summer there will not be enough concentrating area, i.e. if the brine flow is controlled to give pickle at the salting

point then the bitterns density will rise giving rise to further impurities in the product. To prevent this, the crystallising ponds must be drained 2 or 3 times per year and refilled with fresh pickle. This is fairly normal practice in sea water evaporation (6). Alternatively, if the area is split according to the summer evaporation ratios, there will not be enough crystallising area at the beginning and end of the salt season, and salt will be deposited in the concentrator, if brine flow is controlled to keep a constant bitterns density. This salt will be redissolved during the winter months.

Since the production of salt is dependent on the area of the crystalliser, it is preferable to consider the area split according to the yearly total nett evaporation ratios which gives the greater crystalliser area. Part of this crystalliser area should be further subdivided to give a "pickle pond" where salt may or may not be deposited depending upon the season and the weather conditions prevailing at the time.

The total available area in Weavers Lagoon is 576 acres

Hence crystallising area = $\frac{576}{2.1}$ = 274 acres

and concentrating area = 302 acres.

Considering summer conditions, the crystallising area need only be 576/2.35 = 245 acres. So subdivide the 274 acres to give a pickle pond of 29 acres in which salt may or may not be deposited.

In the calculations above concerning the concentrator the ideal condition of no mixing in the direction of flow and perfect mixing in the plane normal to flow was assumed. In fact, mixing in the direction of flow will take place and evaporation will be lower because of the increase in density. The greater the number of ponds, the greater will be the output for a given area. The cost, however, of construction also increases with subdivision of the area, so that an economic balance must be achieved. Free (7) has investigated this problem analytically assuming complete mixing in each pond. The case of an infinite number of ponds in series, each with perfect mixing, is equivalent to the ideal case of a single pond with no mixing in the direction of flow. For the case of evaporating sea water and assuming no leakage Free found that one pond gave 51% of the ideal yield, two ponds gave 81%, and three ponds gave 89%.

Carrying out a similar analysis for the evaporation of Stansbury brines, again assuming for simplicity of calculation that there is no seepage, we find that one pond gives 77% of the ideal yield. Two ponds, with the optimum area ratio such that the first is 72% of the available area, and where the interpond salinity is equivalent to 22% NaCl by weight, gives 90% of the ideal yield. For the three pond system 98% of the ideal yield is achieved. The optimum area distribution is such that area ratios of $1:\frac{1}{2}:\frac{1}{4}$ would be satisfactory. The inter pond salinities are approximately 20% NaCl by weight after the first pond, and 24% after the second.

It is therefore suggested that a three pond system be adopted.

Layout of Area. 39.

The total area of Weavers Lagoon is 576 acres and this is to be subdivided into 302 acres of concentrating ponds and 274 acres of crystallising ponds.

It is suggested that there are three concentrating ponds with series flow of brine through each. The area of the first pond should be 173 acres, the second should be 86 acres and the final pond should be 43 acres.

The crystallising section should be subdivided for convenient harvesting. Parallel flow through the crystalliser is suggested also for convenience in harvesting, so that only one pond need be drained at a time. Individual ponds normally vary between 20 acres or less to more than 60 acres, the size being determined by the capacity of the harvesting machine. With smaller ponds more time is lost in transferring equipment from one pond to another, while with larger ponds salt is left exposed for a longer time, and also a larger percentage of the area is out of production at any time during harvesting. Smaller ponds require more construction with greater capital expenditure.

On the basis of an assumed harvesting machine capable of 200 tons per hour, it is suggested that the minimum subdivision required would be as follows :

1 pickle pond of 29 acres, which depending on weather conditions may or may not provide harvestable salt.

5 crystallising ponds each of 49 acres with parallel flow of brine through each. Each pond should take approximately one week to harvest.

Annual Production from Weavers Lagoon

The salt production per 1" evaporation from 1 acre of crystalliser is 35.4 S. tons (derived above).

The mean yearly nett evaporation from brine of density 1.215 is 0.49 x 33.3 = 16.3" i.e. nett evaporation from crystalliser.

Hence the annual production of salt = 35.4 x 16.3 x 274
= 158,000 S. tons.

A mass balance can be drawn up over the system, and is given in Figure 4, based on mean yearly nett evaporation.

It must be realised that because of weather fluctuations there will be a yearly fluctuation in output. Using the data on yearly deviations given in Table 13 a probability curve for production can be obtained, and this is presented in Figure 5. It can be seen that yearly output can vary between 75,000 S. tons minimum and 280,000 S. tons maximum. There is a 90% probability that the production will be better than 107,000 S. tons per annum.

Harvesting.

The mean annual salt production per acre = 35.4 x 16.3
= 576 S tons. = 514 long Tons

A layer of 1" thickness of salt weighs 123 S. tons per acre. = 110 long tons
Hence, the mean thickness of salt cake = 4.7 inches. This is an adequate thickness of cake to enable the use of a mechanical harvester. Limiting the harvesting period to 6 weeks and assuming 6 ponds i.e. 1 week per pond, and allowing $1\frac{1}{2}$ days per pond for draining and transfer of harvesting machinery, then actual harvesting time available = 6 x $5\frac{1}{2}$ = 33 days

Hence required capacity of harvester = $\frac{158,000}{33 \times 24}$ = 200 S.tons/hr.

From an examination of Figure 3, it is apparent that harvesting must start early in March to be completed before the nett evaporation becomes negative. Each crystallising pond should be refilled with pickle after harvesting.

Control of Evaporating System.

The operation must be controlled to keep a constant bitterns composition and thereby prevent the deposition of bittern salts. At the same time, to make maximum use of the crystallising area, the concentration of the pickle supplied from the concentrating ponds must be kept at or near the salting point. It is impossible to achieve both of these aims because of the varying evaporation ratio between crystalliser and concentrator, and in practice a mid-position between these ideals should be attained with possible draining and refilling of the crystallisers. Control is achieved by pumping the inlet brine to keep a constant level throughout the concentrators, replacing the pickle drawn off to the crystallisers and the evaporation. Pickle is transferred from the concentrators to the crystallisers, either by gravity flow if the ponds are of the same depth or by pumping, to keep constant level in the crystallisers. Bitterns are removed from the system by overflow over a weir of adjustable height. If the bittern density rises, the weir must be lowered to increase the flow to waste, and vice versa.

The slow recovery from changes makes it impossible to obtain good control by adjusting the bitterns flow rate to correct trends away from the target value. Because of the not inconsiderable time factor it is necessary to anticipate seasonal changes in order to achieve optimum control. Thereafter, minor changes will only be necessary to correct long-term drifts from the target density.

The mean monthly interpond flow rates have therefore been calculated and are shown in Figure 6, and should enable the operator to set his rates so that only slight adjustments are needed to obtain optimum output.

The maximum pumping rate of inlet brine will be required during rapid filling of the system. For example, to fill the concentrating ponds at a rate of 12" per week requires a rate of 8500 gpm. Hence, the installation of two 5000 gpm. pumps should be considered, both of which will only be needed for rapid filling. During normal operation one pump will be on service, level controlled, to keep a constant level in the concentrator, with the other pump as a stand-by.

The maximum pumping rate of pickle to the crystallisers (if pumping is necessary) will be in refilling one pond quickly after harvesting or after draining off bitterns because of high density. Normal flow to the other crystallising ponds must also be fulfilled. To fill one pond to a depth of 12" in one week requires a flow of 1500 gpm. The normal flow to the other pond might be as high as 1000 gpm, so the installation of two 1500 gpm pumps should be considered, only one normally being required.

Depth of Brine in Ponds.

Evaporation rates are affected by brine depth for ponds shallower than about 3 feet (4), the shallower ponds giving lower evaporation rates because of reflection of solar energy from the bottom of the pond. This applies particularly to the crystallisers where the deposit of salt provides a good reflecting surface. Bloch (8) et al showed that evaporation rates from a 20" depth were about 16% higher than those for an 8" depth. By adding sufficient 2-naphthol green dye to the evaporimeter, evaporation rates were nearly independent of depth. For example, concentrations of 20 grams per cubic meter gave less than 5% difference between a 20" and a 8" depth.

However, although deep ponds are preferable from the point of view of evaporation rates, deep ponds are undesirable owing

to the high construction costs and to increased seepage. Deeper ponds also mean a longer time interval before salt is deposited in a newly filled system, and a longer recovery time after changes in the bittern flow rate. To avoid high construction costs, the pond depth will be determined mainly by the existing bed of Weavers Lagoon. A depth of between 1 and 2 feet should be aimed at, although if the cyrstallisers are only 1 ft. deep then the addition of a dye should be considered to obtain maximum output (9).

ECONOMIC ANALYSIS

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This section is directed toward revising the hypothetical analysis presented by the sponsor in " Preliminary Report on Saline Minerals in Australia " (R. C. Sprigg, February,1968). Capital and operating costs were assumed in that report to illustrate the approximate economic return the project might offer. The costs assumed hereunder are presented for a similar purpose and are not supported by any detailed engineering investigations. A project life of ten years is assumed, commencing 1970.

(a) Capital Costs

1.	Three wells	$300,000
2.	Casing and production tubing	60,000
3.	Pumps	50,000
4.	Harvesting machines, vehicles,materials handling equipment at Weavers Lagoon	60,000
5.	Modifications,land acquisition, materials handling equipment,buildings at Port Giles	50,000
6.	Purchase or acquisition of other land	20,000
7.	Buildings at Weavers Lagoon	20,000
8.	Construction of ponds and dykes	400 , 000
9.	Contingencies	40,000
		$1,000,000

Construction of ponds, dykes and weirs will be a major cost,and barrierswill be necessary to prevent run-off water entering the lagoon. This cost is the principal departure from the earlier analysis.

(b) Operating Expenses per Annum.

These are taken as originally postulated except for depreciation which will be (for a 10 year project) $100,000. The straight-line depreciation gives a better result than the reducing balance

method in this case. Therefore, annual operating costs will be $250,000. The cash operating expenses of $150,000 are assumed to rise at 3% per year.

150

(c) Revenue

Average annual production would be 158,000 short tons based on the preliminary conceptual design. Prices are assumed to be $2.50 per short ton in 1970, falling to $2.00 per short ton by 1975; thereafter remaining at $2.00 through 1980. Annual revenues will therefore be :-

Year	Tonnage	Price per ton	Annual Revenue
1970	158,000	$2.50	$395,000
1971	"	2.40	379,000
1972	"	2.30	363,000
1973	"	2.20	344,000
1974	"	2.10	331,000
1975-80	"	2.00	316,000

(d) Discounted Cash Flow

The approximate annual cash flows are shown in Table 14 using a company tax rate of 45%. The initial 20% investment allowance is included, but special deductions which might be obtained have been neglected. The cash flows are discounted below, revealing the prospective rate of return to be 9% approximately.

Discounted Cash Flow Calculation

Year	Cash Inflow (Outflow)	Discount Factor @ 9%	Discounted Cash Flow
0	(1000)	1.0000	(1000)
1	245	0.9174	225
2	225	0.8417	189
3	172	0.7722	133
4	133	0.7084	94
5	126	0.6499	82
6	114	0.5963	68
7	118	0.5470	65
8	114	0.5019	57
9	112	0.4604	52
10	108	0.4224	46
11	(9)	0.3875	(3)
	458		8

45.

TABLE 14 : YORKE PENINSULA SALT PRODUCTION ANNUAL CASH FLOWS FOR 10 YEARS ($,000)

(Taxes paid one year in arrears).

Year	0	1	2	3	4	5	6	7	8	9	10	11
Revenue		395	379	363	344	331	316	316	316	316	316	31
Depreciation		(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	0
Cash Operating Expenses		(150)	(154)	(159)	(164)	(169)	(174)	(179)	(185)	(190)	(196)	20
Pre tax Profit		145	125	104	80	62	42	37	31	26	20	11
Investment Allowance		(145)	(55)	-	-	-	-	-	-	-	-	-
Taxable Income		-	70	104	80	62	42	37	31	26	20	11
Tax @ 45%		-	-	(32)	(47)	(36)	(28)	(19)	(17)	(14)	(12)	(9)
After Tax Profit		-	70	72	33	26	14	18	14	12	8	(9)
Add back :Depreciation		100	100	100	100	100	100	100	100	100	100	-
Invest. allwnce.		145	55	-	-	-	-	-	-	-	-	-
Cash Flow		245	225	172	133	126	114	118	114	112	108	(9)
Capital Cost	(1000)											

This rate of return is too low to make the project attractive. Depending upon a wide variety of factors, the cost of capital for this project could be approximately 9%. The venture, therefore, does not have a nett present value and offers no extra cover against the considerable risks which would be encountered. 152

The above discounted cash flow analysis incorporates several critical assumptions which might not hold in practice :

1. All salt produced in a given year is sold in that year. In fact, the majority of the salt may not be salable unless long-term contracts could be arranged with Japanese consumers. The principal Japanese users have aligned themselves with the W. A. projects and this, together with the over-supply conditions which are likely to prevail during 1970-80, will make long-term contracts extremely difficult to obtain.

2. Each year's revenue is based on the average salt yield. This is unrealistic and some storage would be necessary from bumper years to meet contracted obligations in lean years.

3. All equipment is assumed to last 10 years with appropriate maintenance. In practice, further capital expenditure might be necessary during the project's life.

4. Because of seasonal production fluctuations, the company could make a loss in any given year. This would alter the taxation liability and hence the cash flow.

5. The capital and operating costs are very approximate. Both figures should be regarded as minima since they are not supported by detailed engineering investigations.

6. No "start-up" difficulties have been built into the analysis. As with most new ventures it would be prudent to allow for operating difficulties in the early stages. This is particularly true here, where no exact claypan permeability or brine pumping data have been obtained.

The items listed above (except for number 4) show how vulnerable the project would be to adverse occurrences which could reduce revenue or increase costs. There is not a sufficient cushion of profitability to enable the venture to withstand unfavourable conditions.

Lastly, and perhaps most important, the poor rate of return makes the project unattractive. Other investment alternatives should be available to the sponsor which offer a much better rate of return.

15

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2. MYERS, D. M. & BONYTHON, C.W., "The Theory of Recovering Salt from Sea Water by Solar Evaporation", J. Appl. Chem 8, April 1958 pp 207-219.

3. PENMAN, H.L., "Natural Evaporation from Open Water, Rare Soil and Grass", Proc. Roy. Soc. A193, 1948, pp 120-145.

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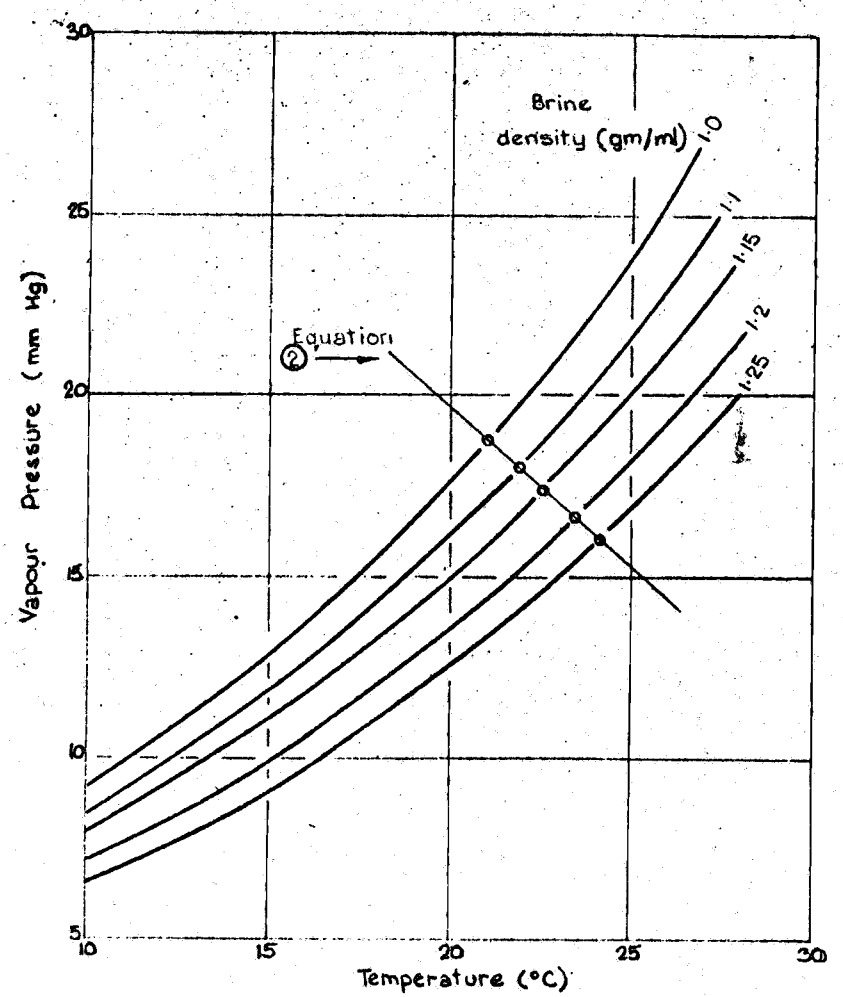


FIG.1: VAPOUR, TEMPERATURE CHART FOR SOLVING EQUATION (2)

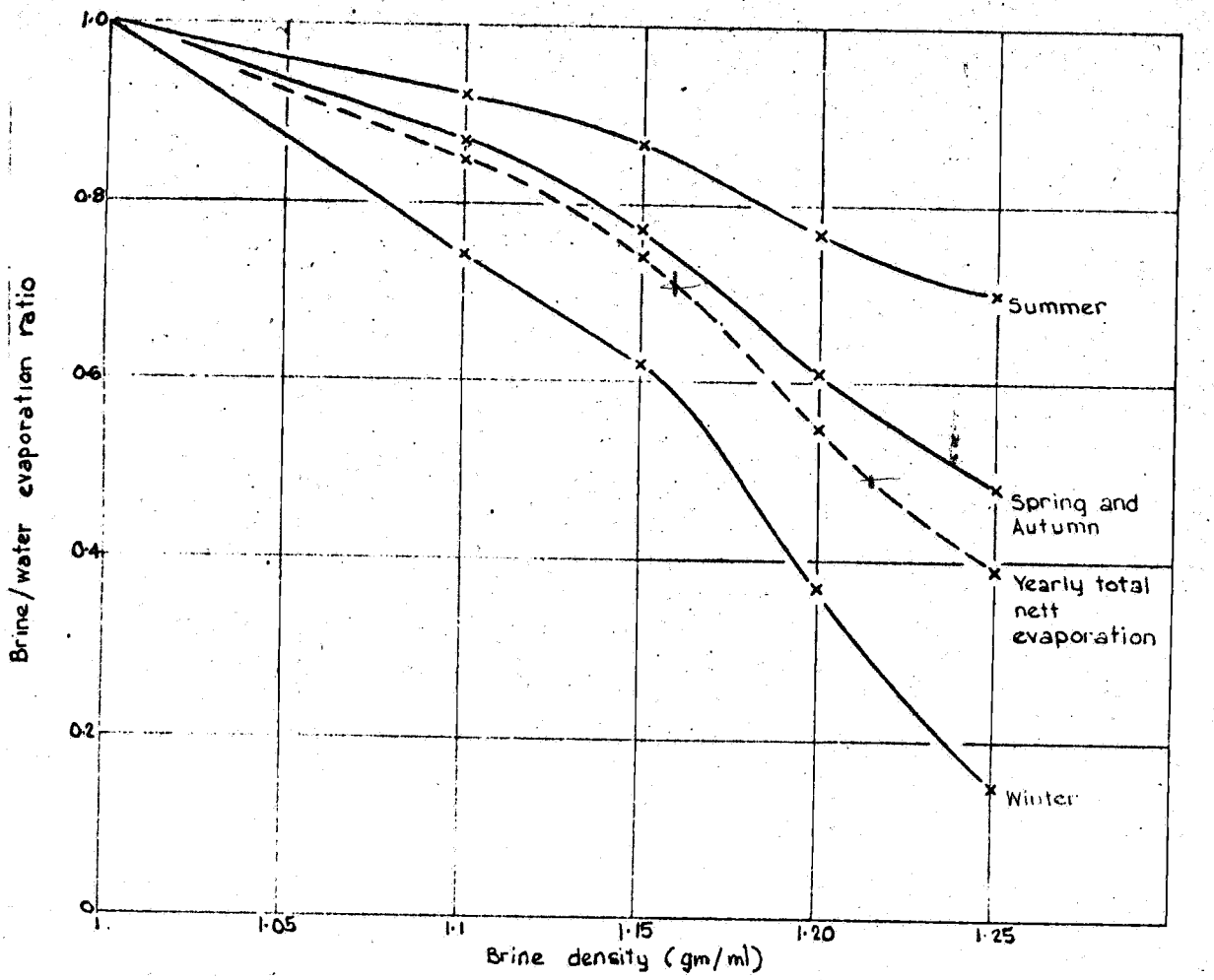


FIG.2: VARIATION OF EVAPORATION RATIO WITH BRINE DENSITY

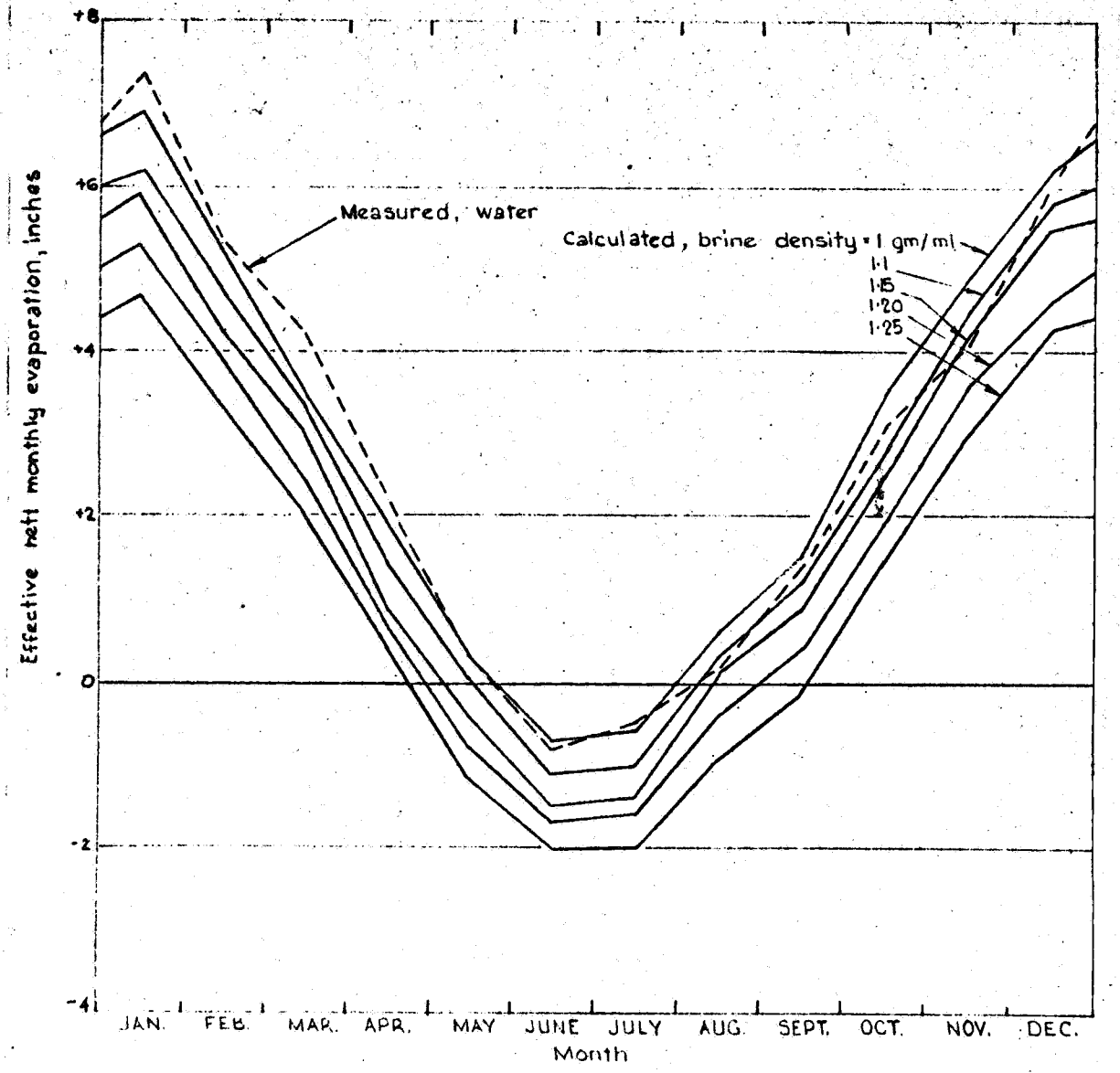


FIG.3: EFFECTIVE NET MONTHLY EVAPORATION

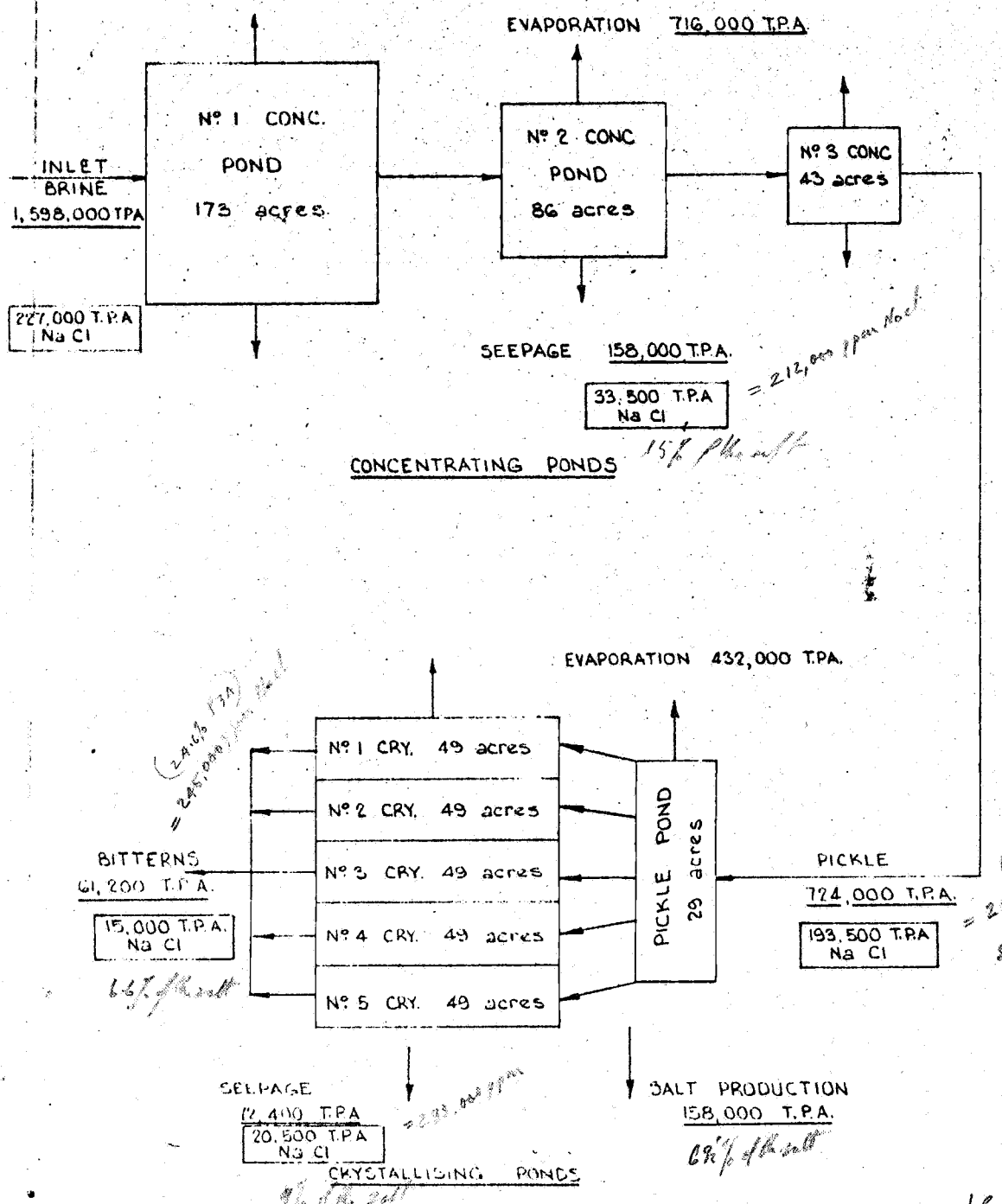


FIG.4: FLOW DIAGRAM AND MASS BALANCE

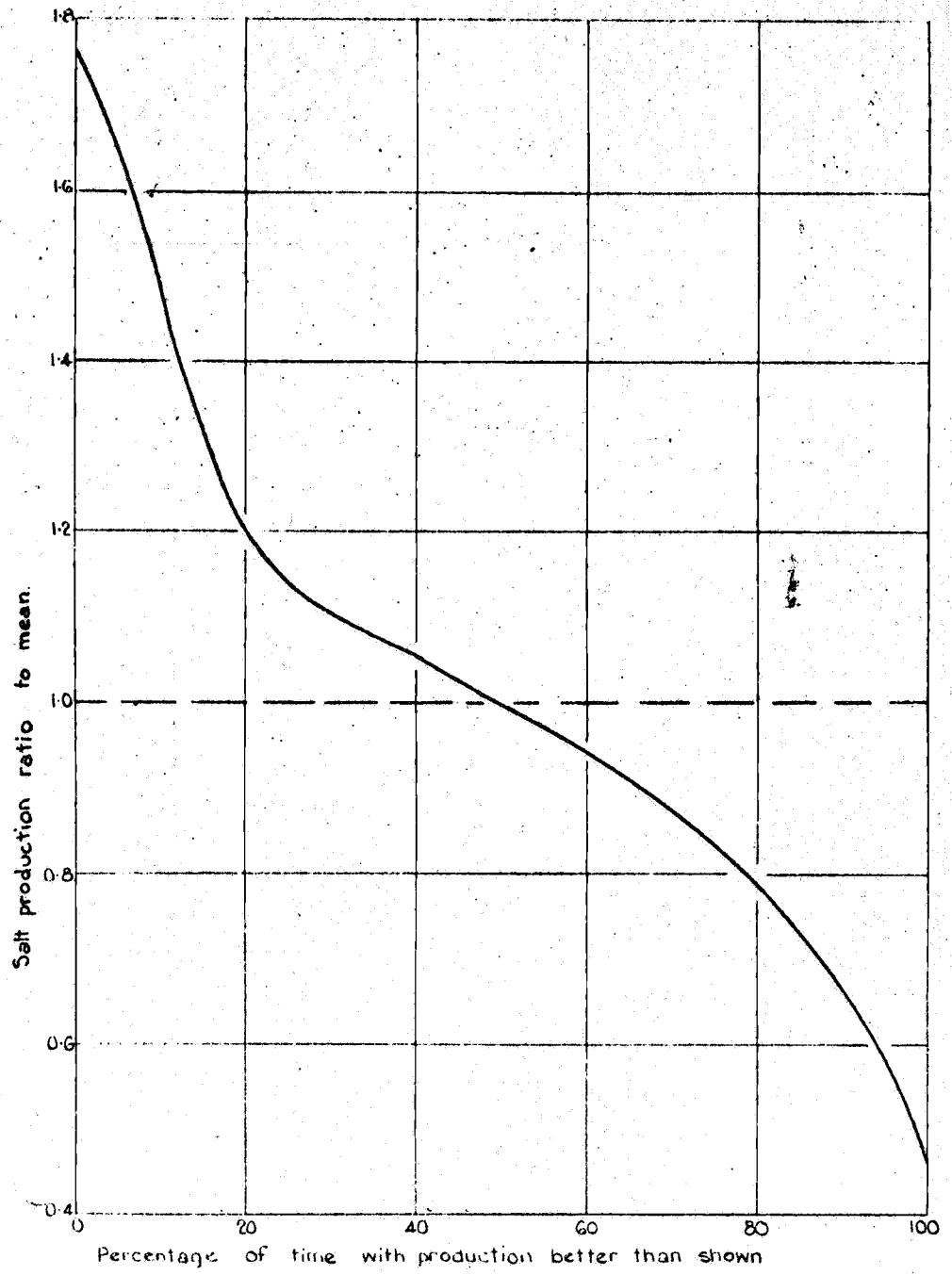


FIG.5: SALT PRODUCTION PROBABILITY CURVE

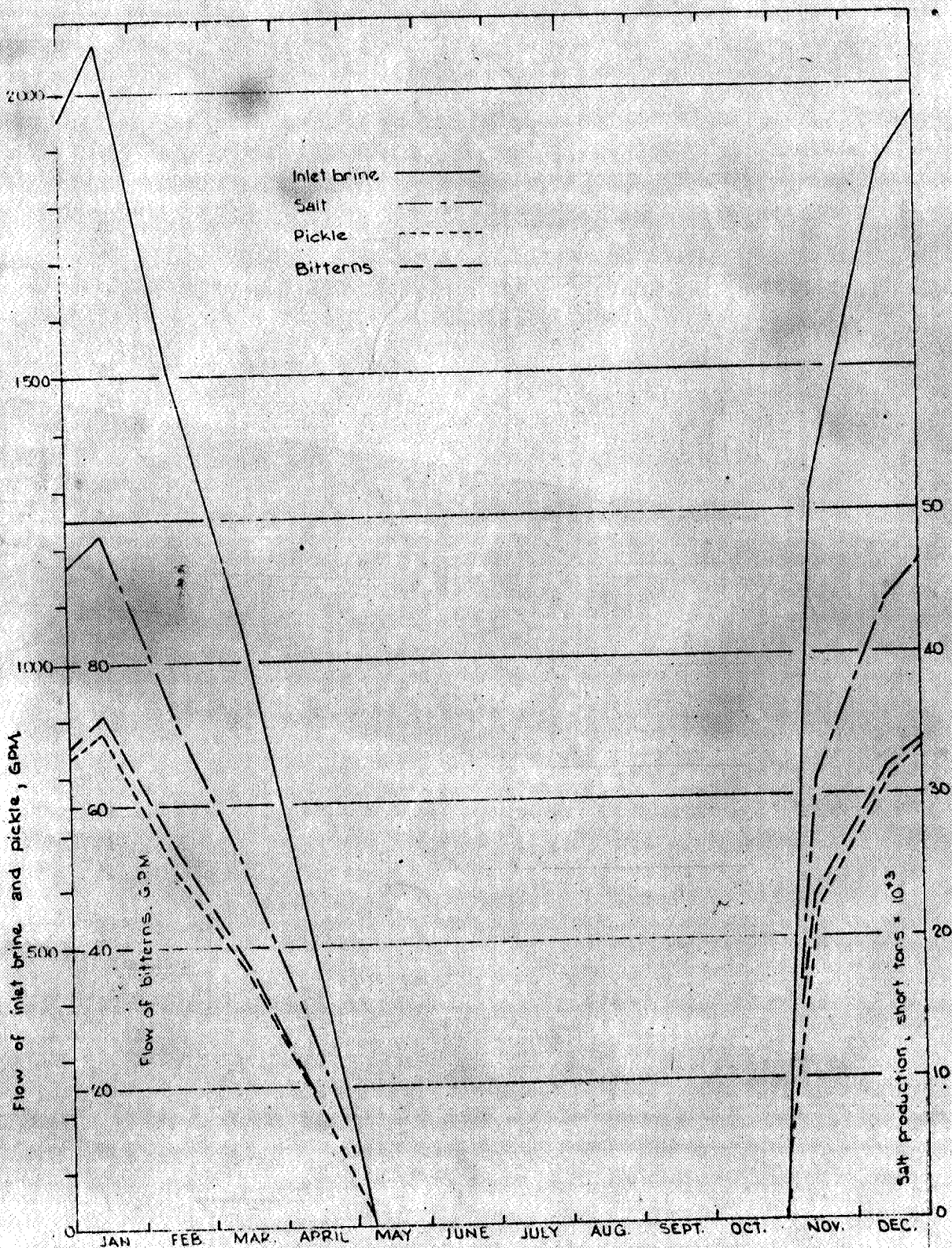


FIG. 6: MONTHLY INTERPOND FLOW RATES AND SALT PRODUCTION

Comments on the I.T.S. Report on
Yorke Peninsula Salt Prospects

J. Madsen
M.D.E.

P 29. only up to 40% of the total Nacl can be obtained at 99% grade
but 80% . . . . . = 98% "

This has been taken from Table 10 but does not allow for the mixing of the salt during harvesting the whole thickness
Using the average grade 90% of the total salt will average 99% grade
(94% . . . . . 98.93% ")

? Should water of crystallisation be included in calculations for 94% sum ? ?
(Fraction 3 seems to contain excess $CaSO_4$ judging by the trends)

P 33. assumptions

(a the mean temps from Meteorology for Warooka
on those actual mean temperatures = mean of max temps)

?a is this actually av humidity or av of humidities at max temp
10% greater seems to be offset right

U wind vel is 10% less than adelaide justified

P 34

refers to data indicated above as being taken
but Inlet brine taken as SG = 113 with 14.2% Nacl + 5.5% other salts
Why? { which Inlet completed on SG = 113 with 15.8% Nacl + 5.9% other salts

Page 35

Seepage only taken over 4 month Evap season but concentrating ponds will be partially full for the whole 12 months
so is 10% assumption justified
also when seepage does occur is it the heavier brine which escapes?

Check with Brick - not evap.
Check with Mel. 1.

6. Env 1069

162

RECEIVED
9 JUN 1969

REPORT ON

ENGINEERING INVESTIGATIONS

CONNECTED WITH THE RECOVERY

OF BRINES

IN DEEP DOLOMITES

IN THE WEAVER'S LAGOON AREA.

P U M P I N G:

The pumping of brines from deep dolomites posed several mechanical problems for which at this time no clear cut answer was available for economic recovery. Several methods were studied as to probability, and the advice of the South Australian Mines Department was sought to discover what they believed to be the most feasible method of recovery.

Following the suggestions of the South Australian Mines Department we investigated the practicability of using air lift as this seemed to present the most feasible means of giving the longest machinery operating life, as all of the pumping equipment would be situated on the surface and out of contact with the highly corrosive 17% brine to be pumped. An experimental bore was equipped at the Woodville laboratories with a special aerating head to allow feasibility to be studied directly.

Attached are photostat copies of our investigation covering air compressor equipment, for the purpose of pumping the said brines.

D R I L L I N G:

Further advice was sought from the South Australian Mines Department with regard to the method they would propose using for drilling, and the calculation here was that the best method would be by air drilling.

Tenders called for the drilling of such holes as would be required to intersect the dolomites were: -

Drilling Contractors (Aust.) Pty. Ltd.
Richter Bawden Pty. Ltd.
Oil Drilling and Exploration Ltd.

Further to this a visit was made to Alice Springs to inspect a drill rig operated by Oil Drilling and Exploration Ltd. on the Magellan's Lease in the Northern Territory to discover whether in fact this machinery would suit our needs. This rig, while operated with both mud pump and compressed air was considered to be a trifle large for the project, but did offer the requirement of compressed air which was felt to be particularly important to minimise the troubles that could ensue in drilling with mud.

C A S I N G:

Further difficulties were anticipated in the casing of the hole as again the highly corrosive nature of the brine would result in rapid deterioration of such casing. Once again advice was sought from the South Australian Mines Department, who put us in contact with a local manufacturer of epoxy resin fibreglass bore case which at this time was proposed to be manufactured in Australia.

Subsequently to our investigations for the supply of locally manufactured casing, the supplier found it not possible to continue with manufacture.
A market research was undertaken to establish an answer to this problem. Advice was sought from overseas suppliers, and replies were received from vendors of such specialised bore casing (see annexure). The successful setting by cement of plastic bore casing into the dolomites was investigated with Dyckerhoff (see annexure).

P O R T H A N D L I N G F A C I L I T I E S:

A study was made of various port handling facilities at Ballast Head, Ardrossan, and the new port complex at Port Giles, all with the object of deciding finally on the configuration that would be required in establishing an outward shipping complex at Port Giles.

Discussions have taken place between the South Australian Harbours Board Engineers and ourselves, with regard to the port complex at Port Giles and its suitability with regard to tonnages that would be needed to be shipped.

Plans were brought to a preformative stage in what would be required engineering-wise to effect such an outward shipping port at Port Giles, bearing in mind what had been done at Ardrossan and Ballast Head.

Yorke Peninsula local and Interstate haulage contractors have been contacted with regard to road transport of salt to Port Giles and a round term figure of 35 cents per ton mile has been established as a transport cost for haulage from the Weaver's area to Port Giles.

On production techniques and general feasibility, the Australian Salt Company was contacted and several meetings took place where these problems were discussed.

Visits were paid to salt production at Whyalla, Pirie and Peesey Swamp to observe production methods.

M A R K E T I N G:

Marketing problems associated with the sale of salt and inspections of the area by representatives of Mitsubishi and Gollins were also undertaken during this period.

D. H. A. von Sanden
OPERATIONS MANAGER.

DVS:hjr

5th December, 1968.

The Manager,
Richter Bauden Pty. Limited,
Perry House,
129 Elizabeth Street,
B R I S B A N E. Qld.4000

Dear Sir,

Drilling Yorke Peninsula, S.A. - Stansbury Brines

The enclosed map, GSO.499 indicates an approximate position for a drilling programme of up to 3 holes. The access to the area is by good roads with all necessary services being available including Hotel accommodation only a few miles away from the Drill sites.

The enclosed Well Log No. BP379-1 and 2 is the Stansbury West No. 1 which is also positioned on the above map. The log shows Kulpara Dolomites intersected at 4220 feet. We are interested in the commercial recovery of brines from this section. You will note that the Dolomite measure extends to 5375 feet in the Log.

Just how far we will penetrate into this zone of interest would depend on the porosity, and therefore the flow rate of the brines emanating from it. Our requirements would be some 400 thousand gallons per day.

After entering the Dolomites there would be a testing period lasting some days to establish pumping feasibilities and volumes. This would determine the programme for ensuing holes as from the first hole and then subsequently again from the second to the third hole.

Provisions would be required for both air and mud drilling as the flow testing would require air pumping of the brine solution. We could of course, at the same time, take advantage of the air situation, and use it for drilling where this was applicable.

(continued)

Richter Bawden Pty. Limited (continued) 5th December, 1968

The casing programme would be such that a special fibreglass polyester or epoxy pipe of 9" O.D. is to be accommodated as a final conductor for the brine to the surface. The plastic casing would have to be cemented into the top section of the dolomites at 4,200 feet approximately to cut off the aquifers in the limestone which would act as a thief zone for the brines we are interested in harvesting.

Maybe this is as far as we need go in explanation at this time. We would be interested to have your reactions for the proposal so far.

Yours faithfully,
GEOSURVEYS OF AUSTRALIA PTY. LTD.

D.H.A. von Sanden,
OPERATIONS MANAGER.

Encl: GEO.499 Map
Well Log BP379-1/2

P.O. BOX No. 2197, BRISBANE, Q. 4001
Cables and Telegrams : "RICDRILL" BRISBANE
Telephone : 2 2851. Telex : AA 40352

RICHTER BAWDEN DRILLING PTY. LTD.

3rd FLOOR, PERRY HOUSE,
ELIZABETH AND ALBERT STREETS,
BRISBANE, QUEENSLAND

December 30, 1968

Geosurveys of Australia Pty.Ltd.,
G.P.O. Box 1479L,
ADELAIDE 5000

ATTENTION: Mr.D.H.A. von Sanden

Dear Sir,

re: Drilling Yorke Peninsula, S.A.-Stansbury Brines

Reference is made to your letter dated 5th December, 1968 and to our acknowledgement of same. We regret the delay in following up your enquiry but our technical staff have been fully occupied with the Marlin platform gas blowout.

We will be contacting you again just as soon as personnel can be released from the Bass Strait operations.

Yours faithfully,
RICHTER BAWDEN DRILLING PTY.LTD.

G.W.Rogerson
Commercial Manager

DVS:hjr

26th November, 1968.

Mr. G. Richards,
Drilling Contractors (Aust.) Pty. Ltd.,
199 Churchill Road,
PROSPECT. SA.5082

Dear Sir,

Drilling Yorke Peninsula, S.A. - Stansbury Brines

The enclosed map GEO.499 indicates an approximate position for a drilling programme of up to 3 holes. The access to the area is by good roads with all necessary services being available including Hotel accommodation only a few miles away from the drill sites.

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Provisions would be required for both air and mud drilling as the flow testing would require air pumping of the brine solution. We could of course, at the same time, take advantage of the air situation, and use it for drilling where this was applicable.

The casing programme would be such that a special fibreglass polyester or epoxy pipe of 9" O.D. is to be accommodated as a final conductor for the brine to the surface. The steel casing would have to be cemented into the top section of the dolomites at 4,200 feet approximately, to cut off the aquifers in the limestone which would act as a thief zone for the brines we are interested in harvesting.

(continued)

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Yours faithfully,
GEOSURVEYS OF AUSTRALIA PTY. LIMITED.

D.H.A. von Sanden,
OPERATIONS MANAGER

Encl: B.P.379/1
379/2
GMD.499

SOUTHERN YORKE PENINSULA

SHOWING LIMIT OF

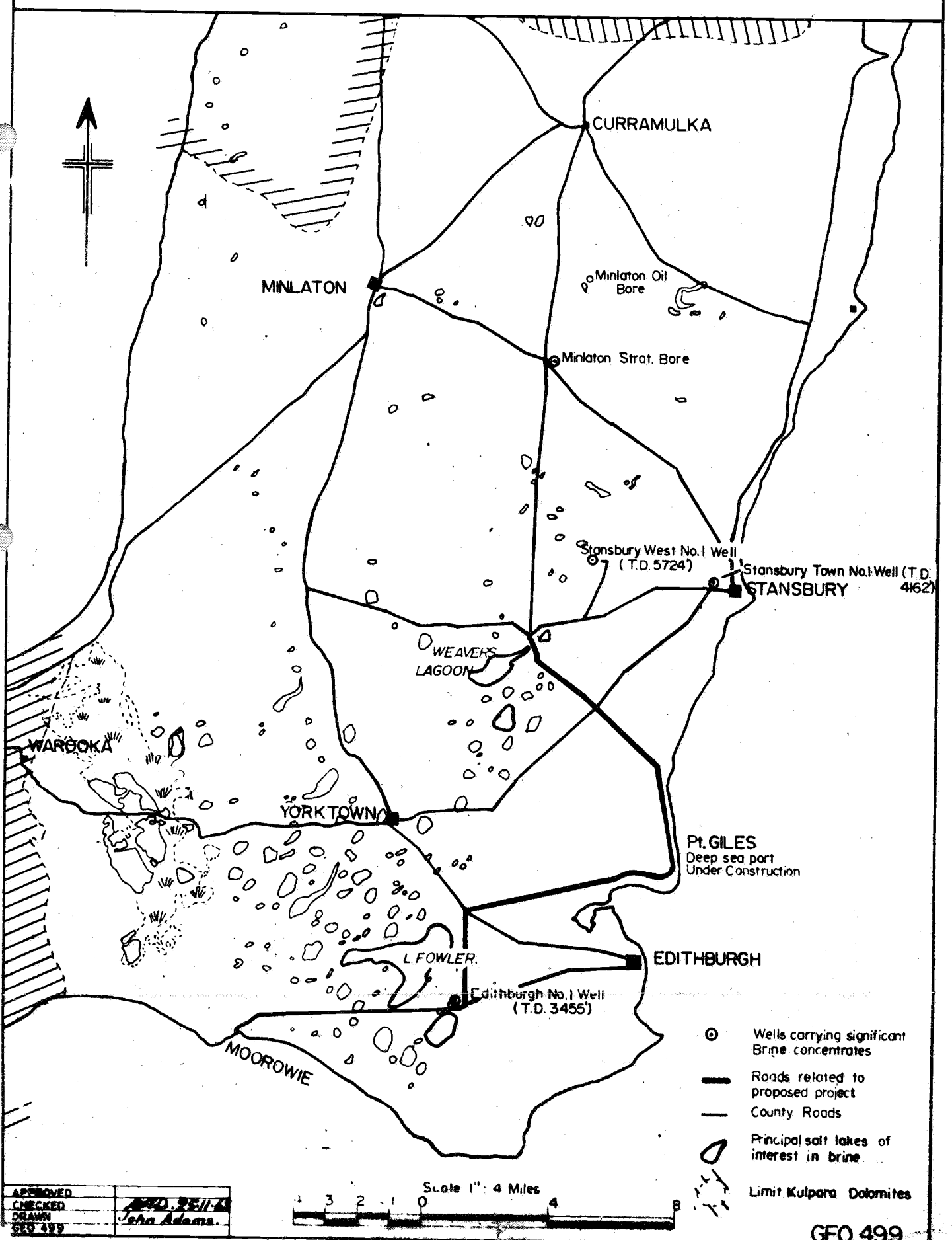
SPECIAL MINING LEASE NO. 187

in relation to

REGIONAL EXTENT OF BRINE CARRYUP

KULPARA DOLOMITE FORMATION.

170



APPROVED	
CHECKED	A.G.D. 25-11-68
DRAWN	John Adams.
GEO 499	

GEO 499

DRILLING CONTRACTORS (AUSTRALIA) PTY. LIMITED

OIL WELL DRILLING CONTRACTORS
Members of ODCAA

168-170 KENT STREET.
SYDNEY 2000
TELEPHONE 27 3381
Cables Address 'Drilcon' Sydney
Offices at Perth and Adelaide

Mr. D.H.A. von Sanden,
Operations Manager,
Geosurveys of Australia Pty. Ltd.
G.P.O. Box 1479L,
ADELAIDE S.A. 5001

Dear Mr. von Sanden,

We must apologise for not having written to you earlier in reply to your letter of November 26, 1968 which referred to your drilling programme on Yorke Peninsula, S.A. for the recovery of Stansbury Brines.

Your programme interests us and we have been trying to develop the most economic proposal possible, but unfortunately this has taken longer than expected.

However, we are now able to offer you for this work a "Drive In" Ideco Rambler DIR550 Rig which we consider will be adequate and economical for the programme planned.

This rig is owned by Clarence River Basin Oil Company and may shortly be used to drill a shallow hole near Grafton, N.S.W., but drilling time for this hole should be not longer than 15 days.

The depth rating for the DIR550 is 6,000 feet with 3½" pipe.

Operating rates for the use of this rig with full crews would be:

Drilling rate	$900/day
Moving Rig, Rig up Rig down	$700/day
Production Testing	$700/day

Positioning of the rig from Grafton to the first location on Yorke Peninsular and return to Grafton from the last location would be chargeable to you at cost. We will try to establish a firm price for these moves and as there is only approximately 140 tons of equipment for haulage, the total charge should not exceed $12,000.

Your company would also pay costs for the following, although Drilcon could arrange for the supply or service as required.

Accommodation for personnel
Fuel
Water
Mud
Air Compressors
Rock Bits
Casing
Cement and Cementing Service
Wellhead and Surface equipment
Site preparation and cleanup
Access Road

Our National 50A may also be available for this work and should this larger rig be preferred, the rates would be as follows:

Drilling rate	$1,100/day
Moving Rig, Rig Up Rig Down	$ 700/day
Rig Up to Spud	$4,200
Rig Down on Last Location	$1,400
Production Testing	$700/day
Positioning to Location	$15,500

Costs for the supplies and services as referred to above would remain the responsibility of and be payable by your company.

Air compressors could be hired from Intairdril for flow testing of the brine solution and if economical, could also be used for drilling.

Our drilling superintendent, Mr. Joe Watson, is resident in Adelaide and will be available at your convenience to discuss the drilling programme and to inspect the locations.

We hope that you will be interested in the DIR550 Rig and that we can be of further service to you.

Yours very truly
DRILLING CONTRACTORS (AUSTRALIA) PTY. LIMITED

A.G. Harris
MANAGING DIRECTOR

DVB:gg 16th September 1968.

The Manager,
Oil Drilling & Exploration Ltd.,
Greenwattle Street,
TOOWOOMBA. Q.4350

Dear Sir,

DRILLING YORKE PENINSULA, S.A. - STANSBURY BRINES.

The enclosed map GEC.499 indicates an approximate position for a drilling programme of up to 3 holes. The access to the area is by good roads with all necessary services being available including Hotel accommodation only a few miles away from the Drill sites.

The enclosed Well Log No. BP379-1 and 2 is the Stansbury West No. 1 which is also positioned on the above map. The Log shows Kulpara Dolomites intersected at 4220 feet. We are interested in the commercial recovery of brines from this section. You will note that the Dolomite measure extends to 5375 feet in the Log.

Just how far we will penetrate into this zone of interest would depend on the porosity, and therefore the flow rate of the brines emanating from it. Our requirements would be some 400 thousand gallons per day.

After entering the Dolomites there would be a testing period lasting some days to establish pumping feasibilities and volumes. This would determine the programme for ensuing holes as from the first hole and then subsequently again from the second to the third hole.

Provisions would be required for both air and mud drilling as the flow testing would require air pumping of the brine solution. We could, of course at the same time, take advantage of the air situation, and use it for drilling where this was applicable.

The casing programme would be such that a special fibre-glass polyester or epoxy pipe of 9" O.D. is to be accommodated as a final conductor for the brine to the surface. The steel casing would have to be cemented into the top section of the dolomites at 4,200 feet approximately to cut off the aquifers in the limestone which would act as a thief zone for the brines we are interested in harvesting.

.....2

Maybe this is as far as we need go in explanation at this time. We would be interested to have your reactions for the proposal so far.

Yours faithfully,

GEOSURVEYS OF AUSTRALIA PTY. LIMITED.

D.H.A. von Sanden,
Operations Manager.

Encls. 3

OIL DRILLING & EXPLORATION (N.T.) PTY. LTD.

(Incorporated in New South Wales)

RAILWAY TERRACE, ALICE SPRINGS, N.T., AUSTRALIA

Telephones: 21-784, 21-154 Cables: "Oildril" Alice Springs

Head Office:
93 York Street, Sydney, N.S.W.
Telephone: 29 7961-3

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KRS/CS

11th October, 1968.

Mr. D.H.A. von Sanden,
Operations Manager,
Geosurveys of Australia Pty. Ltd.,
G.P.O. Box 1479 L,
ADELAIDE, S.A. 5001

Dear Sir,

We regret the delay in responding to your letter of September 16th and now have pleasure in submitting our proposal for drilling your Stansbury brine wells.

We have based our proposition on using our National T32 Rig # 4, which is at present located at Tyler # 1 location in the Northern Territory.

We have studied Well Log No. BP 379-1 and 2 and believe the programme you envisage would best be drilled with air circulation. We have therefore based our proposal on the use of this medium. Details of mud circulation system available with Rig # 4 are also shown for your information. The drilling programme we suggest to enable you to run 9" O.D. epoxy pipe would be as follows:-

Conductor	0 - 30' Drill 24" hole set 16" O.D. x $\frac{1}{4}$" wall conductor pipe.
Top of Dolomites	30' - 4220' Drill 13-3/4" hole set 10-3/4" O.D. J55 casing.
To T.D.	4220' - T.D. Drill 9-7/8" open hole.

This is a very tentative programme, requiring correlation between materials available and proposed starting date. It may be deemed more practical and economic to use 13-3/8" or 9-5/8" casing as the basis of your programme.

. ../2.

For the initial well we are quoting on a daywork basis, but would be pleased to consider a footage rate for any subsequent wells of this nature.

FLAT RATE CHARGES

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A.	Firm rate to position T32 rig and ancillary equipment	$12,000.00
B.	Rig up at first and subsequent locations	$3,200.00
C.	Rig down at first and subsequent locations	$2,400.00
D.	Move rig between locations	At Cost
E.	Transport rig from last location to Port Augusta, or other depositioning point to be specified by contractor	$6,000.00

DAYWORK DRILLING RATE

1.	Rate with drill pipe	$54.00 per hour
2.	Rate without drill pipe	$50.00 per hour
3.	Standby with crews	$800.00 per day
4.	Standby without crews	$400.00 per day

CONTRACTOR TO PROVIDE

1. T32 rig and ancillary equipment as described in attached list of major components.
2. Lubricants for T32 rig and ancillary equipment.
3. Maintenance parts for T32 rig.
4. Workers' Compensation Insurance, Rig Insurance and $1,000,000 Public Liability Cover.
5. Oilfield Truck to rig up and rig down.

...../3.

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OPERATOR TO PROVIDE

1.	Site prepared, with cellar sump and access road	ODE can provide at cost
2.	Water supply to location	ODE can provide at cost
3.	Fuel supply for engines	At cost
4.	Accommodation for drilling crews at camp	At cost. Local hotel estimate $120 daily
5.	Transportation of consumable items, additional plant from source of supply	Chargeable at cost
6.	Consumables including casing, bits, coreheads, barites, mud and chemical materials, cement and additives, lost circulation material etc.	Available from Oilfield Supply Pty. Ltd.
7.	Hole opener cutters, stabiliser rubbers etc.	Available from Oilfield Supply Pty.Ltd.
8.	Engineering supervision and wellsite geologists.	
9.	Logging, testing, cementing and associated well services.	
10.	Radio communication.	

GENERAL

1. CREW:

O.D.E. will provide four(4) crews comprising:-

1	Toolpusher
4	Drillers
4	Derrickmen
12	Roughnecks
1	Rig mechanic welder

...../4.

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2. RIG AVAILABILITY

Rig # 4 is at present stacked at Tyler # 1 location and is available for hire to the first operator who accepts our quotation to hire on a firm basis.

3. DRILLING AGREEMENT

If we are successful in obtaining work with your company, we would be pleased to enter into an A.A.O.D.C. single well day work type agreement.

4. CONTROL

We would envisage controlling this operation from our Sydney office, with the supporting back-up of our Alice Springs office.

We are enclosing a separate tender for provision of air drilling services. Should you desire further information on these quotations or details of other services we can provide, we would be pleased to visit you and discuss these more fully.

Thank you for the opportunity of submitting a tender.

Yours sincerely,
OIL DRILLING & EXPLORATION (N.T.) PTY. LTD.

K.R. Simpson
Operations Co-ordinator.

Encs:

MAJOR COMPONENTS OF RIG

Drawworks	Ideal Type T-32 - fitted with 22" Parkersburg Hydromatic Brake - drum grooved for 1-1/8" drilling line.
Drawworks Engines	Two(2) Twin GMC 471 Engines.
Mud Pumps	Two(2) Ideal C250 $7\frac{1}{4}$" x 15" independently driven by one twin GMC 471 and one twin GMC 671 engines.
Mast & Substructure	Emsco 127" series 12 mast - equivalent API Derrick rating 416,000 lbs. Substructure 45' long x 8' high.
Blowout Preventers	One(1) Shaffer Model GB, double blowout preventer, 12" 3000 lbs WP, Series 900. One(1) Hydril GK 12-3000 flanged blowout preventer, series 900, Koomey Accumulator.
Drill Pipe and Drill Tubing	8000' $4\frac{1}{2}$" drill pipe, grade 'E' internal upset 16.60 lb/ft. with super shrink grip square shoulder tooljoints $4\frac{1}{2}$" FH x 6" OD with hard banding. 6000' $3\frac{1}{2}$" drill tubing, grade N80, 9.50 lb/ft. with 4-3/4" OD tooljoints, $3\frac{1}{2}$" IF connections.
Drill Collars	Twenty-seven(27) $6\frac{1}{4}$" OD x 2-3/4" bore x 30' long with 4" IF pin and box connections. Three(3) 8" OD x 2-13/16" bore x 30' long with 6-5/8" regular pin and box connections.
Core Barrel	One(1) Hughes 7-5/8" - 8-3/4" 'J' core barrel.
Rotary Table	Ideal $17\frac{1}{2}$" type FE - $17\frac{1}{2}$ - 44.
Travelling Block and Hook	Ideal Model 4-30E-140, grooved for 1-1/8" line.
Crown Block	Emsco 5 sheave (one 44" diameter, four 36" diameter) grooved for 1-1/8" line.
Swivel	Ideal type 'F'.

(cont.)

Electric Generator	Two(2) Caterpillar D330 TAC 50kw, 50 cycle, 3 phase, 120-208 volt.
Shale Shaker	One(1) Thompson Model A54 shale shaker complete with sample machine, sink, cabinet, mud tank and bypass, powered by electric motor.
Mud Tanks	Three(3) mild steel, skid mounted, equipped with walks and mud guns - each 30' long x 8' wide x 4' high.
Water Tank	One(1) mild steel, skid mounted - 30' long x 8' wide x 7' high.
Pipe Racks	90' tumble type tubular pipe racks complete with walk.
Overshot	One(1) Bowen series 150 7-5/8" OD SH Overshot.
Jars	One(1) set McCullough 6-1/8" OD Jars.
Washover Pipe	Ten(10) joints 7-5/8" OD 29.70 lb/ft. FJ Hydril casing.
Dog House	One(1) steel Dog House 8' x 20'.
Shed	One(1) steel Generator Tool Shed 28' x 8' x 7'.

ALSO SENT TO: Atlas Copco Aust. Pty. Ltd.,
950 Port Road,
ALBERT PARK. SA.5014

DVS:hjr

27th November, 1968.

Holman Bros. (Aust.) Pty. Limited,
380 South Road,
R I C H M O N D. SA.5033

Dear Sirs,

Water Pumping by Compressed Air

We have a proposal requiring the pumping of 400,000 gallons per day from an underground brine reservoir 700 ft. deep. The standing height of the water column will be 200 ft. from the surface, and we would anticipate 100 to 150 pull down. The weight of the brine solution that it is proposed to pump is 1.12 specific gravity.

We would like you to formulate your technical information and quotation to meet the above, and in the following order:-

(1) The total quantity of compressed air required in cubic feet per minute, and its pressure for:-

(a) Initiation.

(b) The maintenance of flow where the required flow rate is 400,000 gallons per day.

(2) A single compressor capable of supplying the above demand on a continuous basis.

(3) The monthly running cost of operating the compressor on a continuous basis when the power supply would be 415 volts, 3-phase, 50-cycle. (With power supplied at 2 cents per unit, a 250 h.p. motor at 200 KW. costs $2,880 per month).

(continued)

Holman Bros. (Aust.) Pty. Ltd. (continued) 27th November, 1968

(4) The period and elapsed time of maintenance requiring shut down for plant. The type of cooling for the compressor, having in mind that the discharge air with its moisture and heat burden is of no consequence. In the instance of water cooling for the compressors (if required), we would need that you nominate the cubic capacity of an atmospheric water cooling tower and the volume of water to be re-circulated.

(5) It is not envisaged that any air accumulator would be necessary in this installation, but we would like to have your recommendations in this regard.

(6) The type of unit installation, i.e. permanently mounted, skid mounted, frame mounted, and the approximate installation cost of each such item.

(7) An alternative proposal covering the previously paragraphed air capacities of compressor dividing the requirement over no more than four (4) integrated complete systems.

(8) What engineering responsibilities your organisation would be prepared to undertake to ensure proper installation, start up and hand over, and if such, what would be the cost involved separately from the purchase of the system.

(9) What performance guarantees and free maintenance period is provided for in terms of sale.

Hole Equipment - Detail

Considering the proposed volumes to be pumped, we would like your recommendation for:

(a) The hole casing diameter, and
(b) The diameter of the air quill that conducts the air to the 700 ft. level.

I hope that the preceding is quite clear, but do not hesitate to come back to me with any enquiries.

Yours faithfully,
GEOSURVEYS OF AUSTRALIA PTY. LTD.

D. von Sanden,
OPERATIONS MANAGER

Holman

A MEMBER OF THE HOLMAN GROUP

HEAD OFFICE:
34-40 RICKETTS ROAD, MOUNT WAVERLY, VICTORIA

HOLMAN BROS. (AUSTRALIA) PTY. LTD.
SOUTH AUSTRALIAN BRANCH:
380 SOUTH ROAD, RICHMOND, S.A
TELEGRAMS: AIRDRILL ADELAIDE PHONE: 57 3197
POSTAL ADDRESS: BOX 35, P.O. HILTON, S.A.

CJB:MP.

QUOTATION NO. 0085/68.

Geosurveys of Aust. Pty. Ltd.,
Box 1479L.,
G.P.O.,
ADELAIDE, S.A., 5001.

19th December, 1968.

Attention: Mr. D. von Sanden.

Dear Sirs,

Water Pumping by compressed air

We thank you for your letter of the 27th November, bearing the above heading and set out our recommendations hereunder.

We have presumed that pumping would be continuous, i.e., 400,000 gallons per 24 hour day. Appropriate allowances have been made in our calculations to offset the effect of pumping brine as opposed to pure water.

Assuming 100 ft drawdown, we would recommend that the jet be positioned 537 ft from the top of the hole in order to obtain the most efficient submergence of 46%. The initiation air pressure would be 163 p.s.i. and 1.15 c.f.m. f.a.d. at 120 p.s.i., would be required per gallon of brine pumped on completion of drawdown.

Assuming 150 ft. drawdown, we would recommend that the jet be positioned 598 ft. from the top of the hole in order to obtain the most efficient submergence of 44%. The initiation air pressure would be 193 p.s.i. and 1.35 c.f.m. f.a.d. at 127 p.s.i. would be required per gallon of brine pumped after completion of drawdown.

Assuming the worst condition, i.e., 150 ft. drawdown, the minimum output of the compressor required to pump 400,000 gallons of brine per day, would be 375 c.f.m. f.a.d. at 127 p.s.i. The maximum intermittent working pressure of the compressor would be a minimum of 193 p.s.i.

Assuming 100 ft. drawdown, the output required of the compressor would be 320 c.f.m. f.a.d. at 120 p.s.i., with a maximum intermittent working pressure of at least 163 p.s.i.

...../2

19th December, 1968.

In reply to paragraph 2 of your letter, we offer one (1) only Holman T60R two stage, two cylinder, radiator cooled Compressor, which has an output of 442 c.f.m. f.a.d. at 130 p.s.i., when running at 600 r.p.m., complete with 125 h.p. 1460 r.p.m. drip proof sqirrel cage, electric motor, motor pulleys, vee belts, belt guard and base frame for stationary mounting, at a price of $7,300.00, nett F.I.S. ADELAIDE.

The power consumption of the Model T60R when working at 125 p.s.i., is 103 b.h.p., the 125 h.p. motor being required to obtain an initiation air pressure of 193 p.s.i., without overloading the motor.

The Model T60R when operating according to the abovementioned performance figures, would pump 470,000 gallons per day, i.e., 18% more than that specified in your letter. Therefore, a little over 2-3/4 hours would be available per day for routine servicing and etcetera.

Applying the figures quoted in paragraph 3 of your letter on a direct proportion basis, the monthly power bill would be $1,185.00.

In reply to paragraph 4 of your letter, we would confirm that the 2-3/4 hours per day would be more than sufficient for normal servicing such as oil changes etc., but we would recommend that the Compressor be stopped for a full day inspection, three times per year, assuming 24 hours per day, 7 days a week operation.

We agree it should not be necessary to fit a substantial air receiver, but even so a small surge tank would be advisable. The provision of a 4ft. thick concrete base, electric motor starter, all wiring and piping, would be the responsibility of your Company, but we would be pleased to make suitable technical recommendations and attend the commissioning. We would also undertake an inspection of the machine on a free of charge basis after a short period of operation.

Reverting to paragraph 7 of your letter, we offer Four (4) only Holman Model TA13S, two stage air cooled Compressor units, each having an output of 95 c.f.m. f.a.d. at 125 p.s.i., when running at 1050 r.p.m., each complete with 30 h.p. 1450 r.p.m. drip proof sqirrel cage electric motor, motor pulleys, vee belts, belt guard, and base frame, at a price of $2,070.00 nett each, F.I.S. ADELAIDE.

The Model TA13S consumes 25 b.h.p. at 125 p.s.i. operating pressure and would require a 30 h.p. motor to prevent overloading during initiation.

All basic equipment on offer is currently available ex stock, Melbourne, but we would have to allow 30 days for assembly purposes.

Please note that our offer is subject to the standard Holman Conditions of Sale and Warranty, a copy of which is enclosed herewith.

...../3

HOLE EQUIPMENT.

We would suggest that the casing diameter should be 8" and the delivery pipe and air pipe 6" and 2" diameter, respectively.

We believe we have provided sufficient information for you to assess the proposition but should you require any further assistance, please do not hesitate to contact us.

Yours faithfully,
HOLMAN BROS. (AUST.) PTY. LTD.

C. J. Bavage.
Branch Manager, Adelaide.

HOLMAN BROS. (Australia) PTY. LTD.

CONDITIONS OF SALE

1. GENERAL

The acceptance of our offer includes the acceptance of the following terms and conditions.

2. VALIDITY OF QUOTATION

Unless previously withdrawn or amended, this quotation is valid for a period of 30 days. Any order placed after such period is subject to confirmation at time of acceptance.

3. PRICE

(a) **Conditions** The prices provide for delivery to the principal Australian Capital cities (i.e., Adelaide, Brisbane, Melbourne, Perth, Sydney) by the cheapest means. If higher delivery expenses are incurred at the Purchaser's request, full transportation costs will be charged from the Company's Head Office in Melbourne, or from the Company's or his main Distributor's office in the above Capital cities. Airfreight charges at any time will be to Purchaser's account.

(b) **Basis** The Company reserves the right to vary the price between the date of order and date of delivery ex Company store if the product is subject to some additional tariff or other Government tax outside the Company's control.

4. SALES TAX

Sales Tax is not included and will be added at the ruling rate in the absence of the Purchaser's exemption or Sales Tax certificate.

5. DELIVERIES

While the Company shall endeavour to schedule the Purchaser's order for delivery as nearly in accordance with the Purchaser's instructions as possible and advise the Purchaser accordingly, the Company does not guarantee nor assume liability for failure to meet any delivery date.

6. DAMAGE IN TRANSIT

The Purchaser shall be responsible for loss or damage to goods as from the time of despatch beyond the point defined in 3(a) above and the Company shall not be under any obligation to give any statutory notice or other notice that it accepts no responsibility.

7. INSURANCE

Unless otherwise instructed, the Company will not insure any deliveries beyond the point defined in 3(a) above but if so instructed in writing the Company will insure under its open policy with Lloyds of London and will take all reasonable steps to recover from the underwriters any loss or damage for which they may be liable. All charges in this connection will be debited to the Purchaser's account.

8. AVAILABILITY

All goods are quoted subject to prior sales.

9. WORK ON PURCHASER'S PREMISES

Should work of any kind be carried out by the Company on the Purchaser's or any other premises, the Company shall not be liable for any loss or damage occasioned to the Purchaser or to his employees arising from any cause whatsoever connected in any way with such work.

10. GUARANTEE

The Company warrants that the apparatus delivered hereunder shall be of the kind and quality described herein, and no other warranty, except of title, shall be implied. The Company shall repair or replace without charge any part or parts which shall be proved to have been defective either as to material and/or workmanship when shipped for a period of 6 months from despatch, provided the Purchaser promptly notifies the Company in writing of such defect and promptly delivers the defective part to the Company's store, delivery paid. No allowance will be granted for any repairs or alterations made by the Purchaser without the Company's written consent.

11. TESTING

The Company is prepared to conduct witnessed tests at their factory on equipment, if notification of this requirement is given by the customer in writing at the time of order and the test carried out within 7 days of the Company's notification of preparedness for a fee appropriate to the work involved.

12. PAYMENT

Unless otherwise stated, payment shall be net cash within the period of 30 days following the date of despatch of goods. Pro-rata payments shall become due as shipments are made.

ALSO SENT TO: Mr. D. Peters,
Ingersoll-Rand (Aust.) Pty.Ltd.
Box 178C, G.P.O.,
ADELAIDE.

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DVS:hjr

27th November, 1968.

Mr. John Wuttke,
Knox Schlapp Pty. Limited,
27 North Terrace,
A D E L A I D E. SA.5000

Dear John,

Water Pumping by Compressed Air

This is to confirm my telephone conversation regarding the above subject.

We have a proposal requiring the pumping of 400,000 gallons per day from an underground brine reservoir 700 ft. deep. The standing height of the water column will be 200 ft. from the surface, and we would anticipate 100 to 150 pull down. The weight of the brine solution that it is proposed to pump is 1.12 specific gravity.

We would like you to formulate your technical information and quotation to meet the above, and in the following order:-

(1) The total quantity of compressed air required in cubic feet per minute and its pressure for:-

(a) Initiation.
(b) The maintenance of flow where the required flow rate is 400,000 gallons per day.

(2) A single compressor capable of supplying the above demand on a continuous basis.

(3) The monthly running cost of operating the compressor on a continuous basis when the power supply would be 415 volts, 3-phase, 50-cycle. (With power supplied at 2 cents per unit, a 250 h.p. motor at 200 KW. costs $2,880 per month).

(continued)

Mr. John Wuttke,
Knox Sohlapp Pty. Ltd. (continued)

27th November, 1968.

(4) The period and elapsed time of maintenance requiring shut down for plant. The type of cooling for the compressor, having in mind that the discharge air with its moisture and heat burden is of no consequence. In the instance of water cooling for the compressors (if required), we would need that you nominate the cubic capacity of an atmospheric water cooling tower and the volume of water to be re-circulated.

(5) It is not envisaged that any air accumulator would be necessary in this installation, but we would like to have your recommendations in this regard.

(6) The type of unit installation, i.e. permanently mounted, skid mounted, frame mounted, and the approximate installation cost of each such item.

(7) An alternative proposal covering the previously paragraphed air capacities of compressor dividing the requirement over no more than four (4) integrated complete systems.

(8) What engineering responsibilities your organisation would be prepared to undertake to ensure proper installation, start up and hand over, and if such, what would be the cost involved separately from the purchase of the system.

(9) What performance guarantees and free maintenance period is provided for in terms of sale.

Hole Equipment - Detail

Considering the proposed volumes to be pumped, we would like your recommendation for:-

(a) The hole casing diameter, and

(b) The diameter of the air quill that conducts the air to the 700 ft. level.

I hope that the preceding is quite clear, but do not hesitate to come back to me with any enquiries.

Yours faithfully,
GEOSURVEYS OF AUSTRALIA PTY. LTD.

D. von Sanden,
OPERATIONS MANAGER

KNOX SCHLAPP PTY. LTD.
(Incorporated in the State of Victoria)
(A MEMBER COMPANY OF N.K.S. (HOLDINGS) LTD.)

27 NORTH TERRACE
ADELAIDE
SOUTH AUSTRALIA
TELEPHONE 51 6611
CABLES & TELEGRAMS "KNOXSCHLAP"

OUR REFERENCE A.908 JW:LW
YOUR REFERENCE

Geosurveys of Australia Pty. Ltd.,
57 Todville Street,
WOODVILLE WEST. S.A. 5011.

189

Attention: Mr. D. von Sanden

8th January, 1969.

Dear Sir,

Water Pumping by Compressed Air.

We thank you for the above enquiry and further to our discussions with Mr. von Sanden we submit our quotation for a BroomWade stationary Air Compressor which would be capable of pumping 400,000 gallons of brine per day.

From the figures you have provided we have based our calculations on information on pumping with air contained in publication "Compressed Air Data".

From a graph provided the air consumption for 350' lift is 1.24 c.f.m. per gallon.

.. 400,000 gallons per day = 496,000 c.f.m. = 345 c.f.m.

The best submergence wouldbe 50 - 55% of the total pipe length.

The working pressure = 156.4 p.s.i.; however you will appreciate that the initial pressure required to move the brine will considerably exceed the working pressure.

The diameter of the air quill recommended is 4" with a pressure drop of 4.5 p.s.i.

Compressor

The compressor we offer would be the BroomWade Type VHP350 which delivers 338 c.f.m. at 250 p.s.i. when operating at 485 r.p.m. which is the machine's minimum operating speed. This machine is as described and illustrated in the enclosed brochure.

Electricals

For greater efficiency and ease of installation we offer the above compressor unit fitted with a 110 h.p. Brush 492 r.p.m. flange mounted

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ITRACTS SUBJECT TO STRIKES, ACCIDENTS AND CONTINGENCIES BEYOND OUR CONTROL. ALL QUOTATIONS, UNLESS DISTINCTLY STATED
ISE ARE STRICTLY NETT AND ARE SUBJECT TO MARKET FLUCTUATIONS, VARIATIONS IN FREIGHT, MARINE AND WAR RISK INSURANCE.

Electricals (cont.)

squirrel cage motor.

A suitable automatic auto transformer starter is also offered. 190

Running Costs.

The full load power consumption of the BroomWade Type VHP350 delivering 345 c.f.m. of free air at 156 p.s.i. is 80 h.p. at the compressor shaft.

The monthly (28 days) running costs of the machine on a continuous basis with power supplied at 2 cents per unit would be $881.39.

Aftercooler.

The BroomWade Type VHP350 compressor is watercooled and the cooling water requirements are based on a 95°F inlet temperature of the air and a 20°F water temperature range.

The figures listed are based on 250 p.s.i. air delivery pressure.

	B.T.U./Hour	Gallons per Hour
Cylinder Jackets	61,800	309
Intercooler	107,200	536
	169,000	845

The coolers offered would be the Radac Series RW15 forced draft cooler which has a capacity of 15 g.p.m.
This cooler is capable of cooling water entering the spray nozzles at 115°F to 96°F with an ambient wet bulb temperature of 65°F.

Alternatively

We offer the Radac Series RWV20 induced draft cooler which has a capacity of 20 g.p.m.
This cooler is capable of cooling water entering the spray nozzles at 115°F to 89°F with an ambient wet bulb temperature of 65°F.

Installation

We recommend that the BroomWade VHP350, which has 100% primary balance, be installed to an 8" to 12" reinforced concrete foundation. This foundation for the aftercooler need only to be of sufficient strength to support the weight of the cooler (wet).

No allowance has been made for electric wiring or pipework to the various items offered.

We agree with you that an air receiver would not be necessary in this installation.

...../3

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Maintenance

It would be advisable to change the crankcase oil every 2,000 hours and assure that mechanical sight feed lubricator is always filled with oil.

Delivery and suction valve inspection should be made every 5,000 hours and this would take approximately 4-5 hours to perform.

A recommended spare parts list for 2 years operation can be supplied if required.

Commissioning

Providing the installation is a reasonable distance from Adelaide we will undertake to commission the equipment free of charge.

Guarantees

The performance of the BroomWade Type VHP350 is in accordance to BSS726 and 'Conditions of Supply' on the reverse side of Quotation Form Q.1.

Should you require further information regarding our offer we would be pleased to assist.

Yours faithfully,
KNOX SCHLAPP PTY. LTD.

J. WUTTKE
SALES MANAGER

KNOX SCHLAPP PTY. LTD.

Quotation Specification

MELBOURNE Graham Street Port Melbourne 69 5701 | SYDNEY 135 McEvoy Street Alexandria 69 4221 | ADELAIDE 29 North Terrace 51 6611 | PERTH 135 Great Eastern Highway Victoria Park 6 6231 | BRISBANE 23 Lang Parade Auchenflower 7 3041 | TASMANIA 30 Wellington Street Launceston 2 1441

FORM Q1

TO: Geosurveys of Australia Pty. Ltd.
57 Todville Street,
WOODVILLE WEST. S.A. 5011.

Attention: Mr. D. von Sanden

No. A.908 192

DATE 8.1.1969.

MODEL

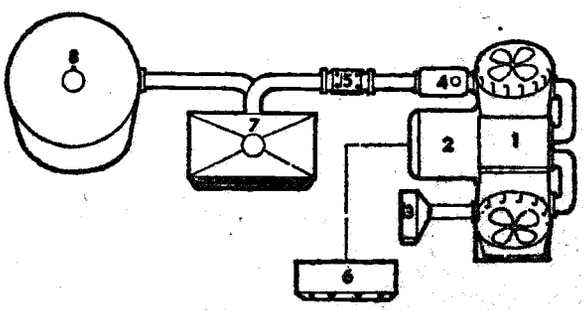
BROOMWADE

"V" AIR COMPRESSOR —DIRECT COUPLED

Explanatory Notes on Ancillary Items Installation

CODE

1. VHP350.. **Two stage Double Acting water cooled Air Compressor including intercooler, L.P. relief valve, instrument panel, light load starting gear, automatic air governor or demand/supply regulator all as standard equipment.** 338.... **cfm/fad at** .250... **lbs. psi at** 485.... **rpm.**
2. **Direct connected shaftless type motor.**
3. **Suction filter.**
4. **Pulsation dampener for reducing power consumption.**
5. **Non return valve.**
6. **Motor starter.**
7. **Cooling equipment — either Radac dual purpose air and compressor cooling water (Evaporative recirculating type), or for delivered air only (Shell and tube heat exchanger type).**
8. **Air receiver to S.A.A. Code with all necessary fittings.**



Typical Arrangement

ode	*Quotation*	*Price*
1	One BroomWade Type VHP350 as above	$6,670.00
2	One Brush 110HP, 492 rpm Squirrel cage flange mounted electric motor frame CTQ544	$3,030.00
3	One Ventex Suction Filter	$110.00
5	One Security 110HP Enclosed Automatic Auto Transformer starter with triple pole thermal overloads and with built-in push buttons, heater coils included.	$615.70
7	One Radac Series RW15 Evaporative Watercooler	$680.00
	One Security D.O.L. Contactor for use with above aftercooler	$18.20
	Alternatively	
	One Radac Series RWV20 Evaporative Watercooler	$910.00
	One Security D.O.L. Contactor for use with above aftercooler	$18.20
	One set Foundation bolts and plates	$12.00
	As further described in accompanying literature	
	Delivery, subject to prior sales. 14 to 16 weeks from receipt of order.	

KNOX SCHLAPP PTY. LTD.

(J. VUTTKE)

BROOMWADE DIVISION

THIS OFFER IS SUBJECT TO SUPPLY CONDITIONS ON BACK OF QUOTATION

CONDITIONS OF SUPPLY

1. ACCEPTANCE— This quotation is subject to confirmation prior to acceptance.

2. TERMS OF PAYMENT— Nett 30 days from invoice date, unless otherwise varied.

3. DELIVERY POINT— Prices quoted include delivery within Metropolitan area.

4. SALES TAX— Prices are plus sales tax if applicable.

5. PRICES VARIATION—

   (a) IMPORTED EQUIPMENT: Prices for equipment not at present in stock are based on the C.I.F. & E. cost, duty and other charges to place F.O.W. current today, and any variation thereof based on costs ruling at the date of clearance of the goods when received in Australia would be to your account, unless otherwise specified in our offer. Prices for equipment which is at present in stock are firm, nett, unpacked ex our Store, and are subject only to prior sales and the cost of transport from interstate, if necessary.

   (b) EQUIPMENT MANUFACTURED IN AUSTRALIA: The prices quoted for items other than of Broom & Wade Ltd. manufacture are based on today's rates for wages and materials, etc., and any variation thereof, which will result in an increase or decrease in cost to us, would be adjusted to your account, unless otherwise specified in our offer.

6. GUARANTEE— "Broomwade" equipment manufactured by Broom & Wade Ltd., England, and/or Broomwade-Knox Pty. Ltd., Australia, is guaranteed by them against defective material and/or workmanship for a period of 12 months for stationary compressors, and for a period of 6 months for portable compressors and pneumatic tools. The guarantee is from the date of delivery, and should any part or parts fail within the period specified due to such causes, fair wear and tear expected, the same will be replaced free of further charge. Items of local manufacture carry such guarantees as are given us by the makers. However, we are compelled to state that our Principals, Broom & Wade Ltd., and Broom & Wade (Ausfralia) Pty. Ltd., the suppliers of ancillary equipment, the sub-contractors or Knox Schlapp Pty. Ltd., accept no further liability whatsoever in relation to any damage, third party claim, or otherwise.

ATLAS COPCO AUSTRALIA PTY. LIMITED
(INC. IN N.S.W.)
HEAD OFFICE: 199-205 PARRAMATTA ROAD, AUBURN, N.S.W.
P.O. Box 257, Auburn 2144 Phone: 648-1711 (13 Lines)
Telegraphic Address: "ATLASCOPCO" Telex 20389

A COMPANY IN THE ATLAS COPCO GROUP

The Operations Manager,
Geosurveys of Australia Pty. Ltd.,
G.P.O. Box 1479L,
ADELAIDE S.A. 5001

Your Ref. Your Letter Our Ref. JIM:RC Date 20th December, 1968

Dear Sir,

Re: Water Pumping by Compressed Air.

We acknowledge receipt of your letter dated 27th November, 1968 forwarded by our Adelaide Office and regret the delay in answering.

As you appear to be familiar with the water-pump principle, you will understand that it is necessary to manipulate the variables to reach an acceptable solution.

Our Company has prepared two publications to simplify these calculations, namely leaflets ADH 03-30 and 32 and these are enclosed for your assistance.

We have taken a quick check on your probable requirements and obtained the following figures, namely:

Water flow Q_w = 400,000 gal/day
= 16,650 gal/hr. = 75 m^3/hr.

H = 350' = 106.5 m

S/H = 0.8

$\therefore \phi$ spec= 10 m^3 of free air /m^3 of water

hence air flow ϕ = 10 x 75 = 750 m^3/hr. of air
$\simeq$ 450 c.f.m. F.A.D.

and working pressure $\simeq$ 125 p.s.i.

starting pressure $\simeq$ 200 p.s.i.

.../2.

DENMARK - FINLAND - FRANCE - GERMANY - GREECE - HOLLAND - INDIA - ITALY - MEXICO - NORWAY - SWEDEN
NEW ZEALAND - NORWAY - PERU - PORTUGAL - RHODESIA - SOUTH AFRICA - SPAIN
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ATLAS COPCO puts compressed air to work for the world

The Operations Manager,
Geosurveys of Australia Pty. Ltd., 20th December, 1968

The above assumes the delivery pipe is directly on the surface of the ground and the liquid being pumped is water. From these figures we note that the starting pressure should be reduced if a standard, 125 p.s.i. max. pressure compressor is to be used.

Regarding the remainder of your questions, we suggest these be held until the final air flow, working and starting pressures are determined. However, we comment briefly:

1. Our Company can supply air cooled, skid mounted compressors in varying capacities up to 600 c.f.m. F.A.D. and pressures up to 125 p.s.i.g. In addition, air-cooled 200 p.s.i. machines are manufactured up to 400 c.f.m. and a compact water-cooled machine (model DR418) is produced, delivering 326 c.f.m. at 250 p.s.i.

   All performance figures are based on continuous operation and guaranteed ± 5% up to 100 h.p. and ± 3% over 100 h.p.

2. All Atlas Copco compressors are guaranteed for a period of twelve (12) months against faulty workmanship and materials. Periodic erection supervision and start-up is a free service in most industrial areas throughout Australia, but should your area of operation be remote, a nominal charge would be made. Typical installation drawings are supplied on request.

We trust these comments and our enclosures are to your satisfaction and look forward to hearing from you again on this matter.

Yours faithfully,
For: ATLAS COPCO AUSTRALIA PTY. LIMITED,

John H. Bishop
Industrial Equipment Manager

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General description of the air-lift pump

An air-lift pump (see Fig. 1) consists of a delivery pipe, with a mixing chamber, to which is connected a compressed air pipe from a compressor. The two pipes, with the mixing chamber, are submerged into the liquid to be pumped. The compressed air is admitted into the mixing chamber and, because the liquid-air mixture has a considerably lower specific gravity than the surrounding liquid, the liquid-air mixture is forced up and flows out of the delivery pipe in accordance with the law for connected vessels.

There are no damageable moving parts in the pumping system. It is therefore easy to instal and operate. It requires no lubrication or overhaul.

Because of the limited space required the pump is especially suited for pumping from deep wells where the delivery head is great. In addition, the required well diameter is small in proportion to the capacity of the pump. Furthermore, the pump is so designed that it can be used for pumping very muddy water.

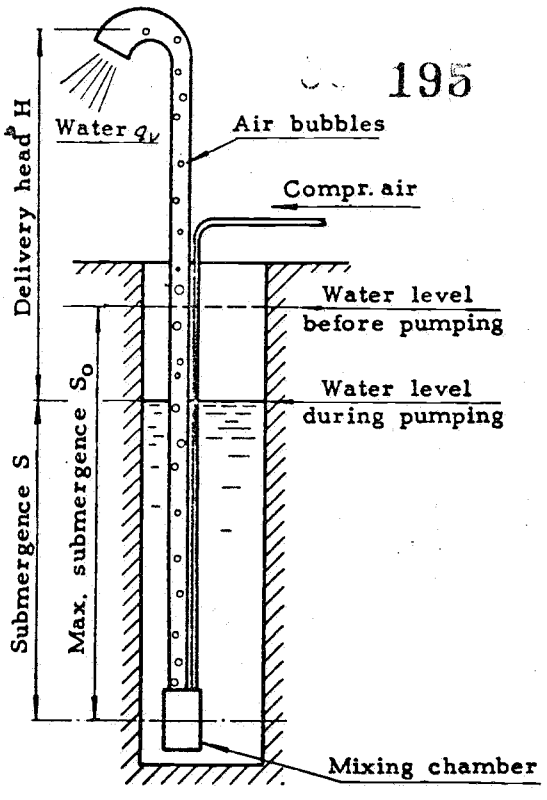


Fig. 1
Arrangement of an air-lift pump

A more detailed technical description of the air-lift pump is given in ADH 03-30.

Examples of installations carried out

In the table below is given data concerning a number of air-lift pump installations (compare Fig. 1), which were arranged by Atlas Diesel.

Sundry air-lift pump installations							
Water quantity pumped (q_v)	Imp. gal./hr.	4,620	4,620	1,320	1,320	1,650	790	160
	m^3/hr.	21	21	6	6	7.5	3.6	0.72
Max. submergence (S_o)	ft.	226	131	230	230	131	147	95
	m	69	40	70	70	40	45	29
Submergence (S)	ft.	102	56	164	164	39	82	33
	m	31	17	50	50	12	25	10
Delivery head (H)	ft.	230	230	262	197	144	230	131
	m	70	70	80	60	44	70	40
Total depth of bore hole	ft.	495	360	321	379	347	279	147
	m	150	110	98	85	106	85	45
Bore hole diameter	in	9	4	4	4	5	4	5
Delivery pipe diameter	in	3	2 1/2	2 1/2	2 1/2	2	1 1/2	1/2
Compressed air pipe diameter	in	1 1/4	1	1	1	3/4	3/4	3/4
Compressor type		NT9 28hp	NT9 28hp	KE6RA 7.5hp	KE6RA 7.5hp	KE5RAS 5hp	KE4RA 4hp	PE3RAS 0.5hp
Working pressure when pumping	lb./sq.in	85	100	100	100	100	100	57
	kg/cm^2	6	7	7	7	7	7	4
Free air per litre of water	cu.ft.	0.30	0.30	0.30	0.30	0.18	0.23	0.19
	l	8.5	8.5	8.5	8.5	5.2	6.7	5.5

Amongst other installations can be mentioned one in the town of São Paulo in Brazil, which supplies 80,000 people with drinking-water. Compressed air is obtained from a number of Atlas Copco AR and CR compressors. The water is pumped from 131 to 164 ft. (40-50 m) deep bore holes and the total capacity of the installation is 5,280,000 Imp. gal. (24,000 m^3) of water per 24 hours.

The arrangement of this installation is shown in Fig. 2.

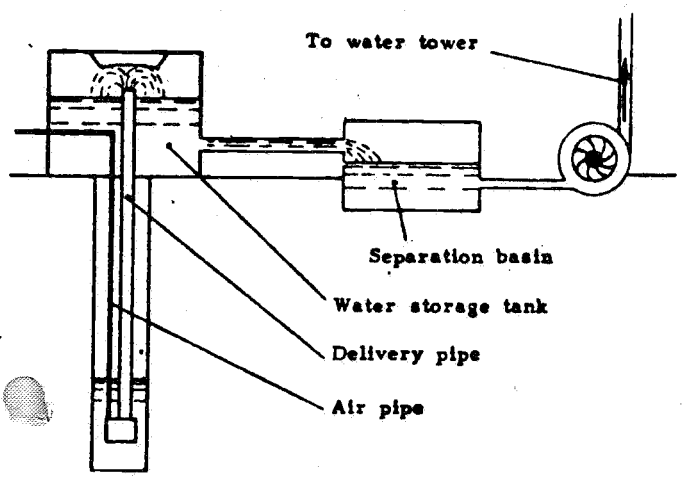


Fig. 2 Arrangement of air-lift pump installation at São Paulo

Another drinking-water installation, included in the three-year plan which the Government of the Union of Burma have started, is shown in Fig. 3. More than 6,000 similar wells are being drilled within the framework of this plan which aims at securing the supply of drinking-water to the country. Burma is often ravaged by severe infectious diseases. The water is pumped from the deep bore holes by means of air-lift pumps which are driven by Atlas Copco compressors of the type NT8MV. In this connection mention can also be made of the fact that drinking-water is favourably affected by the close contact with air which occurs when it is mixed with air bubbles in the delivery pipe of the pump.

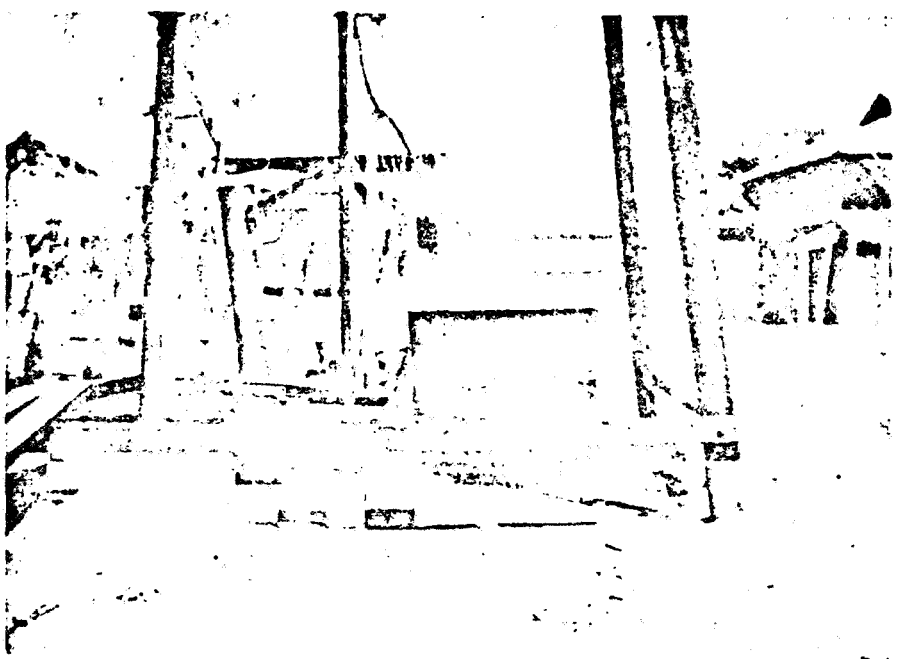


Fig. 3
The water in this air-lift pump installation in Burma is pumped by means of an Atlas Copco NT8MV compressor unit



Fig. 4 At this installation in India an Atlas Copco HR3V compressor unit is in operation. In the centre is seen an arrangement for measuring the capacity of the pump

Close to the town of Jaipur, in the Indian Province of Rajasthan, the Agricultural Research Institute has carried out tests with an air-lift pump driven by an Atlas Copco HR4V compressor unit. During these tests, which resulted in the purchase of the whole pump installation, 20,000 Imp. gal. (91 m^3) of water were pumped per hour. When the pump was started the working pressure of the compressor was 100 lb./sq.in (7 kg/cm^2), but fell to 71 lb./sq.in (5 kg/cm^2) when the water level sank as the water began to flow.

By using such pumping installations, of which one is shown in Fig. 4, it appears as if a solution of the difficult irrigation problem in this part of the world has been found.

Fig. 5 shows how it was possible to salvage, by means of air-lift pumps, the cargo from an ore-carrying ship which was sunk in Narvik, Norway, during the war. The ship was lying at a depth of 115 ft. (35 m) at the time of the salvage work. The total capacity of the compressors was 441 cu.ft./min (12.5 m^3/min) of air at a working pressure of 50 lb./sq.in (3.5 kg/cm^2). By pumping a mixture of ore-water 20 tons of ore were recovered per hour.



Fig. 5 Salvage of ore from a sunken ship in Narvik. The mixture ore-water flows from the delivery pipe of the air-lift pump into the barge. The salvage ship on the left

AIR-LIFT PUMP INSTALLATIONS

An air-lift pump installation at a slaughter-house in Jönköping, Sweden, has worked faultless since 1948. The pumps are operating two water wells each having a 6" diameter. The delivery head is 52.5 ft.(16 m) and the wells provide jointly about 7,480 Imp. gal./hr. (34 m^3/hr.). The water is principally used for 14 refrigerators having a total water consumption of 116,600 Imp. gal. (530 m^3) per 24 hours, but also covers all other requirements, e.g., for steam boilers, laundry, cleaning plants, fat-smelting plants, garage, etc. The customer is quite independent of the Municipal Water Board for his water supply.

A match factory in Jönköping also covers its large requirements of water by means of an air-lift pump. The compressor is of the KE4 type. The water is used for spraying 856 Standards (4,000 m^3) of timber which have to be kept wet from April until September. The capacity of the air-lift pump is about 3,960 Imp. gal./hr. (18 m^3/hr.) and the delivery head is 66 ft. (20 m).

Another pump installation, with a PE4E compressor unit, at the same firm is pumping sulphuric acid from a floor well for the impregnation of matches. The delivery head is about 13 ft. (4 m) and the liquid quantity about 330 Imp. gal./hr. (1.5 m^3/hr.).

We are at all times prepared to assist those interested in air-lift pump installations in setting up such plants.

As basis for our calculations we would require the following information (see Fig. 1):

1. Required water flow, q_v, Imp. gal./hr. (m^3/hr.).
   Check that the capacity of the well is sufficient
2. Delivery head, H feet (metre)
3. Submergence, S feet (metre)
4. Max. submergence, S_o feet (metre)
5. Total depth of bore hole, feet (metre)
6. Bore hole diameter, inches.

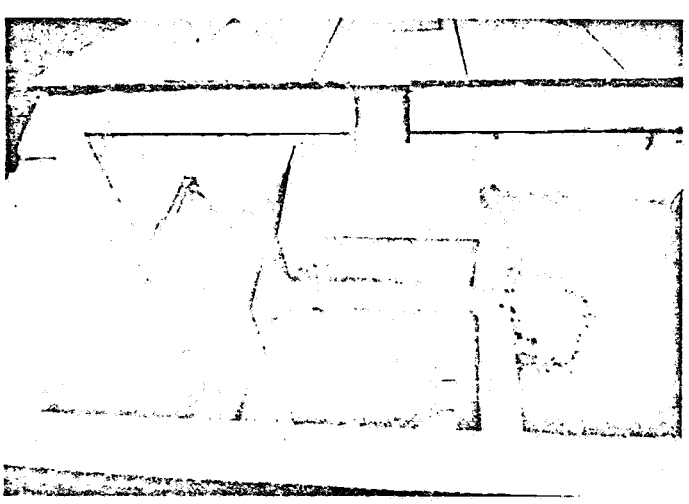


Fig. 6

The sedimentation tank in the pumping plant at the match factory referred to in the text. The different sections serve as a separator for sand and gravel. To the left is a float for controlling the compressor

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AIR LIFT PUMPS

The air-lift pump is a very old invention. It was described as early as 1797 in a small book by Bergmeister Carl Immanuel Löscher.

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Description and method of operation

The pump consists of a vertical delivery pipe which is partly submerged into the liquid to be pumped, a mixing chamber, and a pipe which leads compressed air to the latter. See Fig. 1. For the operation of the pump compressed air of suitable pressure must be available.

The compressed air is admitted into the mixing chamber of the delivery pipe, resulting in the specific gravity of the liquid in the pipe being reduced due to the liquid becoming mixed with air bubbles. According to the law for connected vessels where one vessel is constituted by the pipe which contains the light liquid-air mixture and the other by the chamber outside the pipe which contains liquid of normal specific gravity, the liquid in the pipe rises to the level which corresponds to equilibrium between the liquid and the liquid-air mixture. If the upper end of the pipe is below the equilibrium level for the liquid-air mixture, the latter flows out and liquid is consequently pumped through the pipe.

As appears from the above and from Fig. 1, the air-lift pump is characterized by the delivery pipe extending deep below the liquid level - often to a depth corresponding to the delivery head or more. In certain cases this may restrict the usefulness of the pump but usually involves no trouble.

Qualities and use

The air-lift pump has many good qualities affording advantages over other types of pumps in several fields. It is durable and easily installed. All moving parts in the pumping system are centred in the compressor which can be installed in a place chosen at will. The pump proper has no parts which become worn or require lubrication and overhaul.

It can be used for pumping very muddy and slimy water. When employed as a dredger, the air-lift pump will lift water mixed with clay, sand and pebbles. In this case it has the advantage over ordinary dredgers that the depth of water does not restrict its use. It is also employed for transporting beet in sugar works.

On building sites, in mines, etc. the air-lift pump is used to advantage due to its simplicity and reliability. In these working places compressed air is generally available.

The air-lift pump is specially suited for pumping water and oil from deep wells, as no moving parts need be lowered into the bore hole. In addition, the well diameter required is small in proportion to the capacity of the pump.

The advantages afforded by the air-lift pump often balance its low efficiency. At the best, the total efficiency of the pump and compressor can be about 40%. This efficiency is, however, more satisfactory than that of water ring pumps and equal to that of small-sized centrifugal pumps. Large-sized centrifugal pumps and piston pumps have, however, an efficiency which ranges from 70 to 80%. The installation and maintenance costs of the air-lift pump are low especially in connection with deep wells which otherwise require pump cylinders lowered into the bore hole or entirely submerged centrifugal pumps.

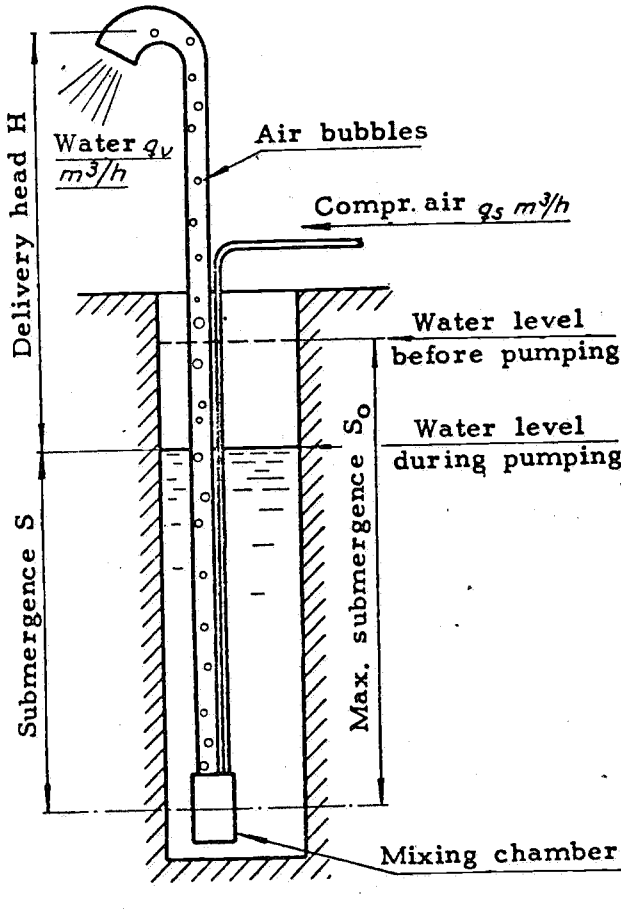


Fig. 1 Arrangement of air-lift water pump

Calculation of principal data

When calculating the size of an air-lift pump, particulars of the flow of liquid, q_v m^3/h, wanted and the necessary delivery head, H metres, must be available. By means of the formulae and diagrams the value, S metres, of the depth of the mixing chamber when pumping (See Fig. 1) can then be chosen, after which the volume and pressure of air etc. required can be calculated. As will be clear from the text, the depth must be adapted to the installation conditions of the pump, its rate of working, the efficiency wanted, etc.

The flow of air required, q_s m^3/h of free air,

is determined by the equation:

$$q_s = q_v \cdot Q_{spec} \ m^3/h$$

where Q_{spec} is the specific air consumption and is expressed in m^3 of free air per m^3 of liquid raised. As will be clear from the following, Q_{spec} can generally be obtained direct from a diagram.

In the case of a carefully designed pump, the specific air consumption when pumping water can be determined from the following approximate formula:

$$Q_{spec} = \frac{H}{C \cdot \text{Log}\left(\frac{S + 10.3}{10.3}\right)}$$

where C is a constant which varies with the ratio of submergence, S/H, i.e. the ratio between the depth of the delivery pipe into the liquid when pumping and delivery head. The value of C is determined from diagram 1.

The above equation is graphically shown in diagram 2 where readings of the specific air consumption Q_{spec} for varying heads H and ratios of submergence S/H can be immediately taken. The continuous lines in the diagram denote the normal working range of air lift pumps. Thus, a smaller ratio of submergence is chosen for the higher heads than the lower ones, to restrict the length of the delivery pipe and also the working pressure of the compressor, which is directly proportional to the depth S. The diagram shows that the air consumption is reduced when the ratio of submergence is increased. The working pressure of the compressor is, however, increased at the same time and consequently also the specific power in kWh per m^3 of free air required to drive the compressor. The efficiency, ηp, of the whole pump installation is, however, increased when the ratio of submergence rises and is proportional to the constant C in the approximate formula:

$$\eta_p = \eta_{is} \cdot 0.042 \ C$$

in which η_{is} is the isothermal efficiency and ranges from 0.5 to 0.7 depending on the size and design of the compressor. The latter figure applies to medium-sized, water-cooled, stationary compressors built for two-stage compression at working pressures above 4 kg/cm^2.

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Working pressure of compressor

During pumping the working pressure M of the compressor is equal to the static pressure of the liquid column S. In the case of water, M is thus equal to $\frac{S}{10}$ kg/cm^2, leaving the loss of pressure in the air main out of account. When starting pumping, the water level in the well may be higher and if the depth is S_o metres, the working pressure of the compressor will be $M_{max} = \frac{S_o}{10}$ kg/cm^2. This latter starting pressure is often 50% higher than the normal working pressure.

The ratio of submergence generally becomes a compromise between various demands. To provide the best efficience, S/H should be high. No appreciable increase of the efficiency will result, if the ratio of submergence selected exceeds 2.0. The ratio of submergence may also be limited by the depth of the well. An air lift pump can work satisfactorily at submergence ratios below 0.1. However, in this case the efficiency becomes a good deal lower than at normal S/H values. It is also advisable to select the ratio of submergence so that the value of the maximum starting pressure M_{max} will be suitable. Compressors of standard design are generally built for working pressures up to 7-8 kg/cm^2. These compressors are less expensive than special compressors for higher pressures which should only be used for high delivery heads.

The diameter of the delivery pipe should be selected so that the velocity of the liquid-air mixture in the mixing chamber ranges from 1.5 to 4.5 m per second. If the diameter of the pipe is excessive, i.e. the velocity of the liquid-air mixture insufficient, there will be a loss of capacity due to the air bubbles rising more rapidly than the surrounding water. On the other hand, when the diameter of the pipe is too small, the frictional loss will be abnormally high. As a rule, higher velocities are selected for low S/H values than for large ratios of submergence. In long delivery pipes the velocity at the upper end of the pipe is much higher than in the mixing chamber due to the expansion of the air. Preferably, it should not exceed 10 m a second. Thus, long delivery pipes should have a larger area at the top. The following equation gives the minimum diameter of the upper end of the pipe.

$$D_{min} = 6\sqrt{q_v - q_s} \ mm$$

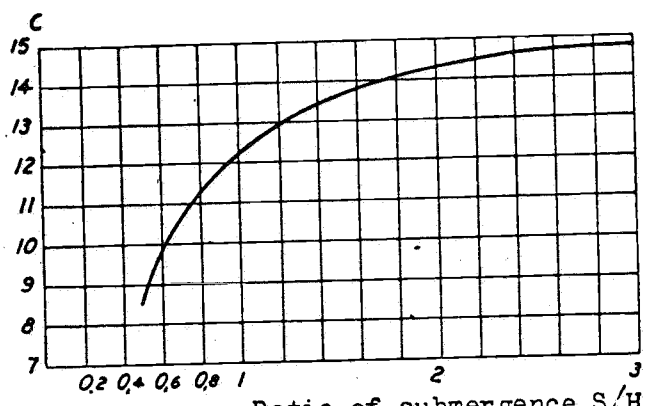


Diagram 1.
Constant C at varying ratios of submergence

Constructional features

The diagram in Fig. 2 shows how the mixing chamber can be made to suit delivery pipe diameters ranging from 1" to 6". Under actual conditions the water quantities shown on this diagram give proper velocities in the delivery pipe for normal ratios of submergence, i.e. the continuous lines in the diagram (Fig. 2).

The delivery pipe should be fitted in as vertical a position as possible and preferably have no

bend at its upper end. If a bend is necessary, this should have a large radius of curvature and be made with a considerably larger cross-sectional area than the delivery pipe. To avoid undue resistance, no section of the pipe should be made with reduced area, also the pipe joints should fit each other perfectly.

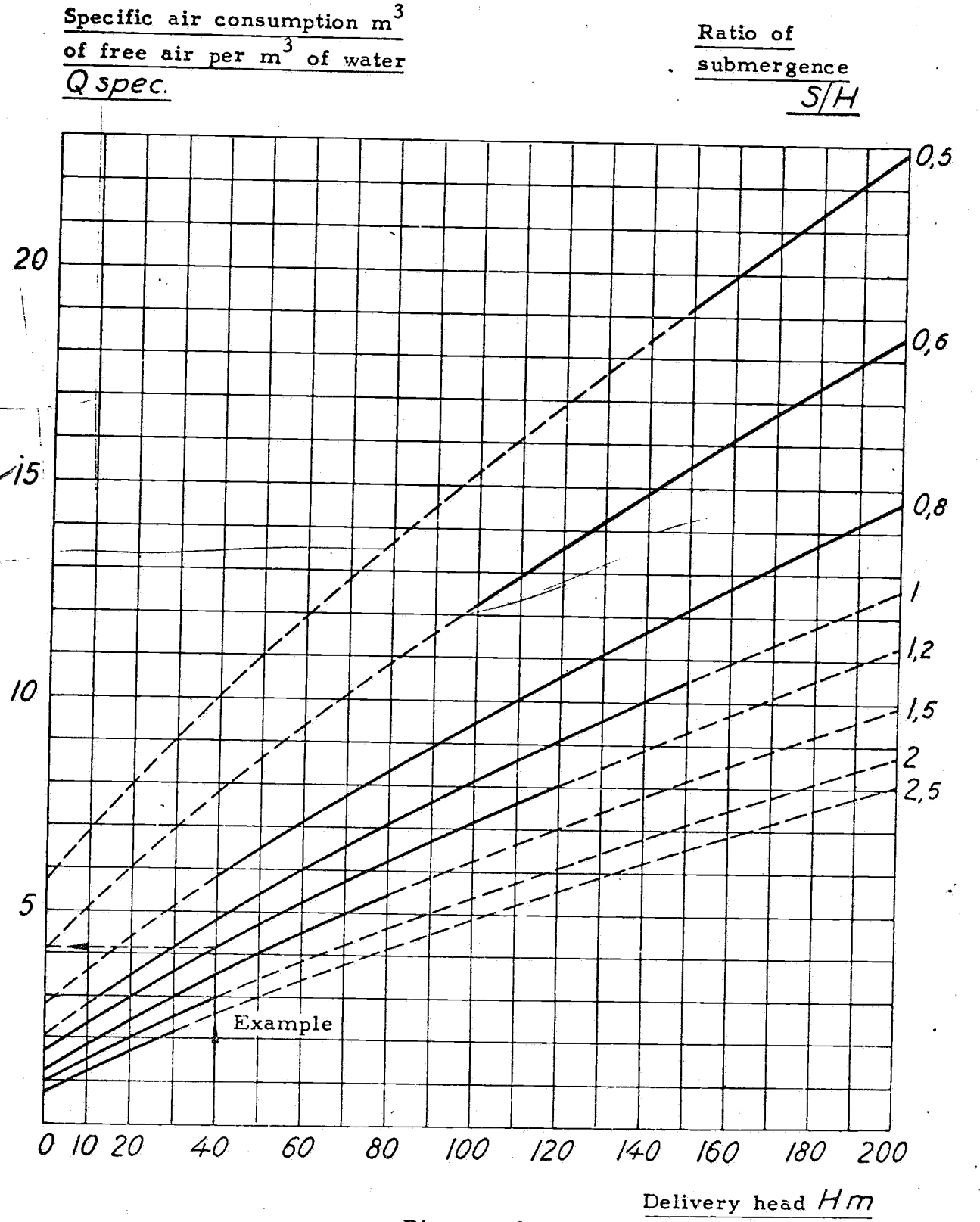


Diagram 2.
Specific air consumption at varying delivery heads and ratios of submergence

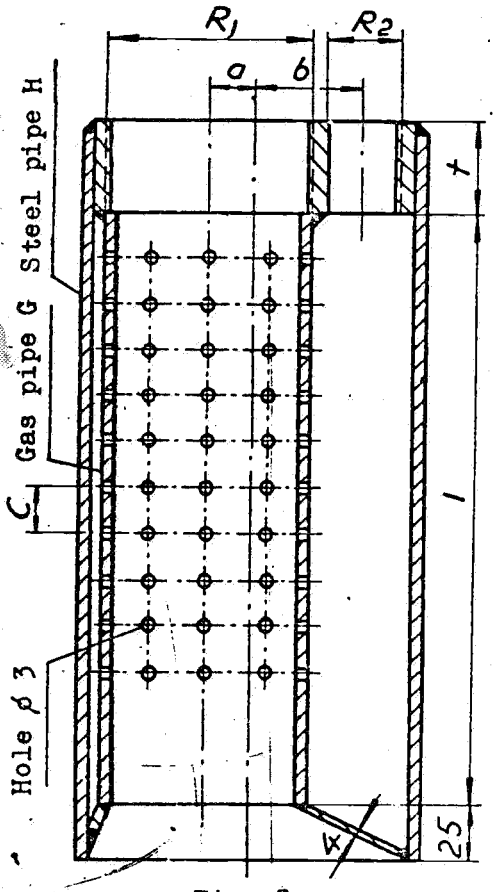


Fig. 2
Mixing chamber for air-lift pumps

Water quantity q_v m³/h min.-max.	R_1	Smallest well diam.	R_2	H mm	G	a mm	b mm	t mm	l mm	c mm	Number of rows x number of holes per row
1-2,5	1"	80	1/2"	70	1"	12	18	25	150	15	6×4
2-4	1 1/4"	90	1/2"	76	1 1/4"	12	23	30	170	15	6×4
3,5-6	1 1/2"	95	1/2"	83	1 1/2"	12	24	30	175	15	6×4
6-10	2"	120	3/4"	102	2"	14	31	35	200	15	10×6
9-16	2 1/2"	140	3/4"	121	2 1/2"	15	39	40	225	15	10×6
15-25	3"	160	1"	146	3"	20	45	40	250	20	10×8
25-40	4"	220	1 1/4"	191	4"	25	59	45	300	20	11×12
40-65	5"	250	1 1/2"	216	5"	27	73	50	350	20	15×12
60-100	6"	275	1 1/2"	241	6"	28	85	55	400	20	16×12

In addition, the inner surface of the pipe should be smooth and preferably treated with a rust preventive.

The inner diameter of the compressed air pipe is determined by the equation:

$$d = 2.7\sqrt[5]{\frac{L \cdot q_s^2}{\Delta m\,(S + 10)}}$$

where L = the length of the pipe in m.
Δ m = the permissible pressure drop in kg/cm^2 (normally 0.1 to 0.2 kg/cm^2).

Example of the calculation of an air lift pump

The following data are assumed to apply to a deep well:

1. Water flow required $q_v = 20$ m^3/h
2. Delivery head H = 40 m
3. Drop of water level $S_o - S = 10$ m

If the ratio of submergence S/H is assumed to be 1.2

S will be equal to $1.2 \cdot 40 = 48$ m and S_o equal to $S + 10 = 58$ m

According to diagram 2

Q_{spec} is equal to 4.2 m^3 of air per m^3 of water, when $q_s = q_v \cdot Q_{spec} = 20 \cdot 4.2 = 84$ m^3/h of free air

Working pressure of compressor:

$M = \frac{S}{10} = \frac{48}{10} = 4.8$ kg/cm^2 plus pressure drop in pipe main

$M_{max} = \frac{S_o}{10} = \frac{58}{10} = 5.8$ kg/cm^2 plus pressure drop in pipe main

If the pressure drop is 0.2 kg/cm^2, the compressor should thus deliver a minimum of 84 m^3/h of free air at a working pressure of 6 kg/cm^2.

3" delivery pipes are chosen according to Fig. 2.

Check of upper end diameter of pipes:

$D_{min} = 6\sqrt{q_v + q_s} = 6\sqrt{20 + 84} = 62$ mm

The area of the pipe need not be increased at the top.

Diameter of compressed air pipe:

$$d = 2.7\sqrt[5]{\frac{L \cdot q_s^2}{\Delta m\,(S + 10)}} = 2.7\sqrt[5]{\frac{88 \cdot 84^2}{0.2\,(48 + 10)}} = 23 \text{ mm}$$

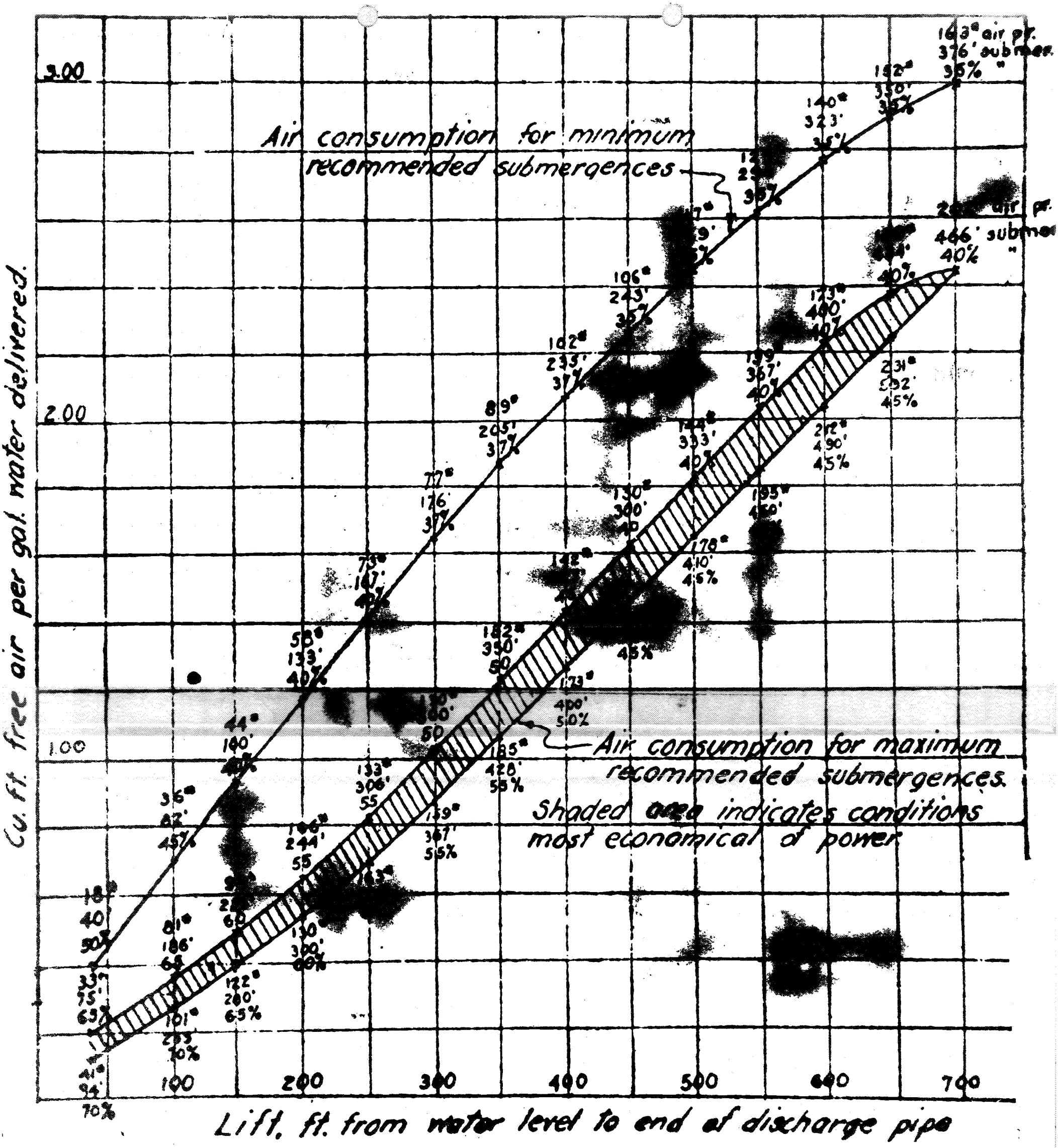
A 1" air pipe as indicated in the table is thus suitable.

Assuming that the isothermal efficiency of the compressor is 0.50, the total efficiency of the pump will be:

$$\eta_p = \eta_{is} \cdot 0.042\ C = 0.50 \cdot 0.042 \cdot 13 = 0.27 = 27\%.$$

References:

Compressed Air Data, 5th edition, N.Y. 1939
Hutton: The design of air-lift water pumps. Compressed Air Engineering, 11 (1946), pages 107-111, 121 - 124, 135 - 140.
Pickert: Die Sümpfung ersoffener Bergwerke durch Druckluftwasserheber. Erzmetall, 2 (1949), pages 118-122.



203

Fig. 40. Air Lift Calculations by Diagram.

STANSBURY BRINE

$$Q = av$$ 204

where:

Q = quantity of the mixture of air and water in cu. ft. per sec.

a = cross-sectional area of the discharge pipe in sq. ft.

v = velocity of mixture in pipe in ft. per sec.

The quantity, Q, at any point in the discharge pipe is ıe volume of the water to be pumped plus the volume of compressed air at that point. Since the air expand as it passes up the discharge pipe under decreasing head the air volume will vary from that of compressed air at inlet pressure to that of free air at the point of discharge.

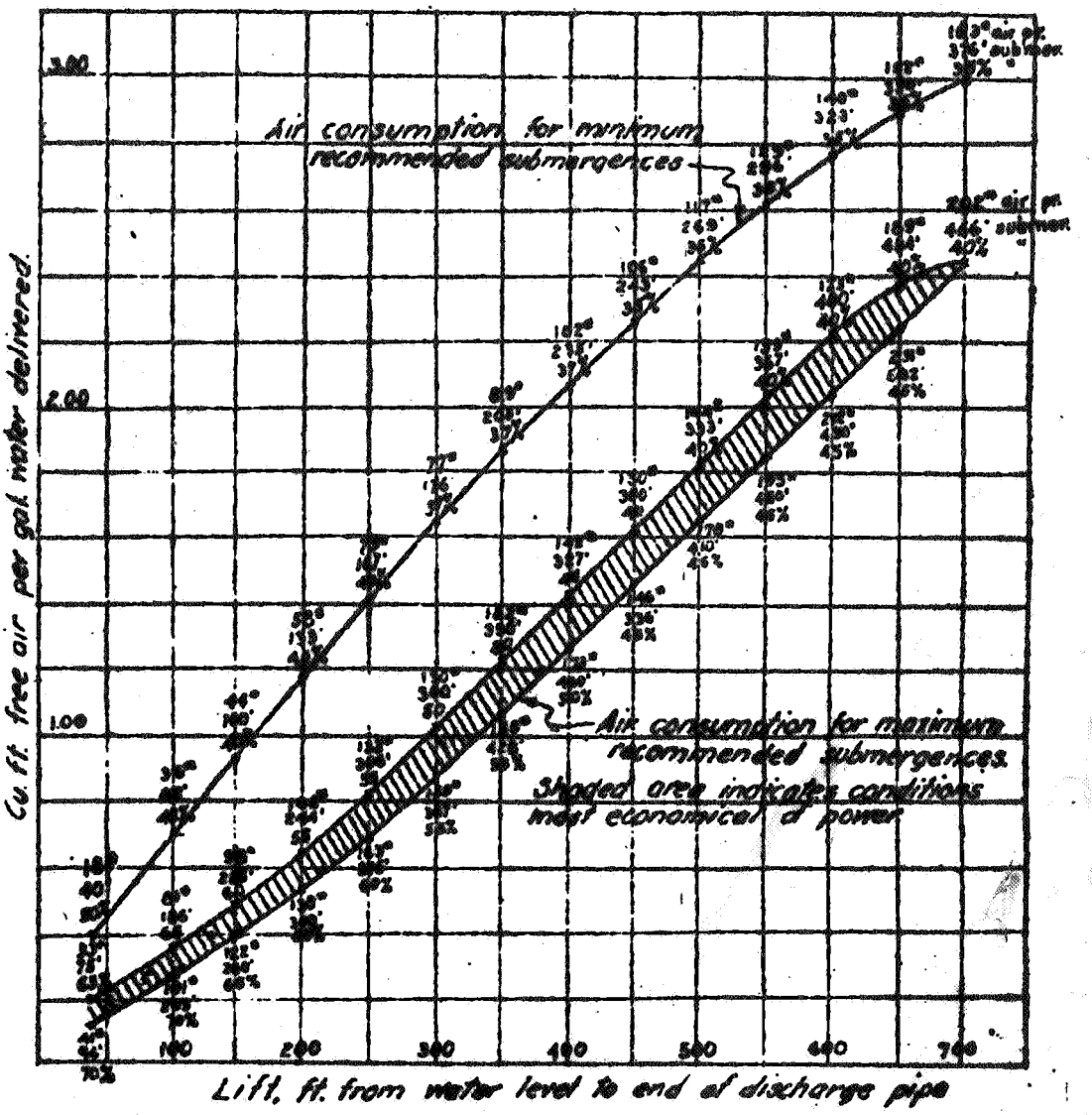


Fig. 40. Air Lift Calculations by Diagram.

DYCKERHOFF

ZEMENTWERKE AKTIENGESELLSCHAFT

WIESBADEN

205

Post-office: 6202 Wiesbaden-Biebrich, Postfach 9139

Geosurveys of Australia Pty. Ltd. Attn: Mr. D. van Sanden

Grenfell Street 68

Adelaide / South Australia

EXPORT-DEPARTMENT

Your Ref.:	Your Letter:	Our Ref.:	Wiesbaden,
		Exp.IBt	30th April, 1969

QUOTATION

Type of Cement	For use to max. static b. h. t. or depth to API Spec.	Destination: Australian main ports Price per bag/~~mt~~ of 94 lbs~~kg~~ incl. Texteplast packing cpndf liner terms Australian main ~~ports~~ DM
DYCKERHOFF HALLIBURTON OILWELL CEMENT		
API Class B (HSR)	170° F (77° C) 6.000 ft. (1.830 m)	7.2e
API Class D (HSR), retarded	230° F (110° C) 10.000 ft. (3.050 m)	8.2e
API Class E (HSR), retarded	290° F (143° C) 14.000 ft. (4.260 m)	8.56
API Class F (HSR), retarded	320° F (160° C) 16.000 ft. (4.880 m)	11.56
POZMIX CEMENT (ordinary)	200° F (93° C) 8.000 ft. (2.440 m)	7.72

Packing: see item No. 2a of attached description.
Extra cost for: Palletization (3e sacks on 1 pallet, pva-covered, steel-banded) 2.5e per bag

Insurance: see reverse side 1,35 %
Quantity: min. 1.2ee sacks per type and shipment
Delivery ex factory: approx. 2 - 3 weeks **to destination:** approx. 8 - 1e weeks
Shipment by: liner vessel ~~cnmbk~~ from: Bremen or Hamburg / Germany

Terms of Payment: net cash against documents

This quotation will be held open for a period of 9e days from date hereof.
However, prices will be subject to change in the event of any increase or decrease in either fob cost of the material or ocean freigt or insurance premium.

Encl.

e.e. Mr. Lauree Daly

Yours very truly,
DYCKERHOFF
Zementwerke AG

Homburg Theobald

p. t. o.

U/Round Burn's Tech. Journal

FIBERCAST

206

FIBERCAST COMPANY

a Division of THE YOUNGSTOWN SHEET and TUBE COMPANY

April 8, 1969

M. F. HUTCHISON
Manager - Pollution Control Products

Mr. D. H. A. von Sanden
Operations Manager
Geosurveys of Australia PTY. LTD.
Da Costa Building
Grenfell Street
Adelaide, South Australia 5000

Dear Sir:

After reviewing the well log taken of your previously drilled well and relating it to the proposed well operation as outlined in your letter, it is our belief that Fibercast casing can be installed successfully.

Due to the difference in strengths of Fibercast reinforced casing, as compared to steel, it will be necessary that the operating pressures of the Fibercast casing be taken into consideration when planning your completion method. Operating specifications for our eight-inch casing are attached for your review.

Fibercast Company is a manufacturer of reinforced plastic products, and our Engineering Staff, though capable of doing design work, are not completely familiar with all of the current methods presently used in well completions. We therefore do not recommend completion programs for wells.

It would be our recommendation that, if information is required on a casing cement program, that this information be obtained from Halliburton, Ltd., 222 Alton Avenue, Torrence Park, Adelaide, South Australia. Mr. W. W. Hicks is the Halliburton representative at this address.

As a suggestion only, we are sending a line drawing showing a method of completion that was proposed for a well, located in the United States, using our Fibercast Casing.

We can see no problems that would be encountered in also using our 1½" or 2" tubing as an air quill for aeration at the depths referred to in your letter.

PLASTICS 100 1868-1968
KEYSTONE OF THE FUTURE

If we can provide you with any further information or assistance, please feel free to contact me.

Sincerely yours,

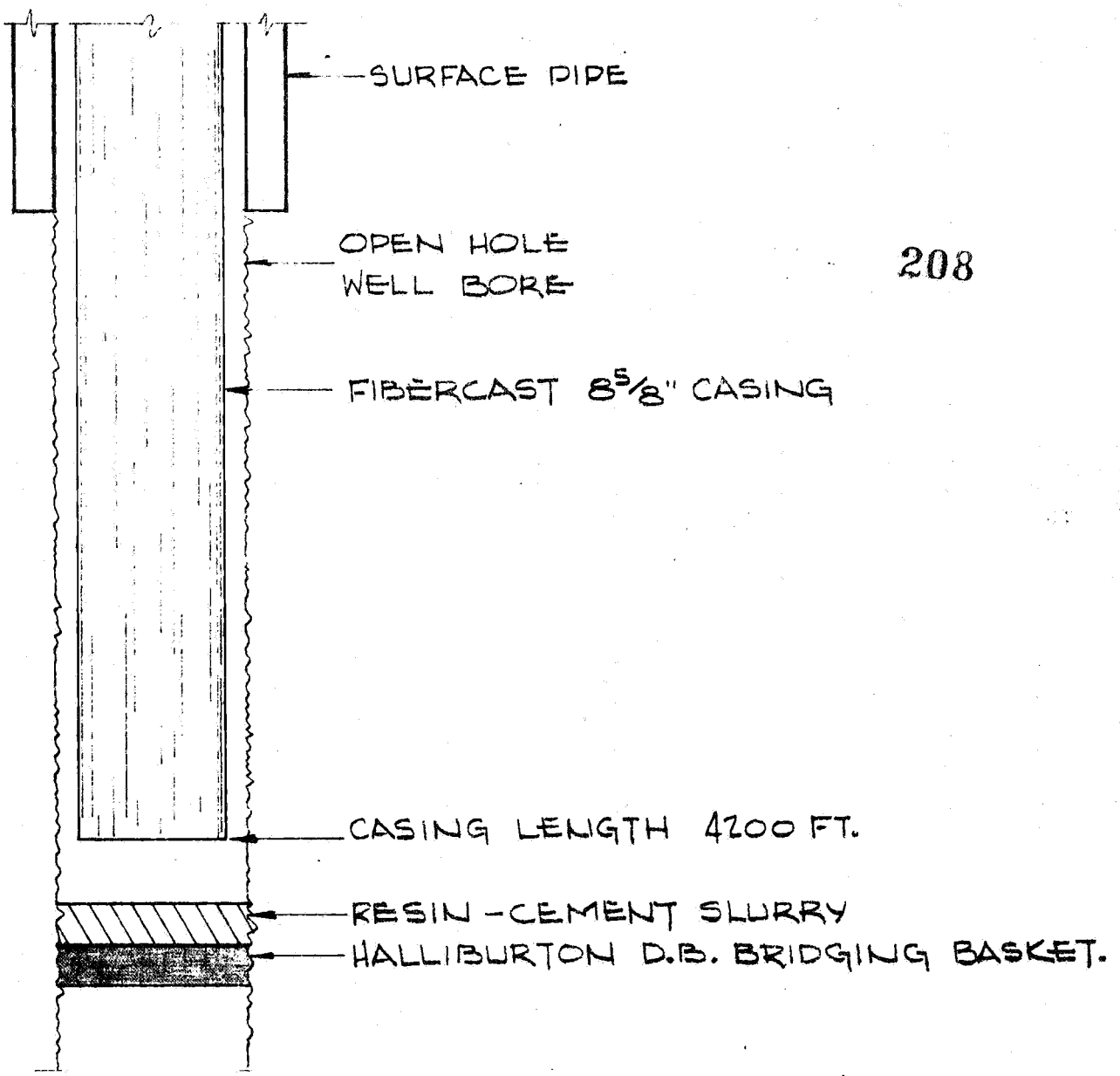
Marion F. Hutchison

Marion F. Hutchison, Manager
Pollution Control Products

MFH:mb

Attachments: Sketch
Casing Specifications

cc: Mr. Robert Laws
Mr. W. W. Hicks
Continental-Emsco Company
International Division



With this type of completion method, the Casing Cement then could be pumped, followed by a mud slurry of equal weight, which would offset any collapse or burst that the casing might be subjected to.

Information on Halliburton Equipment is shown on Pages 74 and 75 of Halliburton Sales and Service Catalog.

J.L. 4-8-69

CHEMICAL DISPOSAL TUBING

SIZE O.D. INCHES	CPLG. O.D. INCHES	WALL THICKNESS	WEIGHT PER FOOT	OPERATING INTERNAL PSI @ 200°F	OPERATING COLLAPSE PSI 80°F	120°F	160°F	RATED AXIAL LOAD LBS.	PRICE PER FT. T & C *
2 3/8	3 1/4	.250	1.25	460	550	425	350	6,000	$ 3.40
	3 1/4	.300	1.45	555	900	800	600	6,000	4.10
2 7/8	3 3/4	.250	1.46	370	300	275	200	7,500	3.90
	3 3/4	.300	1.75	585	500	450	375	7,500	4.67
	3 3/4	.350	1.95	710	800	650	500	7,500	5.24
3 1/2	4 1/4	.250	1.80	430	200	175	125	9,100	4.52
	4 5/8	.300	2.20	585	350	325	250	9,100	5.57
	4 5/8	.350	2.50	710	550	500	450	9,100	6.25
4 1/2	5 1/2	.300	3.00	415	250	200	160	12,500	6.48
	5 7/8	.340	3.40	490	350	290	210	12,500	7.14
	5 7/8	.380	3.70	555	500	410	320	12,500	7.45
	5 7/8	.420	4.00	615	700	575	450	12,500	7.96
	5 7/8	.500	4.70	675	1,100	950	700	12,500	8.74
6 5/8	7 3/4	.300	4.30	340	65	45	35	16,000	9.30
	7 3/4	.340	4.90	395	130	100	85	16,000	10.34
	7 3/4	.380	5.40	450	200	175	125	16,000	10.96
	8 1/8	.420	6.00	505	270	210	165	16,000	12.48
	8 1/8	.460	6.70	555	350	290	210	16,000	13.05
	8 1/8	.500	7.10	615	450	340	275	16,000	13.75
	8 1/8	.580	8.30	690	640	400	320	16,000	14.75
	8 1/8	.625	8.90	725	750	475	375	16,000	15.75
	8 1/8	.750	11.10	860	1,500	1,000	800	16,000	19.00
	8 1/8	1.000	13.40	1,100	4,000	3,700	2,600	16,000	23.95
	8 1/8	1.250	16.10	1,350	8,000	7,000	5,000	16,000	28.75
8 5/8	9 3/4	.25	4.60	130	20	15	10	11,000	15.50
	9 3/4	.30	5.50	160	35	25	18	17,000	16.27
	9 3/4	.40	7.10	240	85	50	37	20,000	18.10

* Prices F.O.B. Sand Springs Oklahoma

Underground Brine

210

DWS:hjr

5th March, 1969.

Mr. M. F. Hutchison,
Manager,
Pollution Control Products,
Fibercast Company,
SAND SPRINGS, Oklahoma 74063, U.S.A.

Dear Sir,

Pumping - Underground Brines

Thank you for your prompt reply of January 7th, regarding our enquiry for Fibercast tube for the production casing of a brine well.

We have enclosed a log section that was taken in a previously drilled position that is adjacent to the area that we have in mind drilling. Unfortunately, the concept of brine pumping from the dolomites did not occur until this hole had been plugged and abandoned. We are therefore faced with the problem of completely re-drilling the section of interest.

Our requirement for pumping, which we propose to achieve by air, is some 400,000 gallons per day from a brine-bearing reservoir at about 4200 feet. We believe that there will be a drawdown of no more than 100 feet or so below ground level. Our thinking at this time is that an 8-inch bore case would be satisfactory. This would be set in the top of the dolomite at 4200 feet, and we would use this casing as a pumping case. We would set in effect, go back down the hole with a pumping case. We would naturally use an air quill of some 2-inch diameter, 700 feet long, to afford aeration of the brines at this depth. The static column of the brine is anticipated to be 100 feet from the surface, and the S.G. of this brine is 1.12.

Would you be kind enough to have your engineers consider the application of Fibercast casing of this project, and let us have your recommendations with regard to well completion and the best methods that they would suggest we use.

Yours faithfully,
SOLUTIONS OF AUSTRALIA PTY. LIMITED.

D. H. A. von Sanden,
OPERATIONS MANAGER

c.c. Mr. Robert Laws
Encl: BP.379-1 & 2

BERCAST

FIBERCAST COMPANY
a Division of THE YOUNGSTOWN SHEET and TUBE COMPANY

211

January 7, 1969

Mr. D. H. A. von Sanden
Operations Manager
Geosurveys of Australia PTY. LTD.
Da Costa Building
Grenfell Street
Adelaide, South Australia 5000

Dear Sir:

In answer to your recent letter requesting information on Fibercast Tubing and Line Pipe, we are enclosing our General Catalogue and Tubing Bulletin.

Fibercast Company manufactures a glass reinforced epoxy and a glass reinforced vinylester piping system that can be used as above ground line pipe or subsurface tubing. Our method of manufacturing is by the centrifugal casting process which enables us to control the OD of our materials to steel pipe sizes.

Our thread system is a upset thread which is molded onto the surface of the pipe. The thread in the pipe sizes 2--6 inch is furnished with a AST reinforced plastic pipe thread which meets the ASTN standard D-1694-59T this is the American Standard 60° stub thread with one in 32 taper in sizes larger than 6 inch. We manufacture modified acme thread.

The insert sheets that are in the tubing bulletin show the dimensions and pressure ratings of the tubing that is manufactured.

Fibercast Company has installed our reinforced tubing in numerous subsurface applications which include Chemical Waste Disposal Wells and Water Supply Wells. In the Water Supply Wells, we have used our pipe with both submergeable pumps and column drive shaft pumps. We wish to thank you for your interest in our product line and if we may supply you with any further information or be of any assistance to you, please feel free to contact us.

Respectfully yours,

FIBERCAST COMPANY

M. F. Hutchison
by-NR

M. F. Hutchison, Manager
Pollution Control Products

MFH:bnr

Enclosure

CHEMICAL DISPOSAL TUBING

SIZE O.D. INCHES	CPLG. O.D. INCHES	WALL THICKNESS	WEIGHT PER FOOT	OPERATING INTERNAL PSI @ 200°F	OPERATING COLLAPSE PSI 80°F	120°F	160°F	RATED AXIAL LOAD LBS.	PRICE PER FT. T & C
2 3/8	3 1/4	.250	1.25	460	550	425	350	6,000	$ 3.40
	3 1/4	.300	1.45	555	900	800	600	6,000	4.10
2 7/8	3 3/4	.250	1.46	370	300	275	200	7,500	3.90
	3 3/4	.300	1.75	585	500	450	375	7,500	4.67
	3 3/4	.350	1.95	710	800	650	500	7,500	5.24
3 1/2	4 1/4	.250	1.80	430	200	175	125	9,100	4.52
	4 5/8	.300	2.20	585	350	325	250	9,100	5.57
	4 5/8	.350	2.50	710	550	500	450	9,100	6.25
4 1/2	5 1/2	.300	3.00	415	250	200	160	12,500	6.48
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	5 7/8	.420	4.00	615	700	575	450	12,500	7.96
	5 7/8	.500	4.70	675	1,100	950	700	12,500	8.74
6 5/8	7 3/4	.300	4.30	340	65	45	35	16,000	9.30
	7 3/4	.340	4.90	395	130	100	85	16,000	10.34
	7 3/4	.380	5.40	450	200	175	125	16,000	10.96
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	8 1/8	.460	6.70	555	350	290	210	16,000	13.05
	8 1/8	.500	7.10	615	450	340	275	16,000	13.75
	8 1/8	.580	8.30	690	640	400	320	16,000	14.75
	8 1/8	.625	8.90	725	750	475	375	16,000	15.75
	8 1/8	.750	11.10	860	1,500	1,000	800	16,000	19.00
	8 1/8	1.000	13.40	1,100	4,000	3,700	2,600	16,000	23.95
	8 1/8	1.250	16.10	1,350	8,000	7,000	5,000	16,000	28.75

COLUMN PIPING

SIZE O.D. INCHES	WEIGHT PER FT LBS	WALL THICKNESS	OPERATING PSI 120°F	RATED AXIAL LOAD/LBS	PRICE PER FOOT *1	PRICE PER FOOT *2	PRICE PER FOOT *3	PRICE PER FOOT *4
6.625	4.2	.250	250	9,000	$ 16.21	$ 24.31	$ 17.83	$ 13.94
6.625	5.1	.300	325	13,000	17.21	25.82	18.93	14.84
6.625	6.3	.400	475	17,000	19.51	29.27	21.46	16.78
8.625	5.5	.250	200	11,000	17.86	26.79	19.64	15.50
8.625	6.4	.300	250	17,000	18.72	28.08	20.59	16.27
8.625	8.0	.400	375	20,000	21.86	32.79	24.05	18.10
10.75	6.7	.250	160	15,000	19.56	29.34	21.52	17.85
10.75	7.8	.300	200	20,000	21.04	31.56	23.14	19.19
10.75	9.8	.400	300	20,000	23.12	34.68	25.43	21.10
12.75	8.0	.250	130	18,000	24.86	37.29	27.35	22.65
12.75	9.4	.300	160	18,000	26.92	40.38	29.61	24.55
12.75	11.8	.400	240	18,000	29.10	42.65	32.01	26.55

1. *Prices shown are F.O.B., Sand Springs, Oklahoma - cut to length of 10 Ft. - Threaded and Coupled.

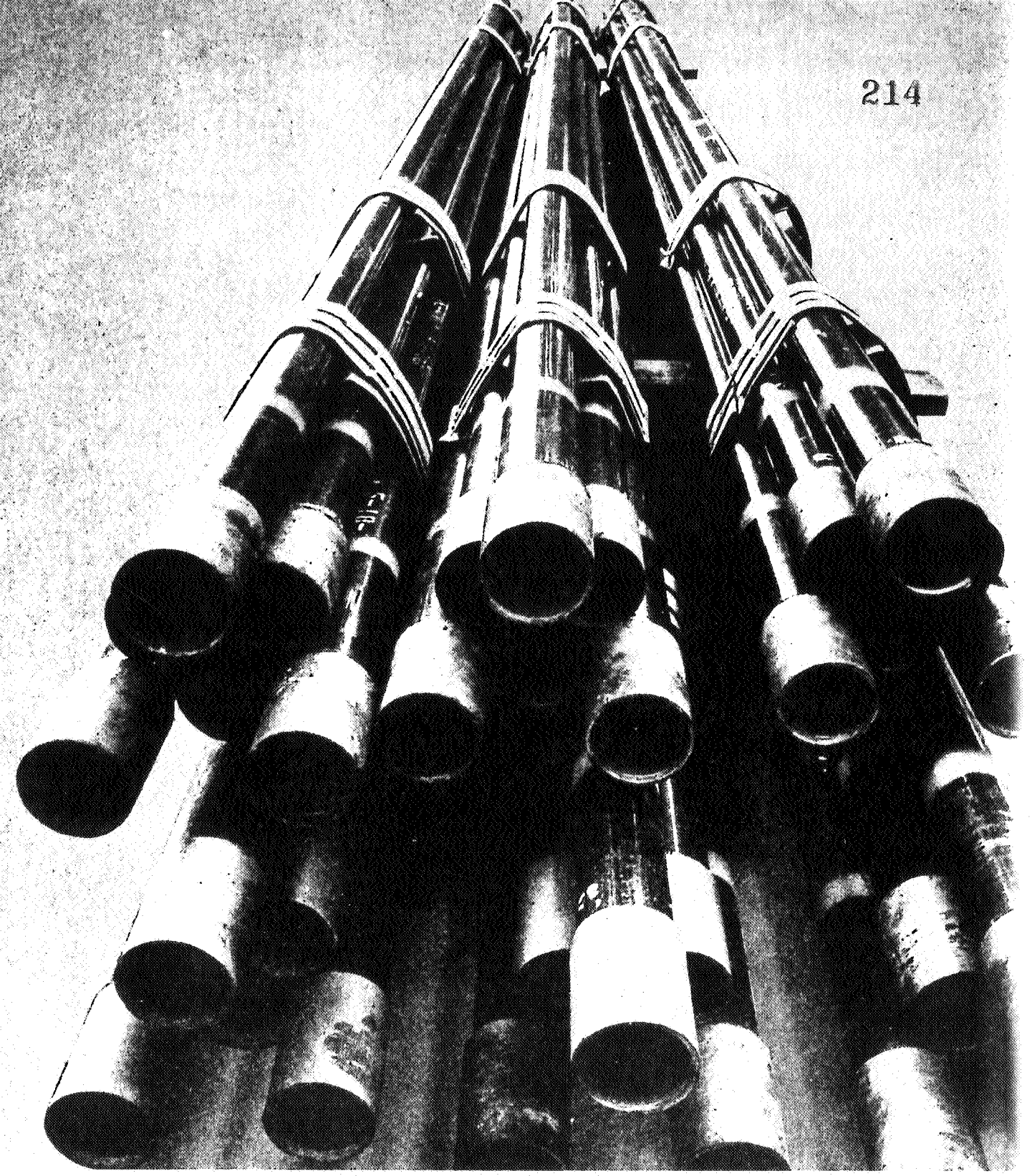
2. *Prices shown are F. O. B., Sand Springs, Oklahoma - cut to length of 5 Ft. - Threaded and Coupled.

3. *Prices shown are F. O. B., Sand Springs, Oklahoma - cut to length of 5 Ft. - Thread by Thread.

4. *Prices shown are F. O. B., Sand Springs, Oklahoma - random lengths 15 Ft. to 20 Ft.

Pipe is furnished with modified Acme Threads one end and Modified Acme Threaded Coupling Adhesied on other end.

MFH/nr
January 8, 1969



FIBERCAST® CHEMICAL DISPOSAL TUBING

Manufactured by FIBERCAST COMPANY, a Division of The Youngstown Sheet and Tube Company

FIBERCAST® CHEMICAL DISPOSAL TUBING

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The Story of FIBERCAST . . .

Fibercast was conceived, in the true Youngstown tradition, to solve specific "impossible" industrial problems.

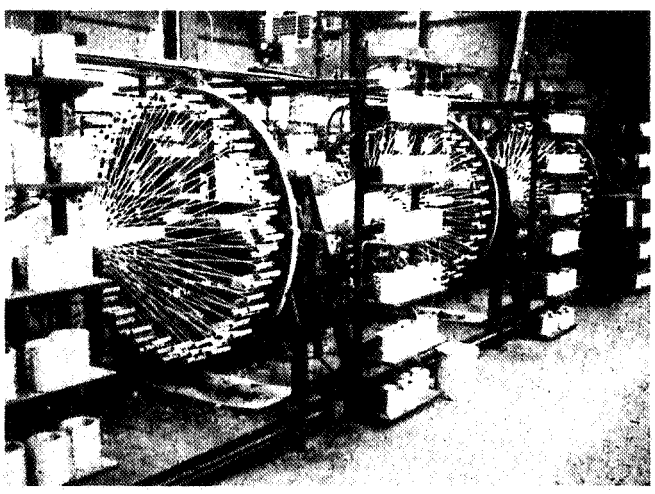
Prior to 1955, the unique demands of the oil industry upon salt water disposal-well tubing made it apparent that a better, more corrosion-resistant piping material was needed . . . and needed badly.

After years of comprehensive research and testing, the material known as Fibercast was perfected and put into production in 1955. Its success was immediate.

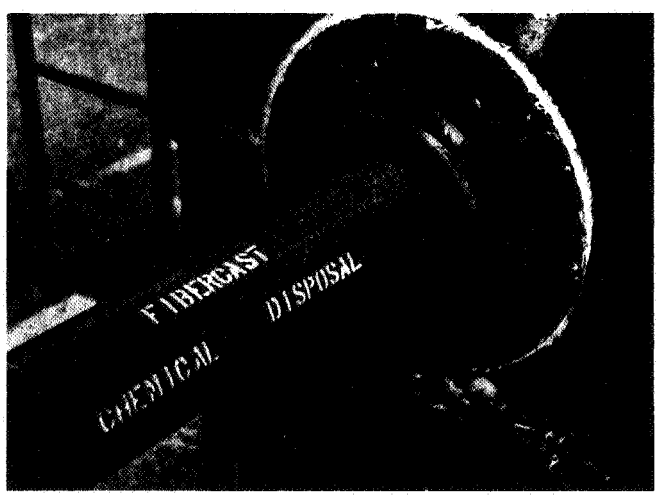
The good news about Fibercast traveled fast. Soon this remarkable new Youngstown product was being manufactured and utilized for a multitude of purposes, not only with the Oil Industry, but in many other process industries where heat, pressure and corrosion resistance were important factors in pipe and fittings.

Youngstown's Fibercast was the first pipe of its kind on the market. It is still far and away the finest.

FIBERCAST - What it is . . .



Hoop and axial strengths may be varied on specially designed braider.



High-speed centrifugal casting machines used in Fibercast's patented manufacturing process.

Fibercast pipe is a two-component material. Pipe tension stresses are absorbed by a mass of very fine glass fibers woven into a predetermined pattern. Pipe up to 3-1/2" O. D. is made with multiple layers of seamless braid. Pipe 4-1/2" O. D. and larger is made with special designed glass cloth in convolute layers. Glass fibers are known to have tensile strengths of 200,000 psi with an elastic strain of 3% at the ultimate strength.

Surface chemistry highlights the design and production concepts at Fibercast. This begins with the glass fibers being heat treated to prepare them for maximum resin adhesion.

The second essential is the controlled curing of the epoxy resins . . .

Epoxy resins are thermoset through chemical reaction, controlled heat and eutectic mixtures of diamines. Fibercast tubing is manufactured from raw materials that must meet very exacting purchase specifications.

In addition, the quality control of these raw materials and the finished product is the most exacting in the industry.

Epoxies have great adhesion strengths; the ability to penetrate minute areas of the fiber mass; tensile strengths of 12,000 to 14,000 psi with an elastic strain of 3 to 4% at ultimate strength.

The woven glass fibers and epoxy resin are brought together in a high speed centrifugal casting machine, at which time air and gas are centrifuged from the resin during the liquid cycle. This union is a chemical one, thus it is important to control temperatures, time cycles and formulations. Fibercast uses modern automatic equipment to do this, resulting in the most uniform reinforced plastic pipe on the market today. The entire production line from the braiding through casting, threading and testing is an automated process.

The cast resin results in a glassy-smooth, highly chemical resistant interior surface.

© 1968
THE YOUNGSTOWN SHEET AND TUBE COMPANY

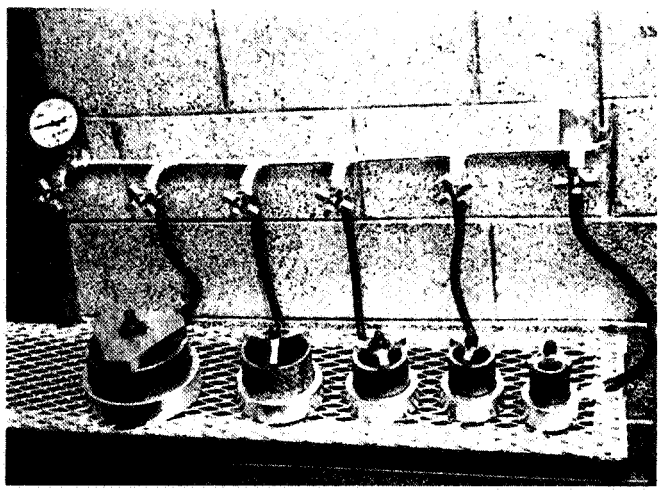
Industrial Waste Disposal Tubing

The problems of disposing of industrial wastes are of great concern to plants as well as local, state and federal governments.

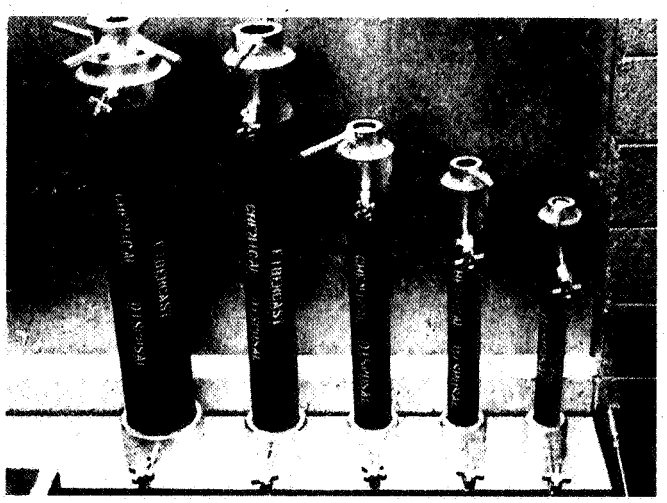
Fibercast has more than 12 years proven successful experience in the field of industrial acid waste disposal wells and can assist you in solving your specific disposal problems.

Fibercast disposal tubing is a tough, rigid epoxy or vinyl ester pipe, centrifugally cast with a backbone of high tensile glass fibers. In addition to being non-corrosive, it offers these plus factors:

- High tensile and joint strength, 3,000# to 197,000# for settings up to 7,000' depths.
- High collapse strength, 50 psi to 1,000 psi, allows filling annulus with protective fluids.
- May be engineered with or without a packer.
- A proven "fast thread" system – shear strengths up to 75,000#.



Proof that **FIBERCAST** is non-porous. This edgewise porosity test subjects a 2-1/2" length to more than 500 PSI water pressure for thousands of hours, with no weeping through the edges.



Test cells like these are used for quality control testing and certification of products.

Laboratory Proven . . .

Fibercast disposal tubing has met the industry's most rigid laboratory testing, not only in its raw material stage, but in its finished product stage.

Standard Test Methods Insure Quality . . .

The use of standard test methods plays a very important part in the design, quality control and establishment of technical and specification data for our FIBERCAST pipe and fittings.

These test methods are used on the raw materials as well as the finished products through the manufacturing process. Some of these methods are:

Raw Materials

ASTM-D-1763-62	Specification For Epoxy Resin
ASTM-D-543-60T	Test For Resistance Of Plastics To Chemical Reagents
ASTM-D-648-56	Test For Deflection Temperature Of Plastics Under Load
ASTM-D-638-64T	Test For Tensile Properties Of Plastics
ASTM-D-790-63	Test For Flexural Properties of Plastics
ASTM-D-759-48	Test For Tensile And Compressive Properties Of Plastics At Subnormal and Supernormal Temperatures
ASTM-D-671-63T	Test For Repeated Flexural Stress Of Plastics
ASTM-D-2343-65T	Test For Tensile Properties Of Glass Fiber Strands, Yarns, And Rovings Used in Reinforced Plastics

Finished Products

ASTM-D-1599-62T	Test For Short-Time Rupture Strength Of Plastic Pipe, Tubing and Fittings
ASTM-D-1598-63T	Test For Time-To-Failure Of Plastic Pipe Under Long – Term Hydrostatic Pressure
ASTM-D-2105-62T	Test For Longitudinal Tensile Properties Of Reinforced Thermosetting Plastic Pipe And Tubing
ASTM-D-2143-63T	Test For Cyclic Pressure Strength Of Reinforced Thermosetting Plastic Pipe
ASTM-D-2153-63T	Recommended Practice For Calculating Stress On Plastic Pipe Under Internal Pressure
ASTM-D-2310-64T	Specification For Reinforced Thermosetting Plastic Pipe

The benefits of using standard test methods are many. Fibercast Company produces superior products by utilizing these accepted standard methods.

Field Proven . . .

Fibercast chemical disposal tubing has been operating in waste acid wells since 1954. Well depths range 400' to 5800'. These systems vary in operating conditions from 27 inches of vacuum to 3400 P. S. I. injection pressures.

A typical example of an acid disposal well using Fibercast tubing as the carrier of waste acid to be disposed is shown below:

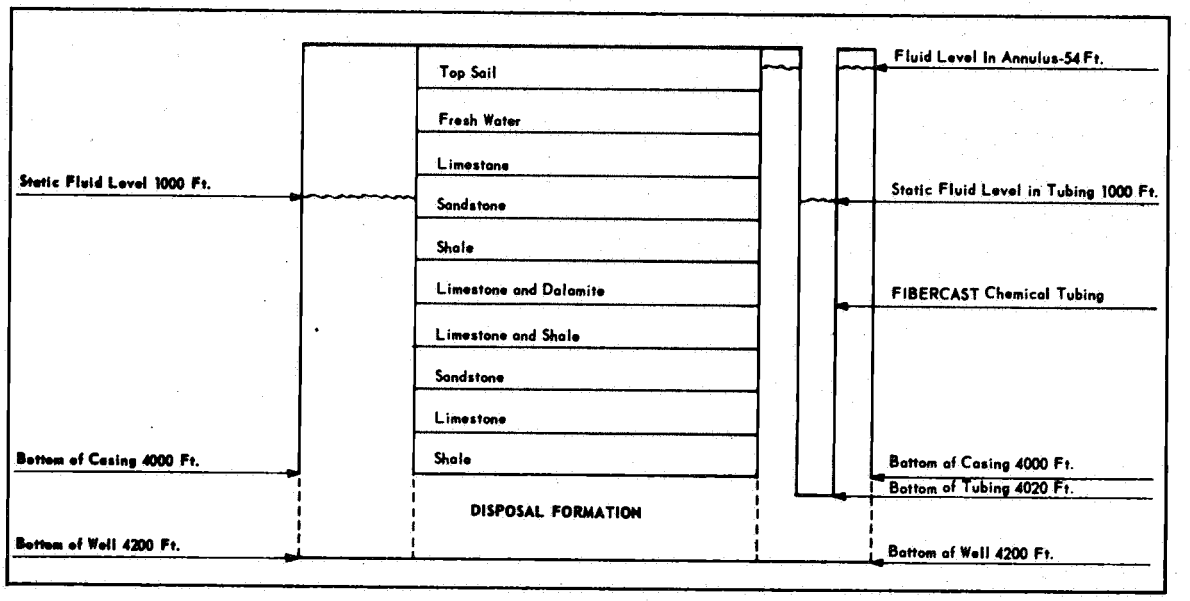


Fig. 1 Fig. 2

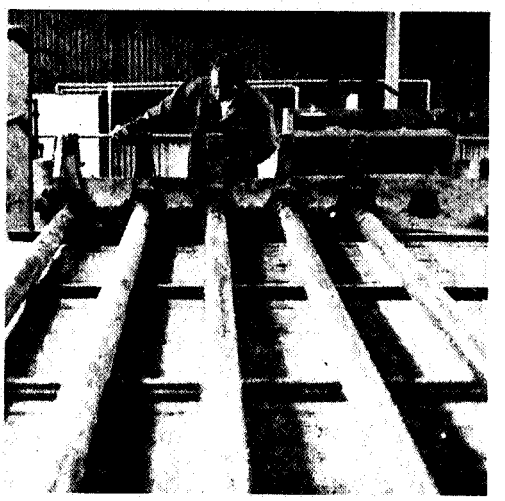
Figure 1 shows the well after being drilled and 7 inch steel casing set to the top of the disposal formation. This formation is generally a porous brine-bearing sandstone. The water drive in this formation has created a static fluid level (level of formation fluid stays after well completion) of 1000' from the ground surface.

Figure 2 shows the well after installation of Fibercast tubing and with the annulus space (opening between casing and tubing) has been filled with a hydrocarbon fluid (kerosene, diesel or third run gasoline) to displace the water into the disposal formation and give permanent protection to the steel casing. By using a hydrocarbon fluid in this manner it is possible to keep the fluid in the annulus displaced, because of its lighter weight than that of the waste acid to be disposed or that of the fluid in the disposal formation. This method of completion is called an open-end system with balance fluid columns. The waste fluid can now be disposed either by gravity-feed through the Fibercast tubing or with injection pumps through the tubing.

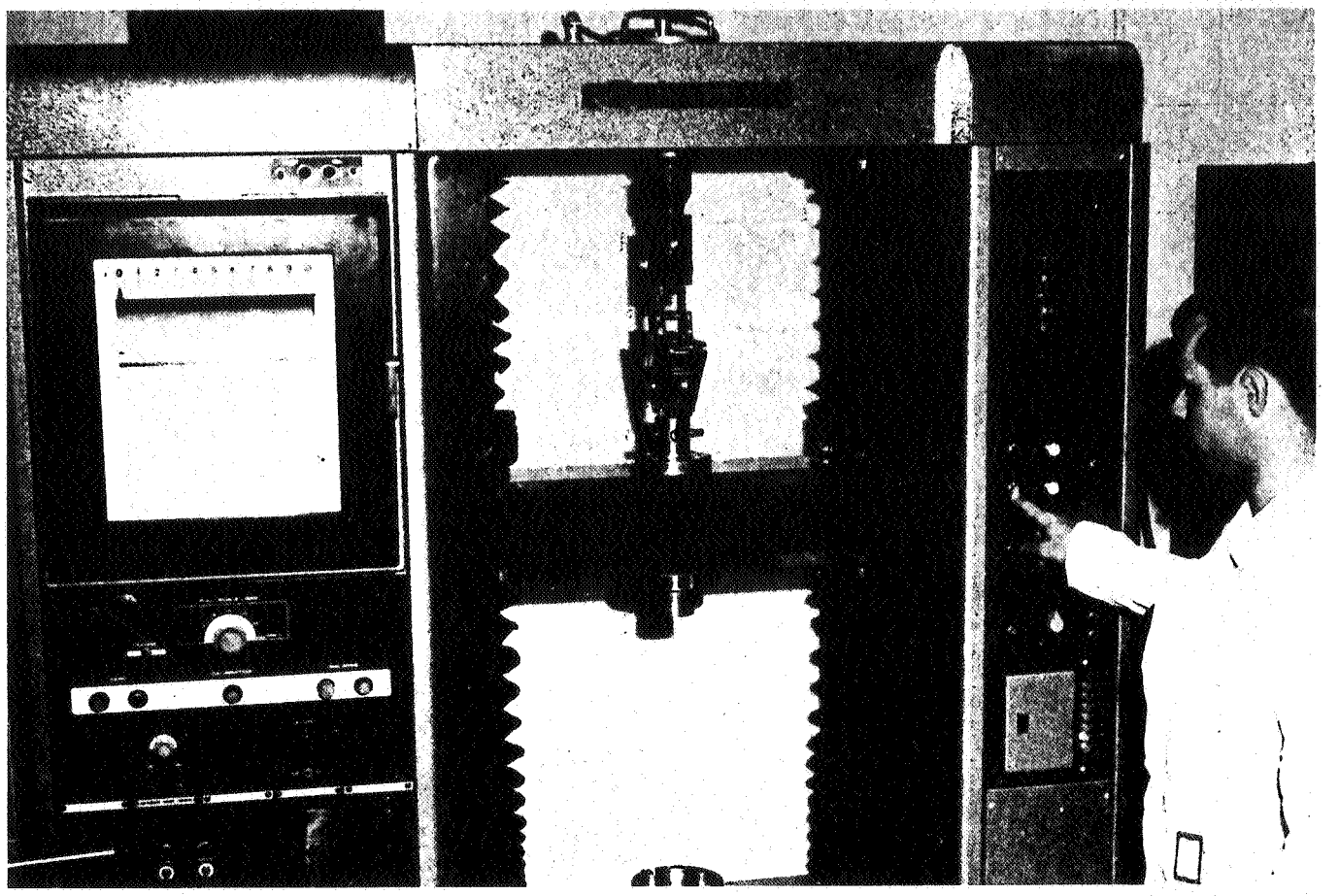
Chemically Resistant . . .

The following chemical resistance chart is for reference only. For specific chemical combinations, consult your **FIBERCAST** representative.

Acetic Acid
Acetone
Aliphatic Hydrocarbons
Ammonium carbonate
Ammonium chloride
Ammonium fluoride
Ammonium hydroxide
Ammonium nitrate
Ammonium sulfate
Benzol
Butanol
Butyric acid
Calcium chloride
Calcium hydroxide
Carbon tetrachloride
Copper chloride
Copper sulfate
Diesel fuels
Ethylene dichloride
Ethylene glycol
Ferric chloride
Hydrochloric acid
Hydrofluoric acid
Hydrogen peroxide
Lactic acid
Oleic acid
Oxalic Acid
Phosphoric acid
Potassium dichromate
Sodium hydroxide
Sodium hypochlorite
Sodium sulfite
Sulfuric acid
Seawater
Tannic acid
Toluene
Urea
Zinc chloride
Zinc sulfate



Pressure chamber for hydraulic testing of Fibercast tubing.



The Universal Testing Machine is used by our Laboratory and Development personnel to evaluate raw materials and finished FIBERCAST products.

Design Assistance . . .

There is an experienced **FIBERCAST** tubing design engineer available to assist you in designing a disposal well for your specific needs. His recommendations can frequently save you money. Feel free to request his services.

Contact your local **Fibercast** representative, or, the home office at Post Office Box 727, Sand Springs, Oklahoma 74063, telephone 918-245-6651.

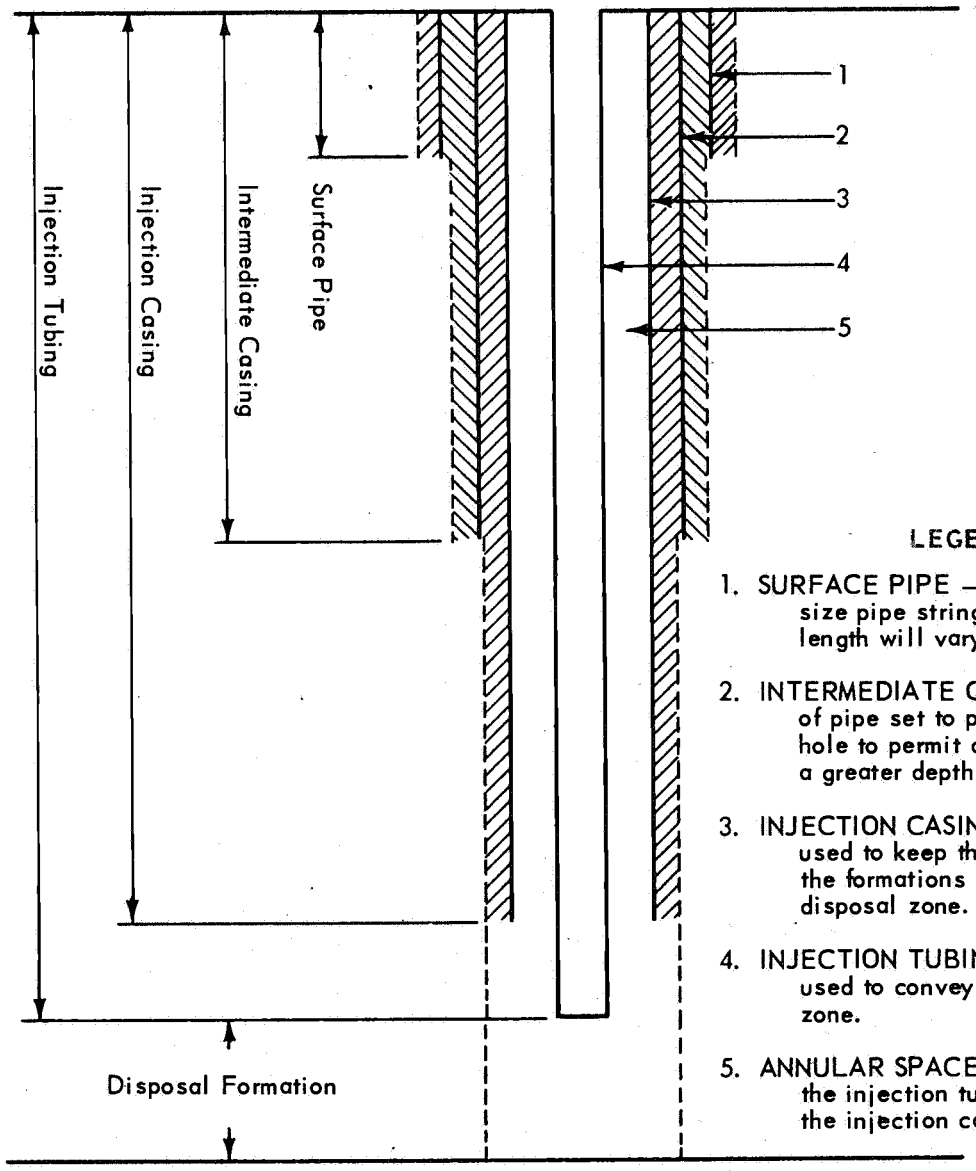
FIBERCAST®

FIBERCAST COMPANY
a Division of THE YOUNGSTOWN SHEET AND TUBE COMPANY
Box 727 • Sand Springs, Oklahoma 74063
Phone: 918-245-6651 • TWX Sand Springs 918-245-2586

BULLETIN F-481
3M-8/67-CE

PRINTED IN U.S.A.

WASTE DISPOSAL WELL



LEGEND

1. SURFACE PIPE – The first and largest size pipe string set in a well. The length will vary in different areas.
2. INTERMEDIATE CASING – The string of pipe set to protect a section of the hole to permit drilling to continue to a greater depth.
3. INJECTION CASING – The string of pipe used to keep the well bore open through the formations down to or through the disposal zone.
4. INJECTION TUBING – The string of pipe used to convey fluids to the disposal zone.
5. ANNULAR SPACE – The area surrounding the injection tubing when suspended in the injection casing.

FLUID LEVEL – The distance between well head and point to which fluid rises in the well.

OPEN END – When no sealing mechanism is used in the annular space to seal the area between the injection tubing and injection casing.

PACKER – A mechanical device used to seal the annular space between the injection tubing and injection casing.

INFORMATION FOR TUBING DESIGN

1. Size & Depth of Injection Casing
2. Fluid Level
3. Volume of Fluid to be Disposed
4. Type Fluid to be disposed
5. Type of completion
   (a) Open Ended
   (b) Packer (if so, type)
6. Type of Fluid to be used in annular space
7. Type & Size of Injection Pump
8. Depth Injection Tubing to be set

FIBERCAST TUBING *and* LINE PIPE



TUBING FIBERCAST LINE PIPE

THE FIBERCAST CORPORATION

P. O. Box 326, Sand Springs, Oklahoma • Phone Tulsa 2-7212

Manufacturers of

FIBERCAST TUBING AND LINE PIPE

Distributed by

THE YOUNGSTOWN STEEL PRODUCTS COMPANY
THE YOUNGSTOWN STEEL PRODUCTS COMPANY OF CALIFORNIA
THE CONTINENTAL SUPPLY COMPANY

FIBERCAST *advantages*

Made from Thermosetting resins

not to be compared with extruded plastic pipe made with thermoplastic materials.

Can be operated between — 65° and 130°F.

Fibercast has no elongation, will follow contours without taking a permanent set, has no cold flow, and is non-shatterable.

This makes it possible for Fibercast to be used where pipe extruded from thermoplastic resins or steel pipe lined with thermoplastic are not suitable.

Coefficient of thermal expansion is essentially the same as steel.

Thermal insulator — no paraffining — no scaling.

Electric insulator — no static.

FIBERCAST TUBING AND LINE PIPE HAVE ALL THE ABOVE ADVANTAGES, *PLUS*

High collapse strength
High burst strength
High beam strength
High tensile strength

Molded threads and precision couplings using our special thread lubricant make handling Fibercast Tubing and Line Pipe easy and positive.

GILBERT LODGE & COMPANY LIMITED
203 MORPHETT ST.
ADELAIDE
Phone: LA 4021 (3 lines).

What is FIBERCAST?

FIBERCAST is a product of thermosetting resins reinforced with glass fibers and cured by heat. FIBERCAST Pipe and Tubing are not affected by corrosive waters or soils, will not rust and are inert or resistant to many corrosive solutions. By bonding the resins to the glass fibers an excellent combination of strength properties is obtained. FIBERCAST Pipe and Tubing are manufactured in 20 foot joints, using a centrifugal casting method. FIBERCAST is joined by the use of couplings made from the same material as the pipe. In most cases threaded joints are used although "slip" couplings may be obtained which can be securely joined with "Weldfast" cement. A graphite grease thread lubricant is recommended for threaded joints. FIBERCAST Line Pipe and Tubing are available in sizes shown on the back page. 90° ells and tees are available made from the same material as the pipe. Saddles also are available for service connections.

TABLE I • FIBERCAST PHYSICAL DATA

The following properties represent actual test data and are for general information. Recommended working pressures listed on the back page should be used for design of installations.

	LINE PIPE		TUBING
	Class 100	Class 200	Class 300
Ultimate Tensile (longitudinal) psi ASTM D-638-52T	7,000-9,000	10,000-11,000	11,000-13,000
Tensile Yield (longitudinal) 0.2% offset	Approximately the same as the ultimate tensile		
Compression (longitudinal) psi ASTM D-348-52	7,000-14,000	14,000-16,000	over 16,000*
Specific Gravity, all classes	1.65		
Expansion (thermal) Coefficient Temp. Range 23-60°C., all classes	4×10^{-3} per °C.		
Moisture Absorption 24 hours at 77°F., all classes	Less than 0.20%		
Di-electric Strength, all classes	500 volts per mil		
Charpy Impact foot-pounds/in. ASTM D-256-47T, all classes	8-13		
Barcol Hardness, all classes	45-60		
Heat Distortion ASTM D-648-45T, all classes	Over 180°F.		

TABLE II • FIBERCAST CHEMICAL RESISTANCE DATA

FIBERCAST can be used satisfactorily for transporting the following at temperatures up to 130°F.:

- Crude Oil—Sour
- Salt Water and Brine
- Acidizing Fluids
- Mineral Salt Solutions
- Organic Acids (Moderate Concentration)
- Dilute Alkalies (up to 1½%)
- Crude Oil—Sweet
- Water
- Gasoline
- Sulfuric Acid—50%
- Hydrochloric Acid—37%
- Dilute Nitric Acid
- Hydrogen Sulfide
- Acid Muds
- Gas
- Chlorine Solution—10 %
- Boric Acid

FIBERCAST has been used also for mine waters, paper mill liquors, tanning liquors, alkalies more concentrated than 1½% and for many other uses, and at temperatures in excess of 130°F., but these particular applications should be checked with our engineering staff to determine suitability of the specific solutions and temperatures involved.

In excess of capacity of testing machine.

FIBERCAST

FIBERCAST TUBING

General Handling Instructions

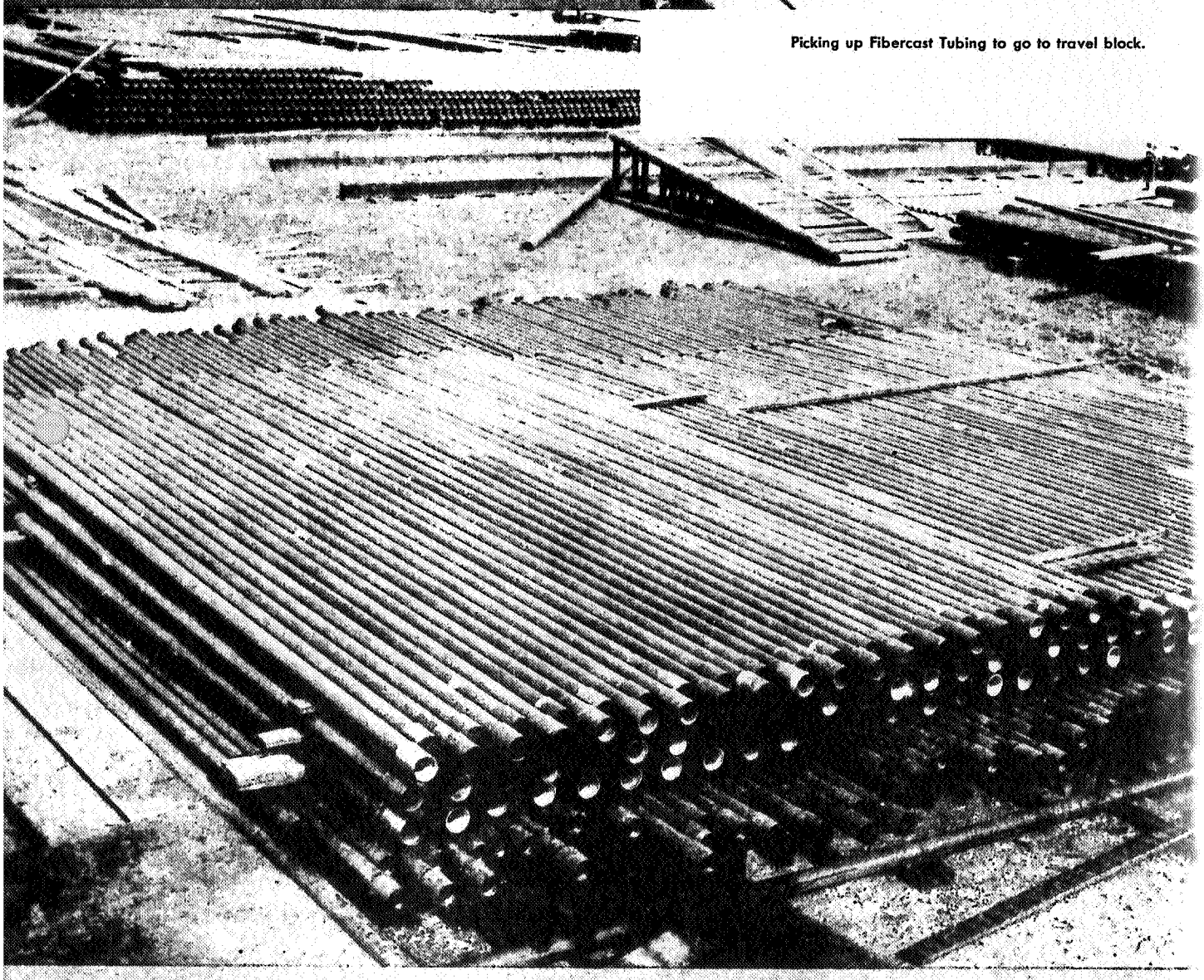
Avoid sharp edges in transporting, storing or running Fibercast Tubing. Use flat bed trucks and tie tubing down with ropes. Store the tubing less than four feet high and on flat ground or platform. Exercise ordinary care in handling, and do not throw around carelessly.

Installation Instructions

Conventional equipment for running tubing may be used with the following exceptions: Use double elevators instead of single elevators and slips. Use Lacrosse type wrenches instead of tubing tongs. Use only thread lubricant provided or approved by manufacturer.



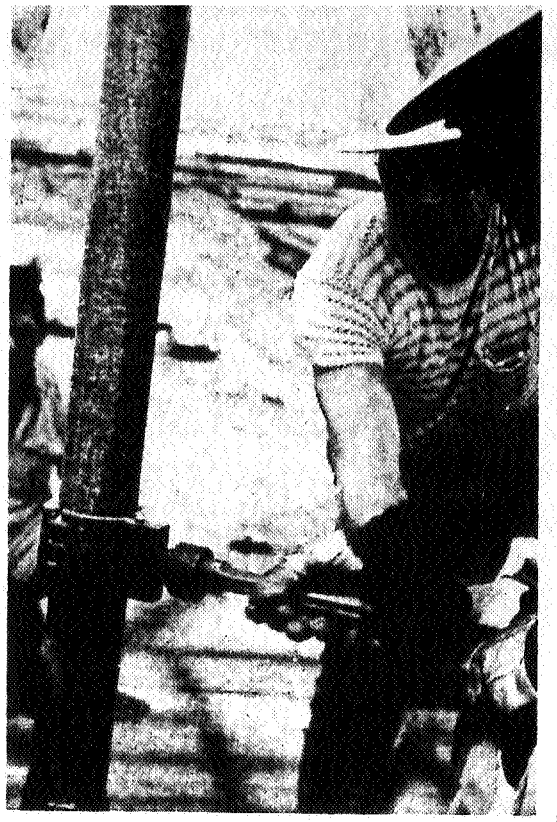
Picking up Fibercast Tubing to go to travel block.



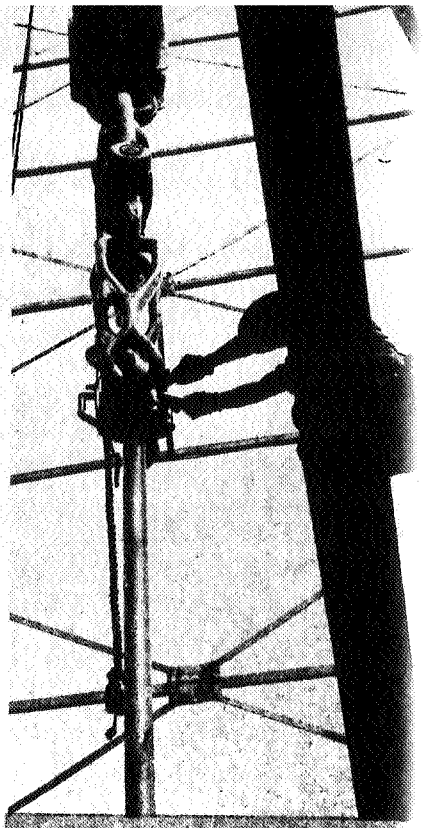
Fibercast Tubing on rod rack.



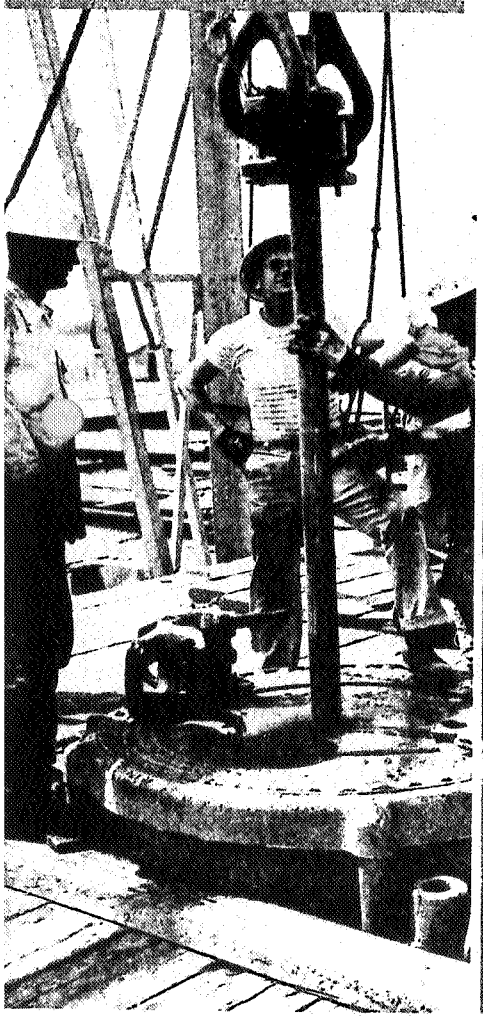
Raising travel block for stabbing position.



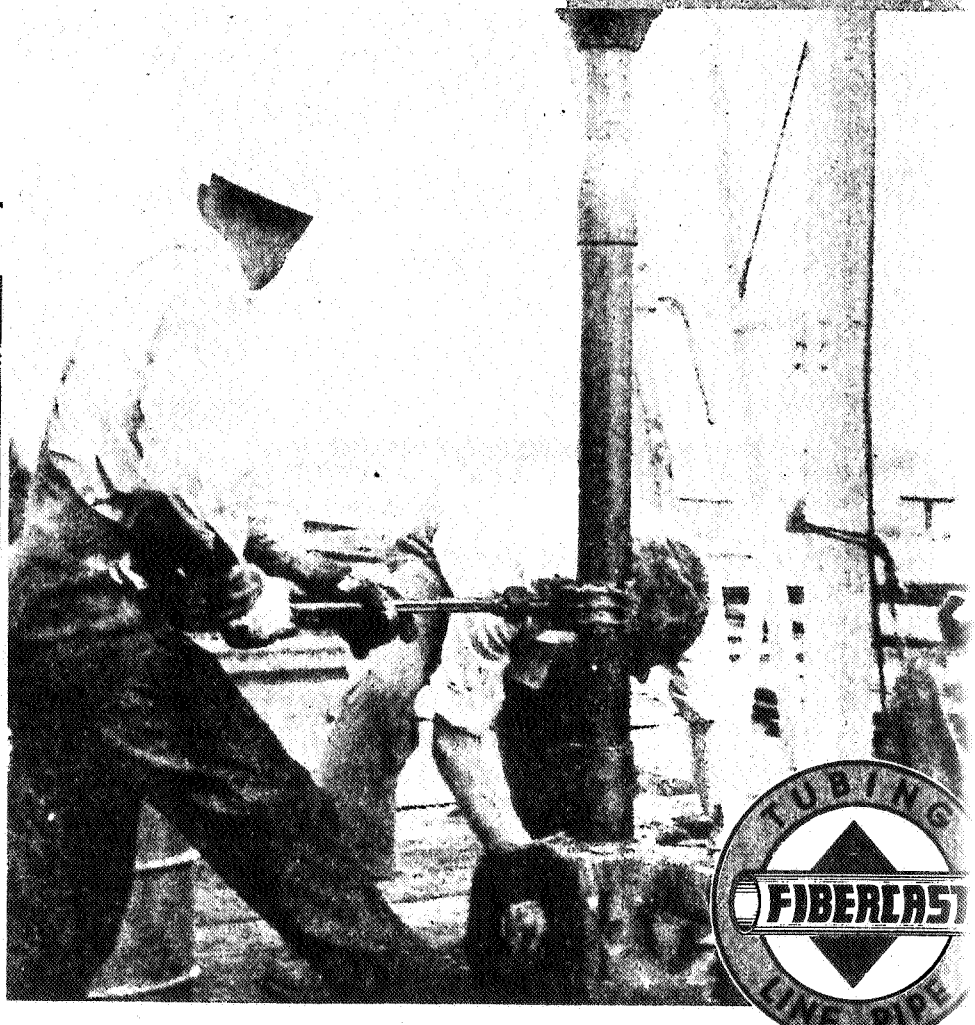
Stabbing and making up with friction wrench.



Engaging elevators to Fibercast Tu



Lowering Fibercast Tubing into hole.

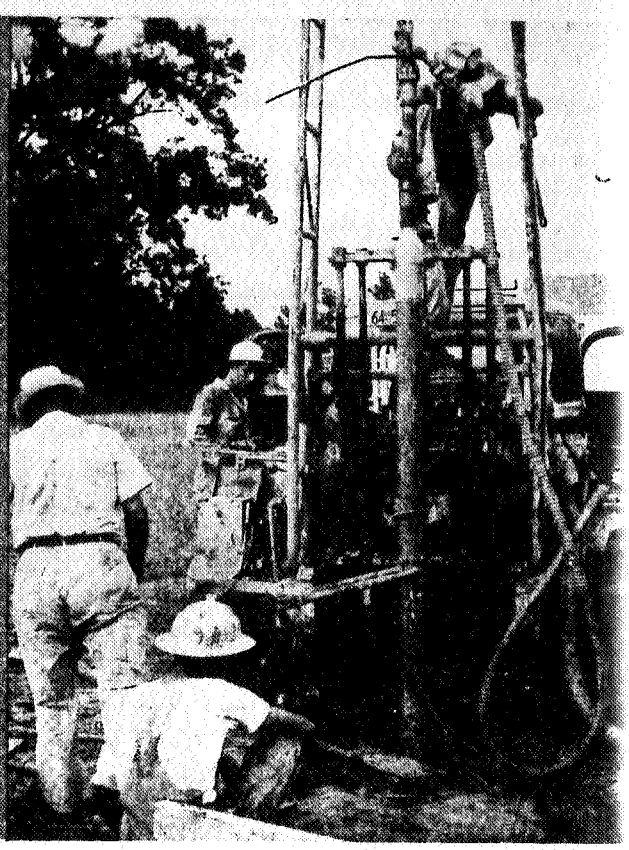


Well completion.

FIBERCAST LINE PIPE

General Handling Instructions

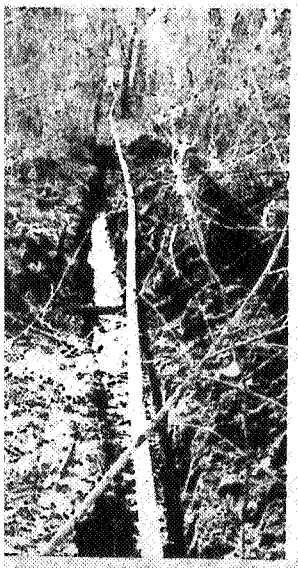
Avoid sharp edges in transporting, storing or laying Fibercast. Use flat bed trucks and tie the pipe down with ropes. Store the pipe less than four feet high on flat ground or platform. Exercise ordinary care in handling and do not throw around carelessly. Allow a minimum 60 feet radius for curves or contouring when laying. If the foregoing precautions are observed and the detailed installation instructions are followed, Fibercast installations will be trouble-free, economical, efficient and permanent. Installation instructions supplied with shipment or upon request.



Water well. Fibercast pipe used as cemented casing. Mud is b through casing before cementing.



Fibercast pipe used in open end siphon system. Three vertical and one horizontal lines between tanks.



lt water disposal line of Fiber- st pipe, immediately prior to tching through swamp.



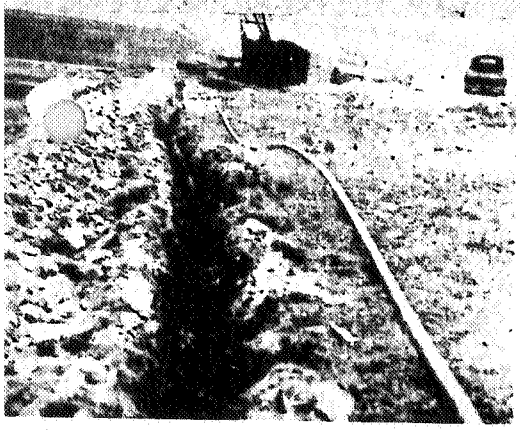
Salt water disposal line of Fibercast pipe. Line laid before ditching.



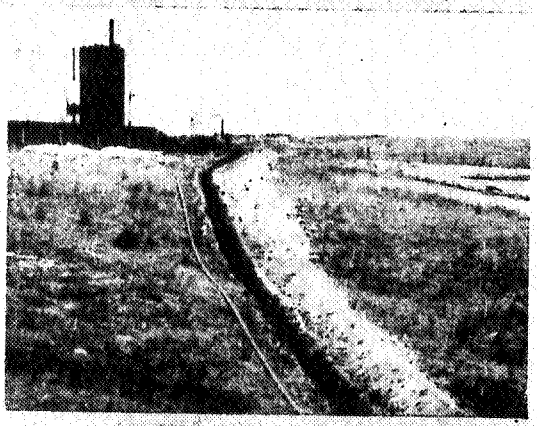
Salt water disposal line of Fibercast pipe before ditching. Note rocky terrain.



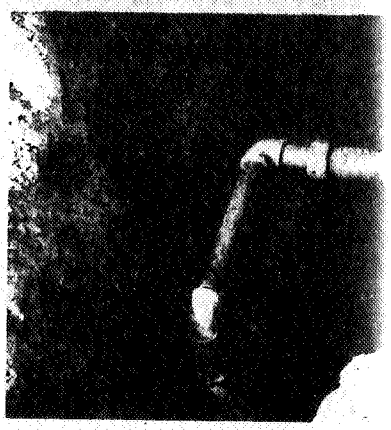
Salt water disposal line of Fibercast pipe. Tank b to disposal well.



Salt water disposal line of Fibercast pipe. Line conforms to irregular contour of ground.



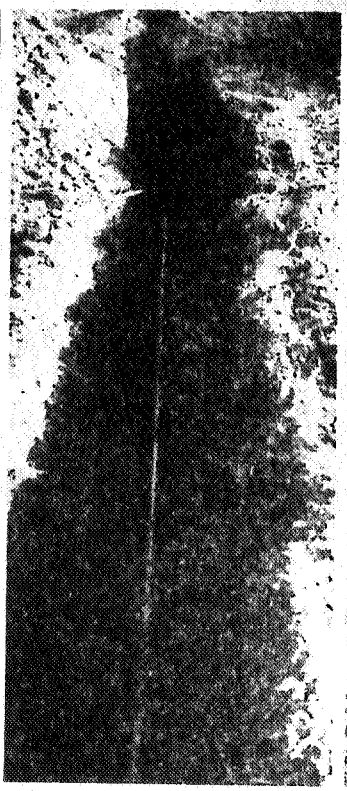
Salt water disposal line of Fibercast pipe. Note that pipe bends to follow curves in ditch.



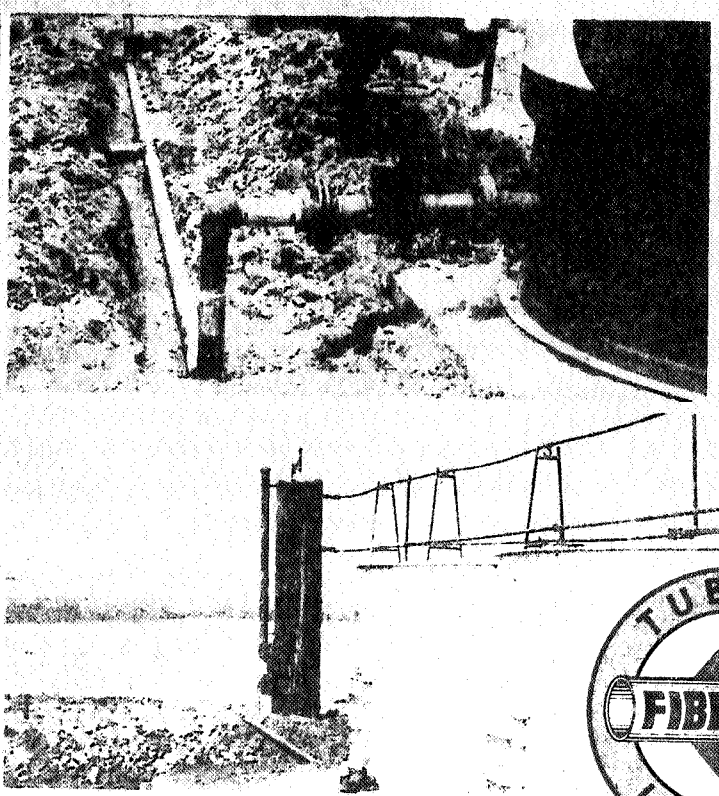
City gas distribution main of Fibercast showing house service connection.



de petroleum flow line of rcast pipe, running from to tank battery.



Crude petroleum flow line of Fibercast pipe, showing road crossing protected by conduit.



Overhead lines of Fibercast pipe, from heater treater to tank battery and return. Pipe supported every 10 feet.

Fiberc pipe s conne two fi to o accumu

TUBIN FIBERCA LINE PIP

TABLE IIIa

FIBERCAST TUBING

Size	Coupling	Color	Wall Thickness	Internal Operating Pressure, psi	External Operating Pressure, psi	Ultimate Burst psi	Ultimate Collapse psi	Weight per foot lbs.	Type Coupling
2⅞"	3⅜"	Brown	.28	300	500	1,200	1,600	1.5	T&C
3½"	4"	Brown	.28	300	500	1,200	1,500	1.875	T&C
4½"	5"	Brown	.375	300	500	1,200	1,200	2.50	T&C

TABLE IIIb

FIBERCAST LINE PIPE

Size	Class	Color	Wall Thickness	Recommended Operating Pressure	Ultimate Burst	Weight per 20' Joint	Type Coupling
2⅞"	100	Yellow	.20	100	900	19#	T&C
2⅞"	200	Green	.215	200	1,200	20#	T&C
3½"	100	Yellow	.20	100	800	26#	T&C
3½"	200	Green	.215	200	1,200	28#	T&C
4½"	100	Yellow	.23	100	900	40#	T&C
4½"	200	Green	.25	200	1,200	42#	T&C

Hazen-Williams Flow Factor $C_1=147$

The recommended operating pressures in Table III are intended for service installations where the temperatures do not exceed 130°F. Where it is desired to operate Fibercast pipe in the temperature range of 130°F. to 180°F. the recommended working pressures should be decreased 50%.

The values in Table III are true values and will not progressively deteriorate so long as the temperature remains constant. Furthermore, operation at elevated temperatures does not injure Fibercast, and after the operating temperature is reduced below 130°F., the original values apply.

90° ells and tees are available for all sizes of pipe listed above.

In joining Fibercast and steel pipe, connection whenever possible should be from a steel fitting with a nipple, on which the Fibercast pipe is connected with a Dresser coupling.

THE FIBERCAST CORPORATION

P. O. Box 326, Sand Springs, Oklahoma • Phone Tulsa 2-7212

Manufacturers of

FIBERCAST TUBING AND LINE PIPE

Distributed by

THE YOUNGSTOWN STEEL PRODUCTS COMPANY

THE YOUNGSTOWN STEEL PRODUCTS COMPANY OF CALIFORNIA

THE CONTINENTAL SUPPLY COMPANY

4th December, 1968.

DVS:hjr

The Fibercast Corporation,
Post Office Box 326,
SAND SPRINGS,
Oklahoma, U.S.A.

Dear Sirs,

Fibercast Tubing

Would you please advise us of the diameters for your "Fibercast" tubing and line pipe. At this stage our interest lies in some 1400 ft. of 8 inch diameter flush joint.

Yours faithfully,
GEOSURVEYS OF AUSTRALIA PTY. LTD.

D.H.A. von Sanden,
OPERATIONS MANAGER.

:hjr

11th December, 1968.

Johns-Manville Corporation,
22 East 40th Street,
NEW YORK. N.Y.10016.

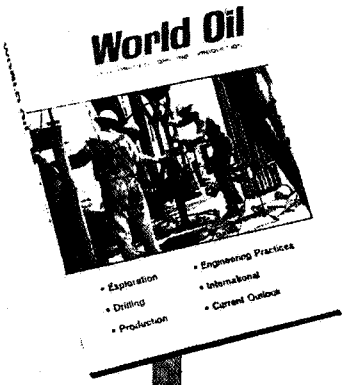
Dear Sirs,

Epoxy-lined Pipe

Following an enquiry made to the Editor of the Petroleum Engineer in Dallas, Texas, we have been given your address, and would be pleased if you could forward full details of epoxy-lined asbestos cement pipe at your early convenience.

Yours faithfully,
GEOSURVEYS OF AUSTRALIA PTY. LIMITED.

D. H. A. von Sanden,
OPERATIONS MANAGER.



Plastic coating of drill pipe—Is it worth the added expense?

H. A. Deem, Sales Coordinator,
AMF Tuboscope, Inc., Houston

Reprinted from
November 1964

World Oil

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Houston, Texas

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Plastic coating of drill pipe— Is it worth the added expense?

New epoxy coating minimizes damage from corrosion pitting and cuts drill pipe costs an average of 28.3 percent per 100,000 feet of hole drilled

H. A. Deem, Sales Coordinator,
AMF Tuboscope, Inc., Houston

GROWING COMPETITION and declining profit margins are leading drilling contractors to look more vigorously than ever for ways to cut costs.

And representing a large and highly sensitive portion of the average contractor's capital investment is drill pipe because it is subject to more severe service damage and creates more direct expense when it fails than any other item of drilling equipment. It is natural, then, that the problem of extending drill pipe life and assuring its condition in the hole has received concentrated attention from contractors, supply companies and service organizations.

From study of more than 20,000 joints of drill pipe, used in widely varying drilling conditions in the Permian Basin, the Mid-Continent area and the Gulf Coast, these conclusions were drawn:

- Corrosion pitting is the largest single factor causing down-grading of drill pipe.
- Reliable electronic inspection and internally plastic coated drill pipe can provide substantial savings.
- Restricted use (No. 3) drill pipe can be economically and efficiently used in shallow drilling operations.

A new internal expoxy coating, designed to withstand the physical stresses, chemical environment and temperatures normally encountered in oil well drilling, promises to help extend drill pipe life. Several recent case histories indicate the effectiveness of this coating in preventing corrosion and corrosion fatigue, the chief causes of drill pipe failure.

In a test, part of a 13,000-foot string drilling offshore Florida was coated. On completion of the well, the coated joints were found to be in like-new condition. while uncoated joints were severely corroded by the aerated salt water drilling fluid.

Two strings coated with the new epoxy compound each drilled 160,000 feet offshore Louisiana. Inspection of both strings revealed no corrosion damage in this normally highly corrosive drilling service.

A Canadian contractor drilled 180,000 feet with a string containing both coated and uncoated joints. Electronic inspection showed all but one of the coated joints to be suitable for continued, normal drilling service (one joint was down-graded for mechanical damage). More than half of the uncoated lengths were found unsuitable for normal service, and one had twisted off, causing a fishing job.

Will coating drill pipe pay out? It is not enough to prove that internal epoxy coating cuts corrosions and fatigue, lengthening drill pipe life. The real question facing today's contractor is, "Will it pay out? Does the new coating cut total drill pipe costs enough to justify its expense?"

Performance records on 23,920 uncoated joints of drill pipe, used in widely varying drilling conditions in the Permian Basin, the Mid-Continent area and the Gulf Coast, were studied. Results indicate substantial economic benefits available through the new coating.

The study disclosed that corrosion pitting is the single largest factor contributing to the down-grading of drill pipe. (See Table 1). More than half of the pipe in each of the areas surveyed was removed from normal drilling service because of corrosion pitting damage.

Using data taken from the Mid-Continent area, where survey results show drill pipe deterioration to be most severe, an economic analysis was made of epoxy plastic coating.

In this analysis, a typical 12,000-foot string of 4½-

inch OD drill pipe with 6-inch OD tool joints is assumed. The analysis evaluates costs associated with (1) drilling 100,000 feet with uncoated drill pipe, as compared with (2) drilling 100,000 feet with epoxy-coated drill pipe.

Typical values, recently determined in the Mid-Continent Area, required for this analysis are as follows:

- Value of new, Grade E, 4½-inch OD drill pipe with 6-inch tool joints — $6.18/foot
- Salvage value of No. 3 (restricted use) classification drill pipe — 1.25/foot
- Salvage value of No. 4 (structural grade) classification drill pipe — 0.60/foot
- Cost of applying epoxy coating to 4½-inch OD drill pipe — 0.75/foot

Average results of inspections performed at intervals of 50,000 feet of hole drilled, as shown in Table 1, are used to determine the amount of drill pipe which must be replaced at each 50,000-foot interval.

TABLE 1—Electronic Drill Pipe Inspection Results

PERMIAN BASIN			MID-CONTINENT			LOUISIANA GULF COAST		
Total Sample: 6,985 Joints; Inspection Frequency: 42,500 Feet Average			Total Sample: 10,743 Joints; Inspection Frequency: 50,000 Feet Average			Total Sample: 6,192 Joints; Inspection Frequency: 60,000 Feet Average		
#2 Good Condition	#3 Restricted Use	#4 Structural	#2 Good Condition	#3 Restricted Use	#4 Structural	#2 Good Condition	#3 Restricted Use	#4 Structural
5,374 76.9%	1,008 14.5%	603 8.6%	6,387 59%	2,815 25%	1,541 16%	4,396 70%	1,238 0%	558 10%
Pitted	Other	Pitted	Other	Pitted	Other	Pitted	Other	Pitted	Other	Pitted	Other
550 7.9%	458 6.6%	510 7%	93 1.6%	1,335 12%	1,480 13%	217 12%	1,324 4%	792 13%	446 7%	234 4%	324 5%

ECONOMIC ANALYSIS

Alternative 1—Maintenance costs with uncoated drill pipe

After 50,000 feet of hole drilled:

1. Purchase 164 joints of pipe to replace pipe damaged by corrosion and other causes—@ $6.18 per foot		$30,405.60
2. Less salvage value of replaced joints:		
No. 3 pipe—100 joints @ $1.25 per foot	$ 3,750	
No. 4 pipe—64 joints @ $0.60 per foot	1,152	(4,902.00)
3. Net drill pipe expense for first 50,000-foot drilling interval.		$25,503.60

After 100,000 feet of hole drilled:

1. Purchase 164 joints of pipe to replace pipe damaged by corrosion and other causes—@ $6.18 per foot		$30,405.60
2. Less salvage value of replaced joints:		
No. 3 pipe—100 joints @ $1.25 per foot	$ 3,750	
No. 4 pipe—64 joints @ $0.60 per foot	1,152	(4,902.00)
3. Net drill pipe expense for second 50,000-foot drilling interval		$25,503.60

Total drill pipe cost to drill 100,000 feet $51,007.20 or $0.51 per foot of hole

Alternative 2—Maintenance costs with epoxy-coated drill pipe

Initially

1. Investment in coating 12,000 feet of 4½-inch OD drill pipe		$9,000.00

After 50,000 feet of hole drilled:

1. Purchase 68 joints of pipe to replace pipe damaged by causes other than corrosion @ $6.18 per foot		$12,607.20
2. Less salvage value of replaced joints:		
No. 3 pipe—52 joints @ $1.25 per foot	$ 1,950	
No. 4 pipe—16 lengths @ $0.60 per foot	288	(2,238.00)
3. Apply epoxy coating to the 68 replacement joints @ $0.75 per foot		$ 1,530.00
4. Net drill pipe expense for first 50,000-foot drilling interval		$20,899.20

After 100,000 feet of hole drilled:

1. Purchase 68 joints of pipe to replace pipe damage by causes other than corrosion @ $6.18 per foot		$12,607.20
2. Less salvage value of replaced joints:		
No 3 pipe—52 joints @ $1.25 per foot	$1,950	
No. 4 pipe—16 joints @ $0.60 per foot	288	(2,238.00)
3. Apply epoxy coating to the 68 replacement joints @ $0.75 per foot		1,530.00
4. Net drill pipe expense for second 50,000-foot drilling interval		11,899.20

Total drill pipe cost to drill 100,000 feet $32,798.40 or $.33 per foot of hole

Comparison of Alternatives

Pipe expense to drill 100,000 feet:	
Uncoated drill pipe	$51,007.20 or $0.51 per foot
Epoxy-coated drill pipe	$32,798.40 or $0.33 per foot
Savings in 100,000 feet of drilling through use of coatings	$18,208.80 or $0.18 per foot
Percent reduction in drill pipe expenses during 100,000 feet of drilling	28.3 percent
Total investment in epoxy coating during 100,000 feet of drilling	$12,060.00

It should be noted again that these cost comparisons are based on average inspection recovery results taken over a large number of individual strings. Variations from these figures will exist, depending upon the previous drilling history of each joint of pipe in any individual string. It is believed, however, that the large number of joints analyzed allows the analysis to approximate closely actual savings available under typical conditions below 10,000 feet through the use of epoxy drill pipe coating.

It should also be noted that this cost comparison presents only savings resulting from minimizing drill



About the author

H. A. (BURT) DEEM is Sales Coordinator for AMF Tuboscope, Inc. in Houston. He joined Tuboscope as Inspection Engineer in 1952 in the Oklahoma-Kansas area. From 1958 to 1964, he was Special Sales Representative for the company in Tulsa. Mr. Deem is a member of the National Association of Corrosion Engineers.

pipe replacement. Obviously, further savings, sometimes amounting to tens—or hundreds-of-thousands of dollars. can be effected through prevention of drill pipe failure and its associated fishing or side-tracking costs.

Electronic inspection. While the new coating helps cut drill pipe expense, Table 1 shows that a substantial amount of drill pipe is down graded from the No. 2 category for causes other than corrosion.

In the Permian Basin, 8.2 percent of all pipe inspected is retired to limited service for such causes as abrasive wear and mechanical damage. In the Louisiana Gulf Coast, this figure amounts to 12 percent of the pipe surveyed. In the Mid-Continent, it rises to 17 percent.

These figures indicate the contractor's continuing need for reliable, electronic inspection of drill pipe to remove potential failures from his string, insuring against the added expense of drill pipe failure.

"Restricted-use" pipe. Finally, while No. 3 category pipe is not normally acceptable in deep wells, it can render valuable and economical service in drilling shallow holes.

One Mid-Continent contractor reports that his routine policy is to transfer No. 3 drill pipe to rigs drilling to about 3,000 feet. Thus additional service life is achieved.

In this instance also, electronic inspection and plastic coating provide substantial savings. Most shallow rigs drillings in this area carry about 125 joints of drill pipe, and contractors estimate average fishing jobs to cost about $200 each.

Referring again to the Mid-Continent data in Table 1 electronic inspection after 50,000 feet of drilling service would locate about 4 percent No. 4 (structural grade) drill pipe—pipe which can be expected to fail in the near future. In the average 125 joints string, this figure amounts to five expected fishing jobs, costing a total of $1,000. Electronic inspection, at a cost of about $600, removes these potential failures from the string and saves the contractor $400.

Under the same conditions with uncoated pipe, the No. 4 reject rate climbs to 16 percent or 19 joints, from the same string. Here, the same $600 investment in electronic inspection produces savings of $3,200 or more than $5 saved for each dollar invested in inspection.

ACKNOWLEDGMENT

The author gratefully acknowledges the invaluable assistance of Loffland Bros. Drilling Co. for providing much of the data used in this article. ■

DVS:hjr

27th November, 1968.

Tubular Lining Corporation,
Post Office Box 20015,
H O U S T O N, Texas 77025, U.S.A.

Dear Sirs,

Bore Casing

We would be pleased to have your recommendations for the protective coating of 8" bore casing. The casing will be of some 3,500 ft. in length and will be required to handle a brine solution with a specific gravity of 1.12.

The brine solution will be pumped to the surface by means of compressed air entrainment.

We would be pleased to have your advice on a protective coating and its method of application, and/or the supply of casing lengths. Our particular concern is the coupling pipes, as the threaded sections are very vulnerable and the brine solution will be in contact with both the inside and outside surfaces.

Yours faithfully,
GEOSURVEYS OF AUSTRALIA PTY. LTD.

D. H. A. von Sanden,
OPERATIONS MANAGER.

DVS:hjr

27th November, 1968.

A.M.F. Tuboscope, Inc.,
Post Office Box 808,
H O U S T O N. Texas, U.S.A.

Dear Sirs,

Bore Casing

We would be pleased to have your recommendations for the protective coating of 8" bore casing. The casing will be of some 3,500 ft. in length and will be required to handle a brine solution with a specific gravity of 1.12.

The brine solution will be pumped to the surface by means of compressed air entrainment.

We would be pleased to have your advice on a protective coating and its method of application, and/or the supply of casing lengths. Our particular concern is the coupling pipes, as the threaded sections are very vulnerable and the brine solution will be in contact with both the inside and outside surfaces.

Yours faithfully,
GEOSURVEYS OF AUSTRALIA PTY. LTD.

D. H. A. von Sanden,
OPERATIONS MANAGER.

AMF TUBOSCOPE, INC.
Subsidiary of AMERICAN MACHINE & FOUNDRY COMPANY
P.O. Box 808, Houston, Texas 77001 • Area Code 713 RI 8-1300

December 12, 1968

W/O. BRINE FILE

Mr. D. H. A. von Sanden
Operations Manager
Geosurveys of Australia Pty. Ltd.
Da Costa Building, Grenfell Street
Adelaide, South Australia 5000

Dear Mr. von Sanden:

Subject: Our Quotation #12-68-716E

Thank you for your inquiry of November 27, 1968, requesting our proposal for the internal and external coating of 3,500' of 8" casing to be used in brine service.

Normal procedure would be for you to purchase the casing with couplings from one of the many oilfield supply companies and have it sent to us for coating. Most suppliers could handle this project turn-key, providing the casing, handling the order to us for coating, and arranging the export shipment to you. The casing should come to us with the couplings boxed separate or hand-tight; otherwise, shipment across town to remove the couplings will be necessary and will cost about $2.50 per joint. If we are to buck couplings on after coating, this same charge will again be necessary on any pipe larger than 4 1/2" O.D.

Our recommended coating application would consist of pickling the casing, then flint-blasting to white metal internally and externally; this would be followed by the baked-on application of Tube-Kote TK-90 PVC providing a film thickness of 18-20 mils to the internal surfaces, around the lips of pins and onto the first external thread. The external coating would consist of multiple coats of TK-21 Epoxy to provide a film thickness of 12-15 mils of TK-21 to all external surfaces except pin threads which would be buried when made up. Our application would also provide priming the internal coupling throughout and installation of high-build polypropylene in the coupling stand-off area so that adequate coupling seal-off on make-up would be assured.

Mr. D. H. A. von Sanden
Operations Manager

It should be anticipated that the external TK-21 will suffer handling and shipping damage as well as damage from slips and tongs when you make up the string. We can crate and ship with the pipe 5-10 one (1) gallon cans of TK-21 with separate containers of catalyst to be added when required. Damaged areas can be sandblasted or sandpapered and the TK-21 applied by brush or spray. Cost of the TK-21 would be approximately $15.00 per gallon. You should also have about 20 epoxy-mastic fast catalyst repair kits (cost - $15.00 each) to use on tong and slips damage while running down-hole.

Coating prices are per foot and include couplings:

Internal application of TK-90	$1.52/ft.
External application of TK-21	$1.65/ft.

Coating prices are F.O.B. our Tube-Kote plant, 2727 Holmes Road, Houston, Texas; payable in United States dollars.

Mr. von Sanden, we look forward to the opportunity of serving you, and are enclosing literature on our coatings for your consideration.

Yours very truly,

AMF TUBOSCOPE, INC.

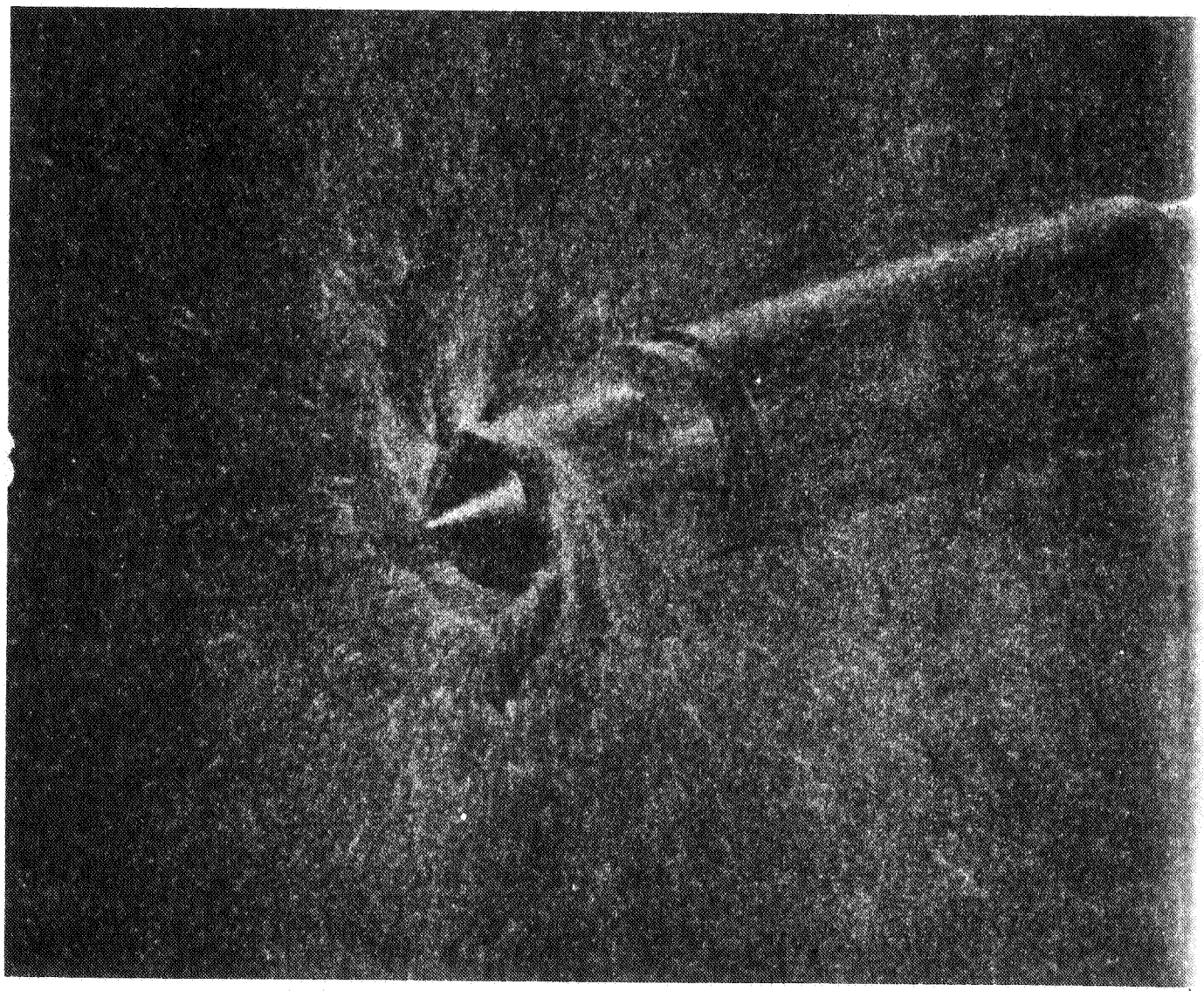
John E. Gilbert

John E. Gilbert
Region Sales Coordinator

JEG/do

Enclosures

TUBE-KOTE COATINGS FOR CORROSION AND PARAFFIN CONTROL



nce 1939, TUBE-KOTE plastic coatings have en used to protect metal from corrosion attack. the beginning, it was oil well tubing. The first ermosetting phenolics helped to create an indus- y that was to expand and radiate throughout the l producing community.

lew applications gave rise to the use of many dif- rent plastic coatings—epoxies, polyurethanes, olyesters and vinyls. Each plastic had its own pecial performance characteristics and each olved a unique coating problem.

oday, TUBE-KOTE Coatings protect production ubing, water lines, drill pipe, tanks, vessels, alves and equipment exposed to severe acid and lkaline environments. An added application is the se of coatings to prevent paraffin deposition; a ractice which works amazingly well even though the phenomenon is not fully understood.

Today, TUBE-KOTE has three plants in the United States and one in Canada to apply coatings to hundreds of tubular and industrial items. The coating cost is minor compared to the value of the equipment protected.

Today, TUBE-KOTE researches, formulates and manufactures its own coatings to meet the varied demands of the market with coatings of uniformly high quality.

TUBE-KOTE came into being because industry had corrosion problems which needed to be solved. Solving some of them helped us to create an industry and build a company.

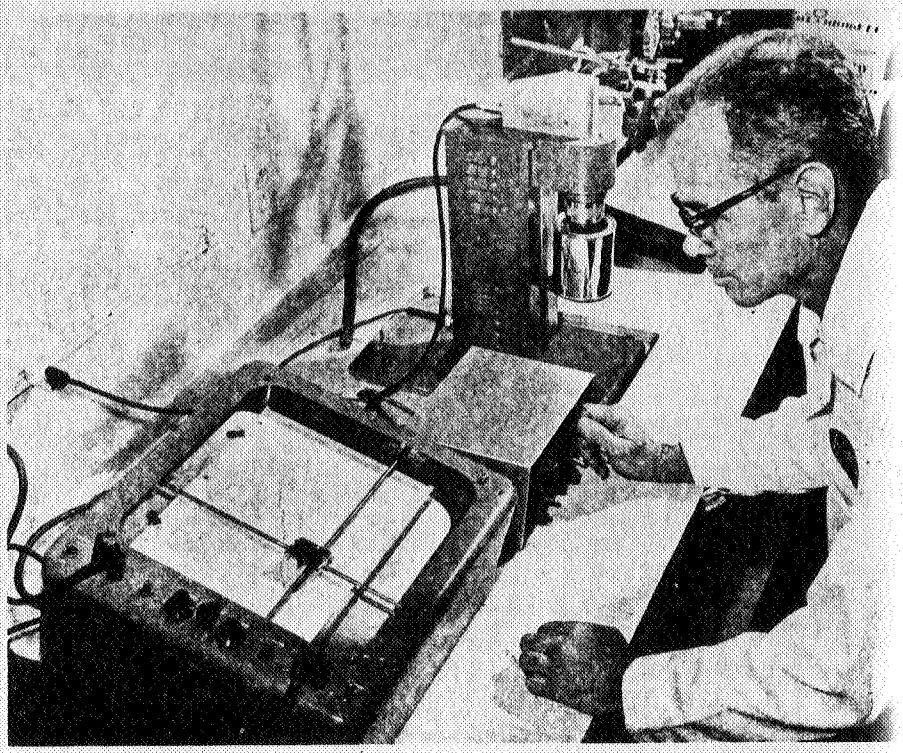
We want to grow a lot more . . . what's your problem?

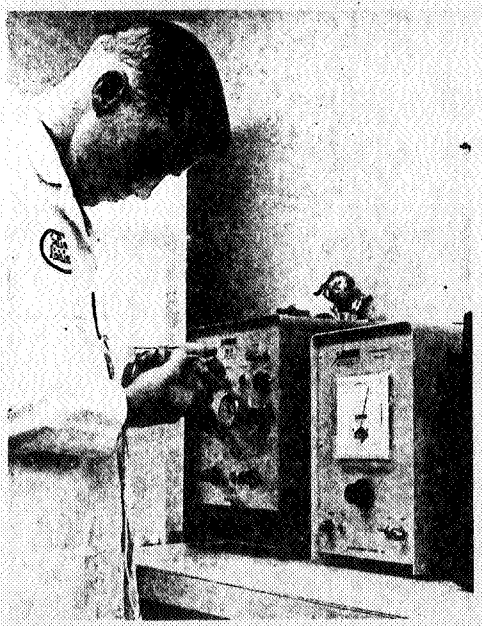
RESEARCH AND COATING MANUFACTURING

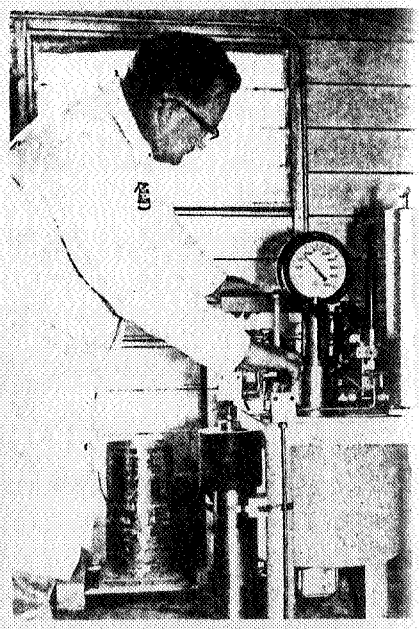


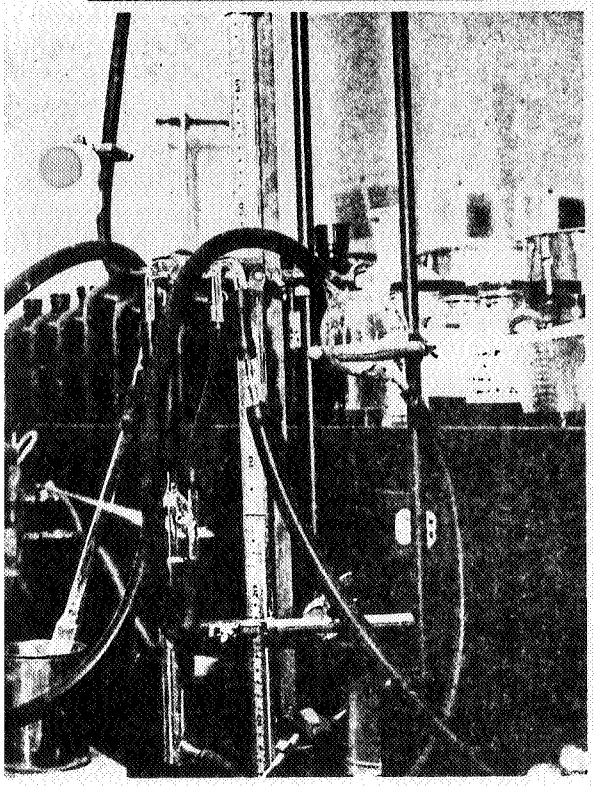
An intensive research program helps keep Tube-Kote coatings the leader in their field. New coatings are constantly being developed to meet the demands of industry and each one is manufactured by Tube-Kote. These are representative scenes of our research and coating activities.

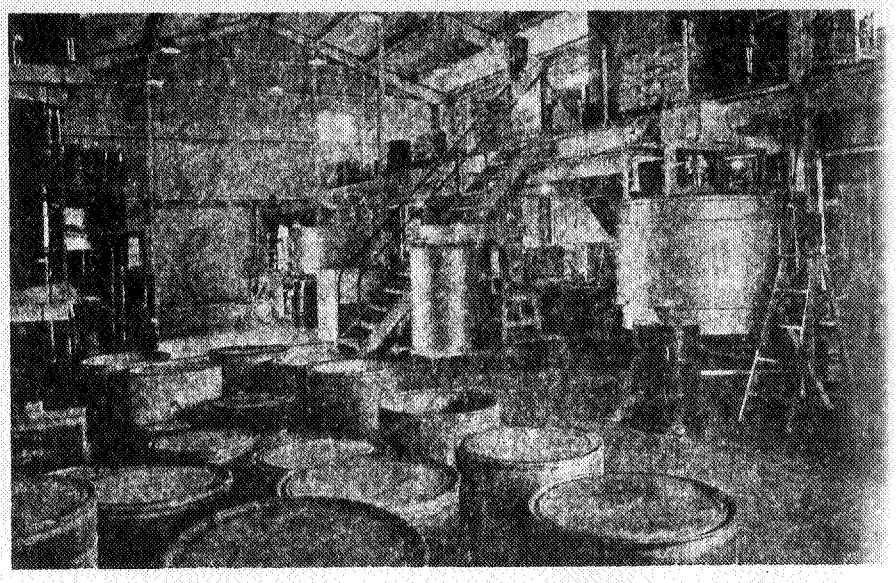












TK-2

A SUPERIOR THERMOSETTING PHENOLIC COATING FOR PARAFFIN AND CORROSION CONTROL.

TK-2 is an exclusive blend of thermosetting phenolic resins and extremely small particles of inert materials. This blend reinforces the mass of the coating and augments its abrasion resistance and adhesive properties.

TK-2 is insoluble in all known oil field and industrial solvents.

PHYSICAL & CHEMICAL PROPERTIES:

1. TK-2 is as hard as some metals (e.g. tin).
2. It is flexible enough to withstand the elongations and distortions normal to oil well operations.
3. TK-2 is inert and will not lose its characteristics in the presence of known industrial solvents and most common acids.
4. It is odorless, tasteless and non-toxic.
5. The smooth, hard surface of TK-2 affords minimum wettability to oil field paraffins thus affording excellent protection against paraffin build-up.

RECOMMENDED USES:

TK-2 is recommended for use in the following:

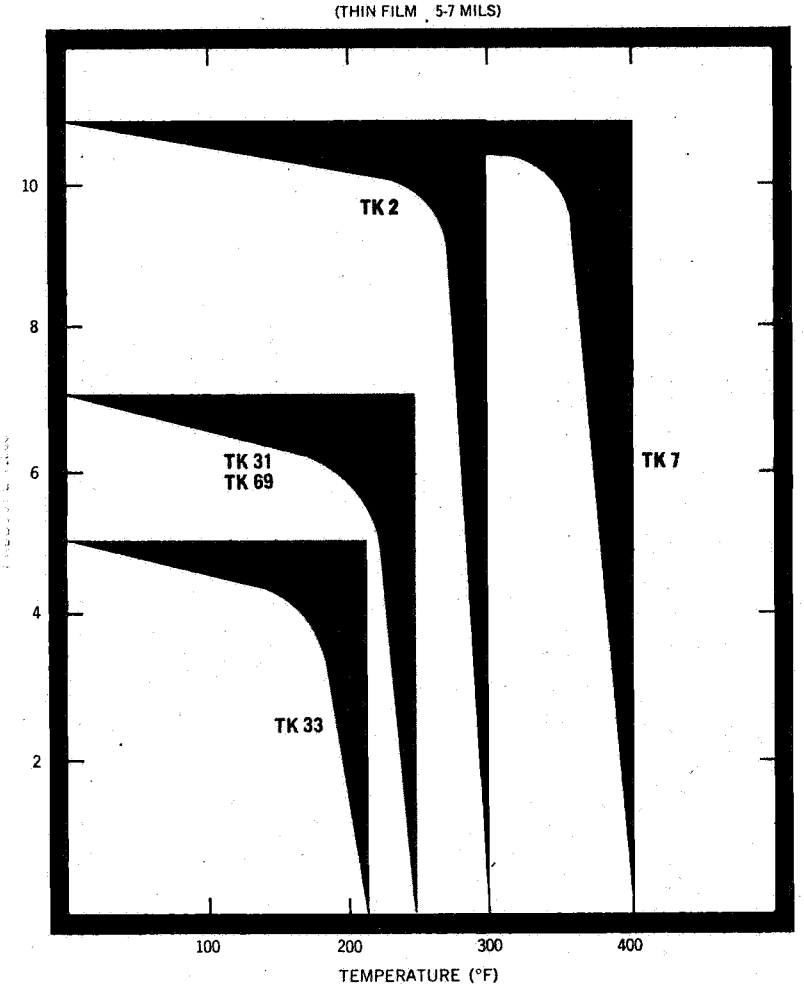
1. Oil field tubular goods.
2. Valves, fittings and packers.
3. Food handling equipment.
4. Chemical vessels.

APPLICATION:

The inner surface is cleaned to remove scale and sandblasted to white metal providing an ideal anchor pattern for coating adherence. Multiple coats are applied and baked after each coat. It is then subjected to a final baking process which blends the multiple coats into one homogenous film.

TEMPERATURE/PRESSURE RECOMMENDATIONS FOR COATINGS

(THIN FILM 5-7 MILS)



Notes:

1. Specific coatings may be used at pressure-temperature conditions of designated limits.
2. For service in shaded areas consult local representative.
3. TK-2 and TK-7 should not be used when pH exceeds 11.5. Above pH 11.5 use TK-31 or TK-33.
4. For service in H_2S or Mud Acids consult local representative.

This data is based on laboratory and field experience and represents good faith opinions, but does not constitute a warranty or guarantee.

TK-7

FOR EXTREME HIGH TEMPERATURE/HIGH PRESSURE APPLICATIONS IN OIL AND GAS WELLS.

- TK-7 is a special and exclusive formulation of phenolic material developed for high temperature, high pressure environments.
- TK-7 withstands all normal caustic muds and acidizing plus normal oil field handling.
- TK-7 has outstanding dielectric resistance and adhesion characteristics.

PHYSICAL & CHEMICAL PROPERTIES:

1. TK-7 withstands pressures of 10,000 to 12,000 psi and continuous temperatures in the 350° to 400°F. range.
2. TK-7 possesses sufficient flexibility to withstand successfully the normal elongation and compression encountered in long production strings.
3. When applied at the recommended thickne 5-8 mils, TK-7 provides a positive corrosion b in the most severe service.
4. TK-7 withstands all common oil field chemicals

RECOMMENDED USES:

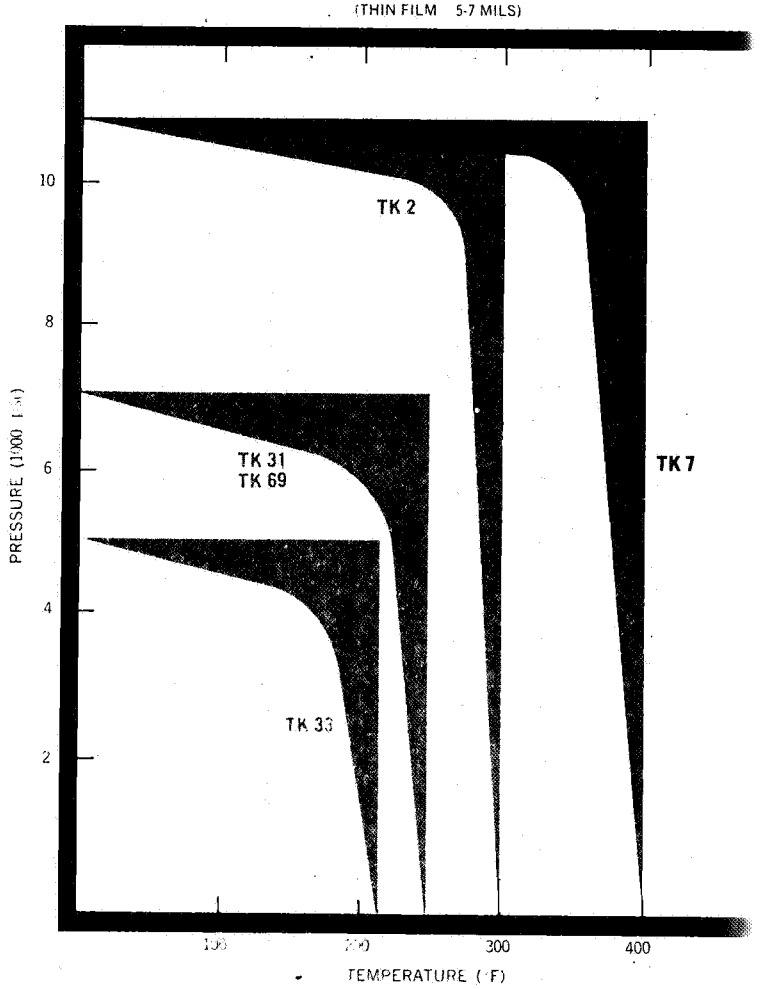
TK-7 may be used in all high temperature, high pre production environments; especially in gas and gas densate wells.

APPLICATION:

The inner surface is cleaned to remove scale and blasted to white metal providing an ideal anchor pa for coating adherence. Multiple coats are applied baked after each coat. It is then subjected to a baking process which blends the multiple coats int homogenous film.

TEMPERATURE/PRESSURE RECOMMENDATIONS FOR COATINGS

(THIN FILM 5-7 MILS)



Notes.

1. Specific coatings may be used at pressure-temperature conditions of designated limits.
2. For service in shaded areas consult local representative.
3. TK-2 and TK-7 should not be used when pH exceeds 11.5. Above pH 11.5 use TK-31 or TK-33.
4. For service in H_2S or Mud Acids consult local representative.

This data is based on laboratory and field experience and represents good faith opinions, but does not constitute a warranty or guarantee.

TK-21

FOR STORAGE TANK INTERIORS AND INDUSTRIAL CORROSION CONTROL

- TK-21 is a chemically cured epoxy coating with outstanding bonding strength and flexibility.
- TK-21 has good chemical resistance and performs well at upper temperature ranges.
- TK-21 possesses longer pot life, better wetting characteristics for steel and is far less dangerous to personnel than other coatings.
- TK-21 imparts no taste or odor in water or air.

PHYSICAL & CHEMICAL PROPERTIES:

1. TK-21 is designed to perform at 150°F., in water, various salt solutions and crude oil.
2. It is applied over adequate metal preparation in thickness of 10-20 mils.
3. It will handle strong chemicals, e.g. mineral acids at 70°-80° F.

RECOMMENDED USES:

1. Water storage tanks.
2. Chemical storage tanks.
3. Fabricated parts.

TK-31

FOR USE IN SALT WATER DISPOSAL AND CRUDE OIL FLOW LINES AND PRODUCTION TUBING

•TK-31 is highly resistant to the three main sources of corrosion problems: chemical attack, abrasion and dissolving agents.

•TK-31 possesses greater flexibility and caustic resistance than phenolic compounds.

PHYSICAL & CHEMICAL PROPERTIES:

1. TK-31 is an epoxy-based coating which is chemically joined to a phenolic resin by a high temperature baking process.
2. TK-31 contains small particles of inert materials to reinforce the coating mass and enhance the adhesion and other characteristics.
3. TK-31 is applied in a 5-8 mil thickness.
4. It is extremely impact resistant and possesses superior flexibility.
5. TK-31 is highly resistant to caustics and, in temperature ranges, has an excellent ability t stand general chemical attack.

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RECOMMENDED USES:

TK-31 is ideal for use in the following:

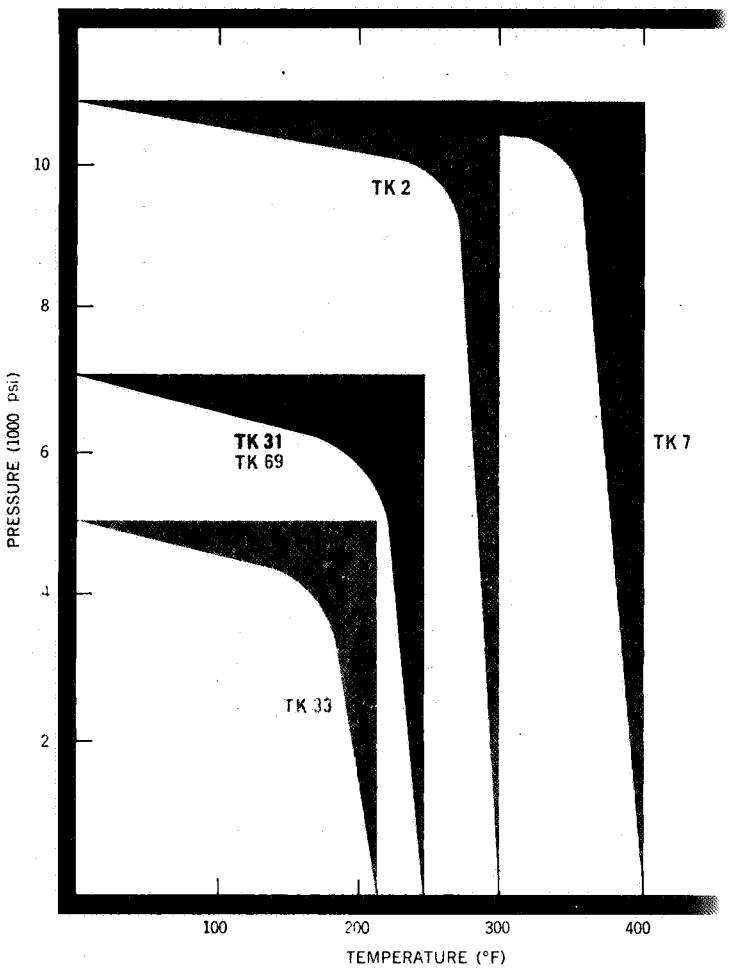
1. Salt water disposal lines.
2. Crude flow lines.
3. Production tubing.
4. Chemical and manufacturing processes subj corrosion problems.

APPLICATION:

The inner surface is cleaned to remove scale and blasted to white metal providing an ideal anchor p for coating adherence. Multiple coats are applie baked after each coat. It is then subjected to a baking process which blends the multiple coats in homogenous film.

TEMPERATURE/PRESSURE RECOMMENDATIONS FOR COATINGS

(THIN FILM 5-7 MILS)



Notes:

1. Specific coatings may be used at pressure-temperature conditions of designated limits.
2. For service in shaded areas consult local representative.
3. TK-2 and TK-7 should not be used when pH exceeds 11.5. Above pH 11.5 use TK-31 or TK-33.
4. For service in H_2S or Mud Acids consult local representative.

This data is based on laboratory and field experience and represents good faith opinions, but does not constitute a warranty or guarantee.

TK-33

R PREVENTION OF PARAFFIN BUILD-UP IN TUBING HILE PROVIDING SUPERIOR CHEMICAL RESISTANCE D CORROSION PROTECTION.

K-33 is a specially formulated thermosetting polyurane plastic coating which combines excellent resistce to paraffin deposition with full chemical resistance d exceptional flexibility.

K-33 retains its smooth homogenous surface despite acks by abrasive materials.

K-33 provides resistance to caustics, acids, salt solunns and organic materials superior to any polyurethane ating.

HYSICAL & CHEMICAL PROPERTIES:

1. The low wettability to paraffin and durable glass-smooth surface serve to prevent paraffin deposition.
2. TK-33 withstands temperatures of at least 220° F. and pressures up to 5000 psi.
3. It will not crack, chip or craze, even when bent double.
4. Adheres to metal despite dropping, smashing or bending.
5. TK-33 retains its smooth homogenous surface despite prolonged attacks by abrasive materials.
6. TK-33 possesses superior resistance to caustics, salt solutions, well-treating acids and organic materials.

RECOMMENDED USES:

TK-33 is recommended for use in the following:

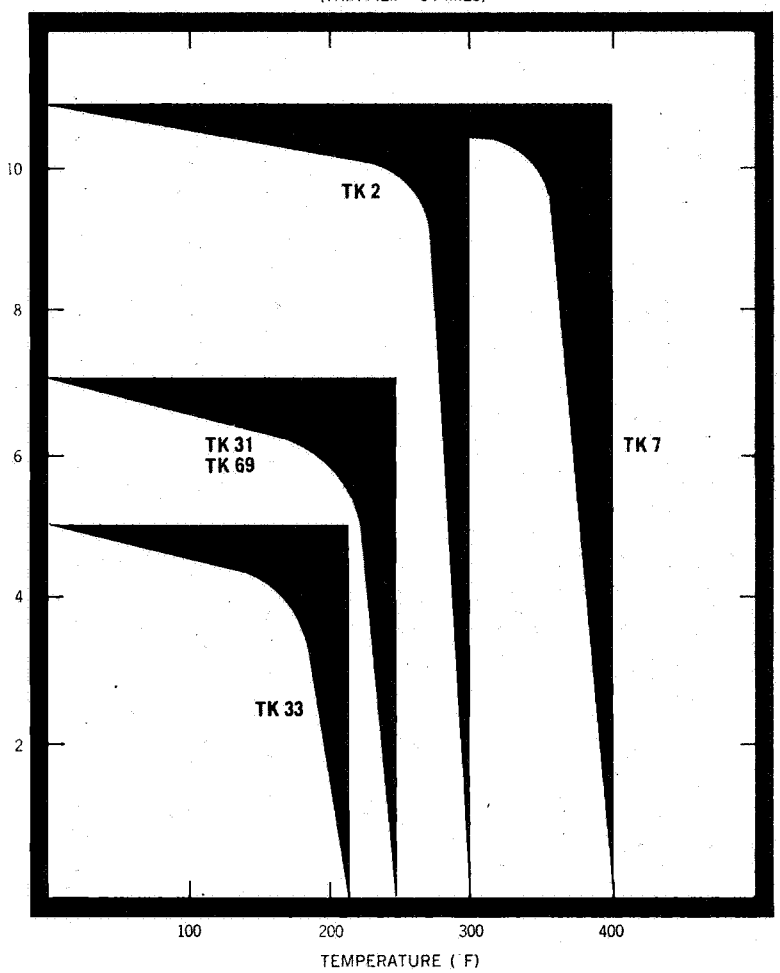
1. Production tubing.
2. Flow lines.
3. Gathering lines.
4. Sucker rods.

APPLICATION:

The inner surface is cleaned to remove scale and sand-blasted to white metal providing an ideal anchor pattern for coating adherence. Multiple coats are applied and baked after each coat. It is then subjected to a final baking process which blends the multiple coats into one homogenous film.

TEMPERATURE/PRESSURE RECOMMENDATIONS FOR COATINGS

(THIN FILM 5-7 MILS)



Notes:

1. Specific coatings may be used at pressure-temperature conditions of designated limits.
2. For service in shaded areas consult local representative.
3. TK-2 and TK-7 should not be used when pH exceeds 11.5. Above pH 11.5 use TK-31 or TK-33.
4. For service in H_2S or Mud Acids consult local representative.

This data is based on laboratory and field experience and represents good faith opinions, but does not constitute a warranty or guarantee.

TK-34

FOR DRILL PIPE COATING

- TK-34 is a heat-cured epoxy coating especially formulated for coating drill pipe. It's physical and chemical properties meet the most rigorous requirements of drilling operations.
- TK-34 resists strong caustic solutions and other corrosive drilling fluids and places a positive barrier between corrosive fluids and the pipe wall.
- TK-34 stands up under conditions of extreme elongation and flexing.
- TK-34's slick surface offers increased hydraulic efficiency.

PHYSICAL & CHEMICAL PROPERTIES:

1. TK-34 is able to withstand temperatures up to 250°F.* and pressures up to 8000 psi.
2. The resistance of TK-34 to deformation is greater than that of the pipe to which it is applied.
3. TK-34 resists 30% caustic soda for extended periods at 200° F.
4. Resists all known corrosive drilling fluids.
5. Exposure at elevated temperatures to hydroch hydrofluoric acid mixtures should be limited t hours.

RECOMMENDED USES:

TK-34 is recommended for use as follows:

1. All drill pipe subject to corrosive conditions.
2. Offshore drilling.
3. All critical drilling operations.

APPLICATION:

The inner surface is cleaned to remove scale and blasted to white metal providing an ideal anchor pa for coating adherence. Multiple coats are applied baked after each coat. It is then subjected to a baking process which blends the multiple coats intc homogenous film.

*250°F. refers to *direct* heat on the coated surface. In some cases bottom hole temperatures will exceed 250°F.; however, fluid flow and depth temperature gradients will offer, in most cases, no more than 250°F. directly on the coated surface.

K-69

R PRODUCTION TUBING WHERE CAUSTIC FLUIDS E USED

K-69 is highly resistant to caustic solutions, (pH 13 more) under high pressure conditions.

K-69 withstands severe temperature and pressure nditions encountered in the production of oil and gas.

YSICAL & CHEMICAL PROPERTIES:

1. TK-69 is a combination coating achieved by applying a base coat of a phenolic compound and covering this with an epoxy coating. These two coatings are then fused into a unified, two component film 5-7 mils thick.
2. TK-69 is highly flexible and resistant to abrasion and chemical corrosion.
3. The outer epoxy coat provides protection from caustic fluids while the inner phenolic coating provides temperature and pressure corrosion protection.

RECOMMENDED USES:

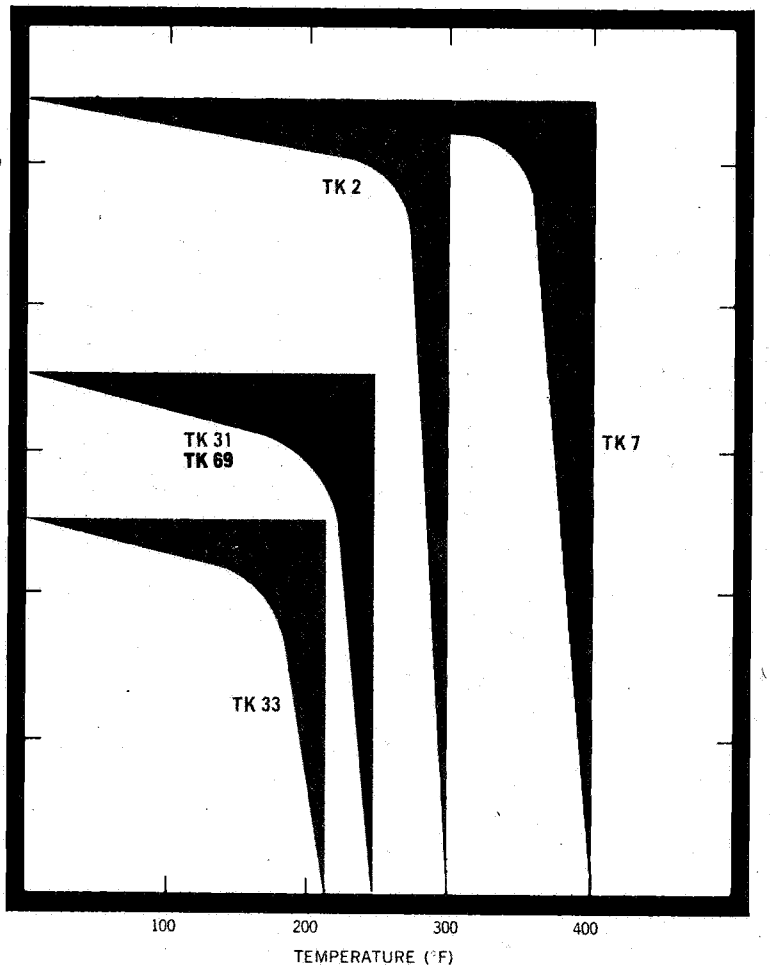
1. Where high caustic fluids are used in completion efforts.
2. Where high pressures and temperatures are encountered.

APPLICATION:

The inner surface is cleaned to remove scale and sandblasted to white metal providing an ideal anchor pattern for coating adherence. Multiple coats are applied and baked after each coat. In the case of TK-69, the phenolic compound coating and the outer epoxy coating are fused in the final baking process and are bonded into a unified, two component film.

TEMPERATURE/PRESSURE RECOMMENDATIONS FOR COATINGS

(THIN FILM 5-7 MILS)



Notes:

1. Specific coatings may be used at pressure-temperature conditions of designated limits.
2. For service in shaded areas consult local representative.
3. TK-2 and TK-7 should not be used when pH exceeds 11.5. Above pH 11.5 use TK-31 or TK-33.
4. For service in H_2S or Mud Acids consult local representative.

This data is based on laboratory and field experience and represents good faith opinions, but does not constitute a warranty or guarantee.

TK-84C

FOR CORROSIVE WATER SERVICE

● TK-84C is a heat-cured polyester plastic coating possessing excellent resistance to water, brine, acids, dissolved oxygen and normal concentrations of carbon dioxide.

PHYSICAL & CHEMICAL PROPERTIES:

1. TK-84C, a 25-mil coating, possesses good impact resistance and ductility.
2. Its smooth surface retards scale build-up.
3. TK-84C withstands pressures of at least 5000 psi and resists temperature to 150°F.
4. TK-84C has superior acid resistance.

TEMPERATURE & PRESSURE RECOMMENDATIONS:

1. TK-84C not recommended for pressures exceeding 2500 psi in presence of over 2% CO_2.

RECOMMENDED USES:

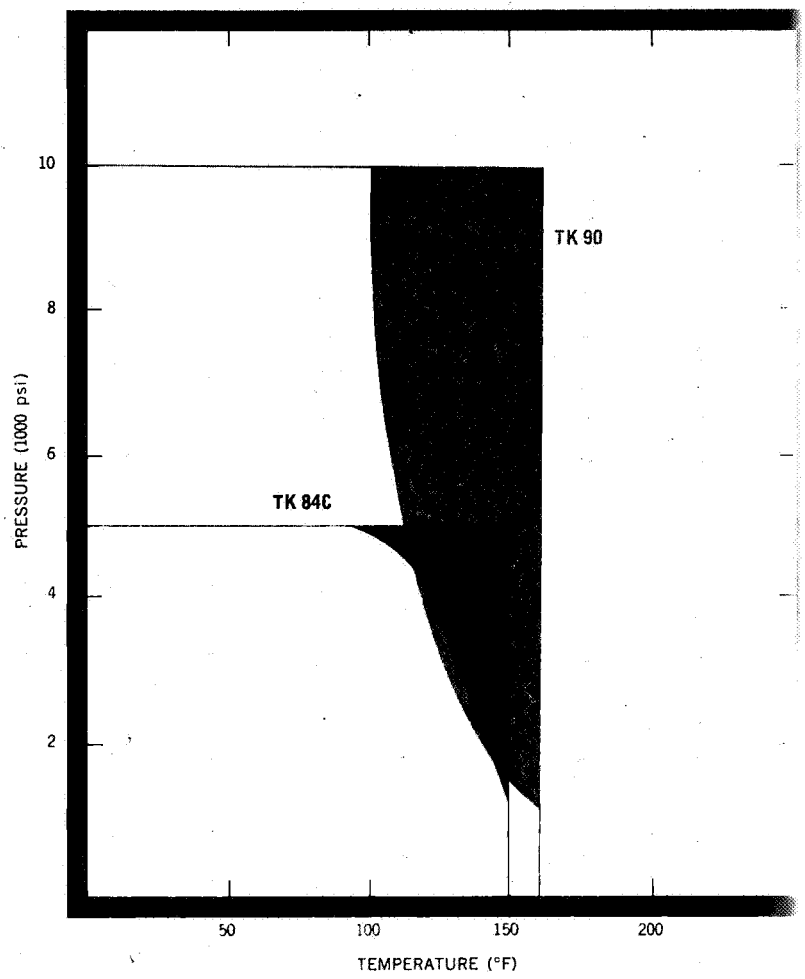
TK-84C is designed primarily to provide superior corr sion resistance in water handling systems such as:

1. Water gathering lines.
2. Water distribution lines.
3. Injection well tubing.
4. Water disposal systems.
5. Oil handling systems.

APPLICATION:

The inner surface is cleaned to remove scale and sanc blasted to white metal providing an ideal anchor patter for coating adherence. Multiple coats are applied an baked after each coat. It is then subjected to a final bal ing process which blends the multiple coats into on homogenous film.

TEMPERATURE/PRESSURE RECOMMENDATIONS FOR COATINGS
(THICK FILM COATINGS 18-20 MILS)



NOTES.

1. Specific coatings may be used at pressure-temperature conditions of designated limits.
2. For service in shaded areas consult local representative.
3. TK-84c should not be used when pH exceeds 11.5. Above pH 11.5 use TK-31 or TK-33.
4. For service in H_2S, mud acids, CO_2 or where oil content exceeds 2%, consult local representative.

This data is based on laboratory and field experience and represents good faith opinions, but does not constitute a warranty or guarantee.

TK-90

FOR CORROSIVE WATER SERVICE

- TK-90 is a tightly bonded, thick film coating capable of withstanding severe oil field handling.
- TK-90 resists all common oil field chemicals including concentrated acids.
- TK-90 is extremely flexible and can tolerate elongation up to 365%.
- TK-90 is 100% holiday free.
- TK-90 quality is assured by a full-length, 4000-volt spark test.

PHYSICAL & CHEMICAL PROPERTIES:

1. TK-90 possesses excellent impact resistance and ductility.
2. It's hardness is Shore "D" 60.
3. It is extremely abrasion-resistant.
4. TK-90 is applied to an 18-20 mils thickness.
5. TK-90 has successfully withstood 1,000 hr. tests using various oil field acids and alkalies.

RECOMMENDED USES:

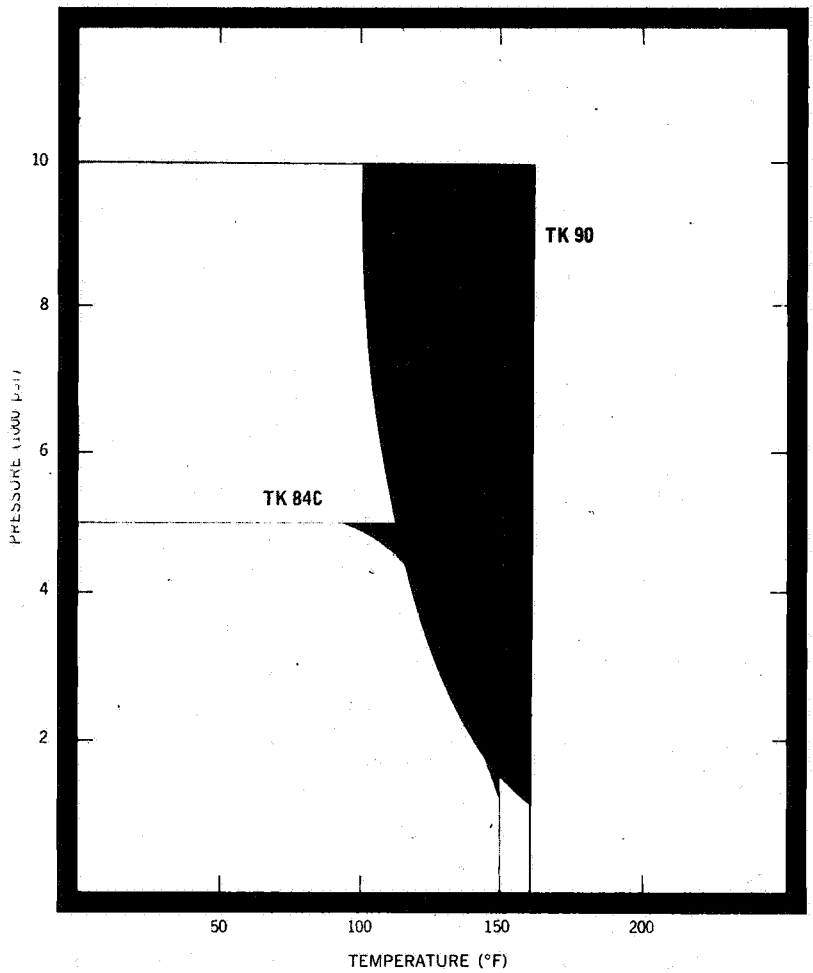
TK-90 is recommended for the following:

1. Water gathering lines.
2. Water distribution lines.
3. Injection well tubing.
4. Water disposal systems.
5. Mine water handling facilities.

APPLICATION:

The inner surface is cleaned to remove scale and sandblasted to white metal providing an ideal anchor pattern for coating adherence. TK-90 is applied to the desired thickness and baked. At the same time, couplings receive a 100-mil application of polypropylene to the critical stand-off areas.

TEMPERATURE/PRESSURE RECOMMENDATIONS FOR COATINGS
(THICK FILM COATINGS 18-20 MILS)



NOTES:

1. Specific coatings may be used at pressure-temperature conditions of designated limits.
2. For service in shaded areas consult local representative.
3. TK-84c should not be used when pH exceeds 11.5. Above pH 11.5 use TK-31 or TK-33.
4. For service in H_2S, mud acids, CO_2 or where oil content exceeds 2%, consult local representative.

This data is based on laboratory and field experience and represents good faith opinions, but does not constitute a warranty or guarantee.

SCHEDULE OF RECOMMENDED USES FOR TUBE-KOTE CONVENTIONAL COATINGS

ACIDS	COATING						
	TK-2	TK-7	TK-31	TK-33	TK-34	TK-84	TK-90
ACETIC—10%	R	R	LR	LR	LR	NR	LR
ACETIC, GLACIAL	R	LR	NR	NR	NR	NR	NR
CARBONIC	R	R	R	R	R	R	R
CHROMIC	R	NR	NR	NR	NR	NR	R
CITRIC—50%	R	R	R	R	R	LR	R
CITRIC—10%	R	R	R	R	R	R	R
FORMIC	LR	LR	NR	NR	NR	NR	LR
HYDROBROMIC—50%	LR	LR	NR	NR	NR	NR	LR
BORIC	R	R	R	R	R	R	R
HYDROCHLORIC (aerated)—36%	NR	NR	NR	NR	NR	NR	LR
HYDROCHLORIC (aerated)—10%	LR	LR	LR	LR	LR	LR	LR
NITRIC—40%	NR	NR	NR	NR	NR	NR	LR
PHOSPHORIC—85%	R	R	R	R	R	R	R
PHOSPHORIC—30%	R	R	R	R	R	R	R
LACTIC	R	R	LR	NR	NR	NR	LR
OXALIC	LR	LR	LR	LR	LR	NR	LR
SULFURIC—98%	R	NR	NR	NR	NR	NR	LR
SULFURIC—70%	LR	LR	LR	LR	LR	NR	LR
SULFURIC—10%	R	R	R	LR	LR	R	R
TANNIC	R	R	R	R	R	R	R
OCTANOIC	R	LR	LR	NR	NR	NR	NR
OLEIC	R	R	R	R	R	LR	R
ALKALIES							
AMMONIUM HYDROXIDE	NR	LR	LR	LR	LR	NR	R
POTASSIUM HYDROXIDE—10%	NR	NR	R	R	R	NR	LR
POTASSIUM HYDROXIDE—50%	NR	NR	LR	LR	LR	NR	LR
SODIUM HYDROXIDE—10%	NR	LR	R	R	R	NR	R
SODIUM HYDROXIDE—50%	NR	NR	LR	LR	LR	NR	NR
CALCIUM HYDROXIDE—10%	NR	LR	R	R	R	NR	R
WATER							
TAP	R	R	R	R	R	R	R
DISTILLED	R	R	R	R	R	R	R
SEA	R	R	R	R	R	R	R

ORGANIC MATERIALS AND SOLVENTS	COATING						
	TK-2	TK-7	TK-31	TK-33	TK-34	TK-84	TK
ETHYLENE DIBROMIDE	R	R	NR	NR	NR	NR	N
BUTANOL	R	R	LR	LR	LR	NR	N
BENZENE	R	R	R	R	R	NR	N
ETHYLENE GLYCOL	R	R	R	R	R	R	
CARBON TETRACHLORIDE	R	R	LR	LR	LR	NR	N
FORMALDEHYDE	R	R	NR	NR	NR	NR	N
METHANOL	R	R	LR	LR	LR	NR	N
ETHYL ACETATE	R	R	LR	LR	LR	NR	N
FATTY ACIDS	R	R	LR	LR	LR	NR	N
METHYL ETHYL KETONE	R	R	LR	LR	LR	NR	N
TOLUENE	R	R	R	R	R	NR	N
XYLENE	R	R	R	R	R	NR	N
SALTS Dry and Water Solutions							
AMMONIUM CHLORIDE	R	R	R	R	R	R	
AMMONIUM SULFATE	R	R	R	R	R	R	
POTASSIUM CHLORATE	R	R	R	R	R	R	
BARIUM CHLORIDE	R	R	R	R	R		
BARIUM SULFATE	R	R	R	R	R		
CALCIUM CHLORIDE	R	R	R	R	R		
CALCIUM SULFATE	R	R	R	R	R		
CUPRIC CHLORIDE	R	R	R	R	R		
CUPRIC SULFATE	R	R	R	R	R		
FERRIC CHLORIDE	R	R	R	R	R		
FERRIC SULFATE	R	R	R	R	R		
MAGNESIUM CHLORIDE	R	R	R	R	R		
MAGNESIUM SULFATE	R	R	R	R	R		
SODIUM THIOSULFATE							
NICKEL CHLORIDE							
NICKEL SULFATE							
POTASSIUM CHLORIDE							
POTASSIUM SULFATE							
SILVER NITRATE							
SODIUM CHLORIDE							
SODIUM SULFATE							

LEGEND:
R = Recommended
LR = Limited recommendation
NR = Not Recommended

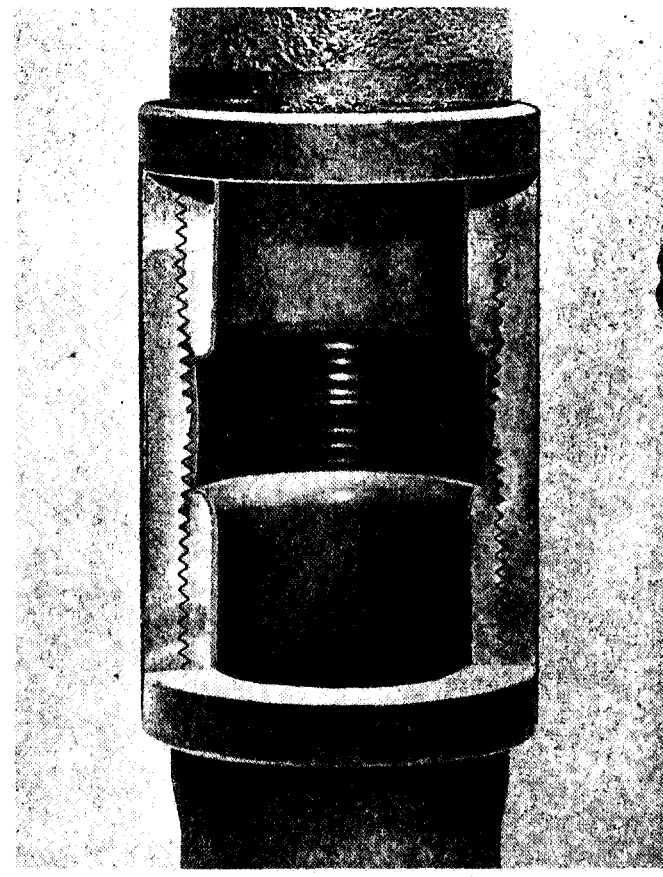
*Based on tests at 150°F at pressure produced by a closed syste of the indicated chemical.
For higher temperatures consult your Tube-Kote representative.

UBE-KOTE SPECIAL CONNECTION & COUPLING PROTECTION METHODS

or complete protection from corrosive fluids throughut a length of pipe. the Tube-Kote process includes a iew method of coupling protection. In this new proedure, coupling protection is assured in pipe service ranging to 200 F. At higher temperatures, Tube-Kote specialized coatings are recommended for coupling protection.*

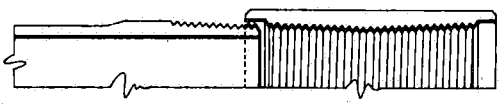
The coupling protection process follows these steps: threads are masked at ends of coupling, leaving center (standoff) threads bare. Polypropylene powder is placed in the unmasked threads, and the coupling is heated in a special oven. The powder melts and flows across the threads to form a smooth holiday free coating baked to the coupling. When the coupling is made up, the in threads cut into the polypropylene coating to ensure a continuous film of protection for the entire length of pipe.

*Note: Before using in Hydrocarbon environment in excess of 2% by volume, please contact your local Tuboscope representative



TUBING JOINT COATING SPECIFICATIONS

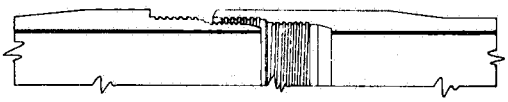
The complete protection of all metal exposed to corrosive environments has been the goal of Tube-Kote engineering. The application of coating to the different types of tubing joints poses problems that are both complex and varied. However, Tube-Kote engineers through research, experience and consultation with manufacturers, have evolved the most efficient, all-around method for coating each type of joint. Shown below in cross-section detail are the areas to which Tube-Kote recommends the coating be applied.



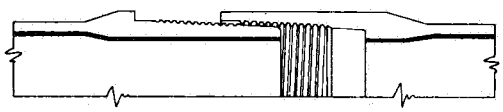
API tubing and coupling



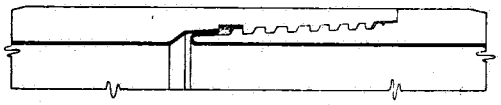
API line pipe and coupling



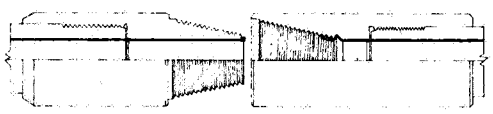
Hydril tubing joint



Spang Extreme Line joint



Hardy-Griffin Dual Seal tubing joint



Drill Pipe joint

HE PLASTIC COATING PROCESS

ery possible step to ensure maximum corrosion control taken during the Tube-Kote process. This process is development of nearly three decades of specialized udy and work toward the achievement of maximum otection of metallic surfaces through application of stic coatings. Every step, no matter how small or insigficant it may seem to a casual observer, has been subject of intensive, painstaking investigation and perimentation. AMF Tuboscope, Inc., maintains comete engineering and research departments which cusm design processes and application equipment.

ipe is received into the plant by either truck or rail, and nloaded in the processing area by trained personnel. me charts and coating specifications are prepared so at exact records may be kept on every joint every oment from the time it enters the coating yard until elivered to the field. The order is inventoried and moved to the pre-cleaning processes.

LEANING

ere couplings are *removed* according to specifications nd channeled into a special coupling coating process. ne tubing itself is drifted through upset area to ensure at every joint meets with API specifications.

Proper cleaning is one of the most important steps in he preparation of pipe for application of coatings. Each ength of pipe is sent through an automatic pre-bake ven and/or a special cleansing bath. The automatic re-bake oven operates at 700°F. to 800°F., and each ength of pipe is baked for one hour and thirty minutes. il deposits are burned and flaked. Impregnated gases re driven out, and all impurities are loosened prior to ending the pipe through a sandblasting operation.

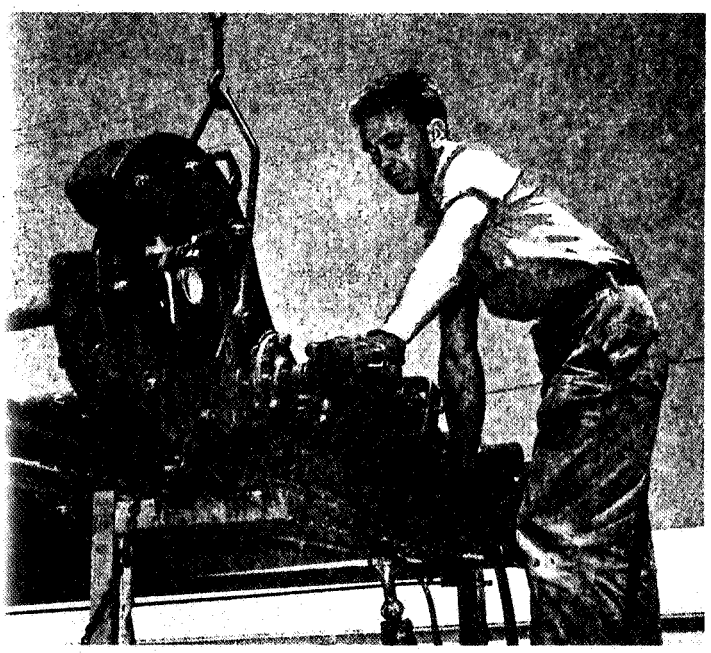
A blasting machine of a very special design has been perfected by Tuboscope engineers for the most effective cleaning of the interior surface of the tubing joint. This machine is operated by trained personnel, and constitutes a very important step in the process. The surface to be coated is blasted to white metal with an angular, extremely hard abrasive. A pronounced "anchor pattern" is created while producing a surface completely free of any and all foreign substances. The anchor pattern is a system of minute peaks and valleys into which the coating will flow, assuring continuity of surface and a tight bond. Adhesion is so great that in testing, sheering of particles of metal has been encountered before coating bond is ruptured. This excellent adhesion is definitely improved by the use of the flint blast.

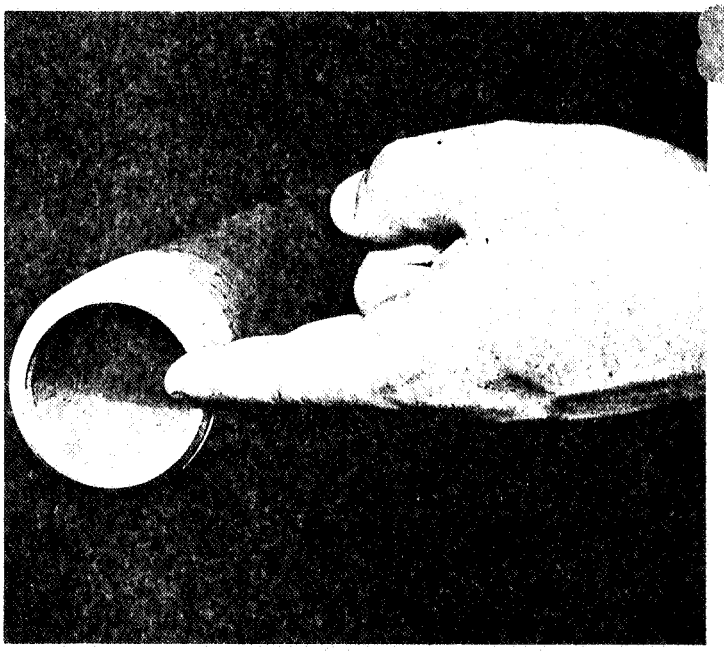
After blasting, the inside surfaces of the tubing are examined. Any foreign matter, metal lamination or rusting detected during this inspection are cause for either reprocessing or rejection of the length as unsuitable for coating. This step of inspection is just one more important measure taken in the Tube-Kote process to ensure the very highest quality coating application possible.

The portions of the tubing, such as certain threaded areas, are then masked to prevent any coating from depositing on those surfaces, according to customers' and manufacturers' desires.

2 COATING

Tube-Kote's revolving spray head system deposits protective plastic coatings with micrometer precision. Atomized by high escape velocity rather than air pressure,





a more dense, uniform coating is obtained. Constant volumetric discharge of the coating material results in greater uniformity from end to end. The adverse effects of weather change, humidity and temperature variations are eliminated.

You get superior protection from your coating investment because Tube-Kote takes the necessary steps to assure success. The pipe is properly cleaned and prepared for coatings. Superior Tube-Kote coatings are used. The coatings are applied by the exclusive revolving spray head system. Curing cycles are carefully managed for a superior bond and service life. Each step of the process is checked with scientific accuracy by Tube-Kote's research technicians.

3 BAKING

Baking between coats is done at temperatures in the range of 275°F. in order to remove solvents and sufficiently set the plastic so that the next coat may be a plied without affecting the previous coatings. Ove used for this baking are also of special design to cilitate handling of individual racks of tubing. These ens are electronically controlled to heat the pipe eve to the exact desired temperature for the specified tir After the total thickness desired has been achieved, t pipe is again visually inspected and placed in the fi bake, a high temperature bake in the range of 40(500°F., depending on the coating. The final bake is ma tained for a sufficient length of time to fuse all co into one mass, and to polymerize or chemically link t plastic to the exact desired degree for maximum c rosion resistance.

4 QUALITY CONTROL

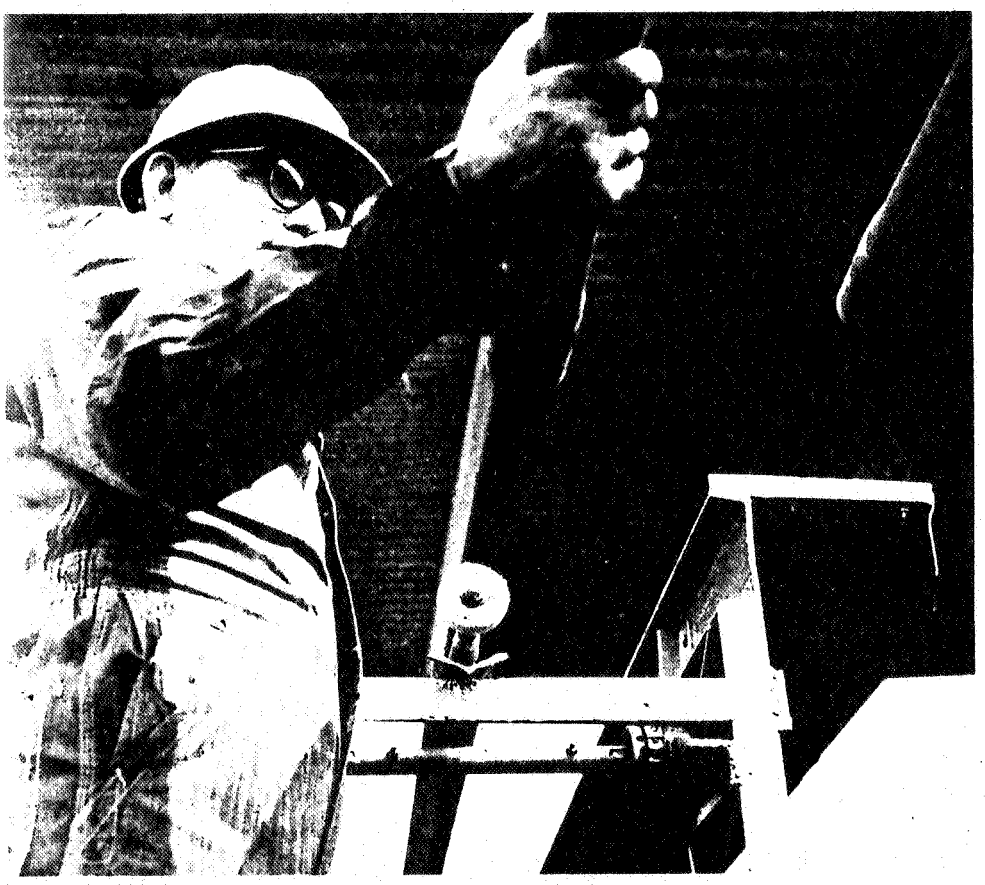
The coating then receives the final visual inspectic Film thickness is carefully checked with the best nc destructive testing equipment available. Electronic te

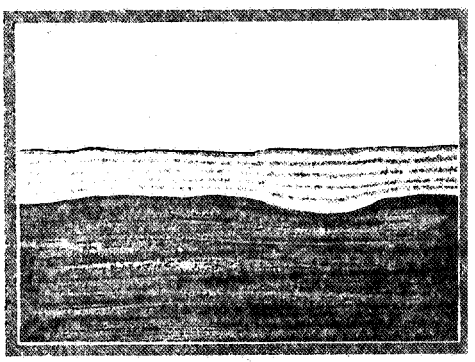


g for voids or holidays is performed on *all* orders to id Tube-Kote specs. Any areas of exposed metal, no atter how small, are detected by means of a closing of electrical circuit. When imperfection is detected, the ure joint is returned to the beginning and is completely processed. No attempt is made to "patch" the coating. While many types of coating material are available which might perform satisfactorily for the majority of ers, Tuboscope refuses to compromise to any extent on quality.

The Tube-Kote process automatic holiday detector was developed after extensive study in the research laboratory. It is now in operation, at no added cost to you, at all plants. Each length of pipe processed is full length examined by this electronic instrument. The transistor circuitry ensures a high sensitivity which signals any coating void detected by the wet sponge head. A constant flow of electrolyte, a uniform lance travel, and a positive power supply combined with the signal mechanism ensure the standard of quality.

After the tubing has passed all testing, it is then moved to a storage area where threads are lubricated with API approved resilients and couplings are replaced at a fixed, measured torque. Thread protectors are replaced, and, finally, the tubing receives an external, air dry coating to afford external protection from the weather if the pipe should be stored for a prolonged period. This service is provided free of charge to the customer. The pipe is then placed in an assigned storage area awaiting delivery to the customer.

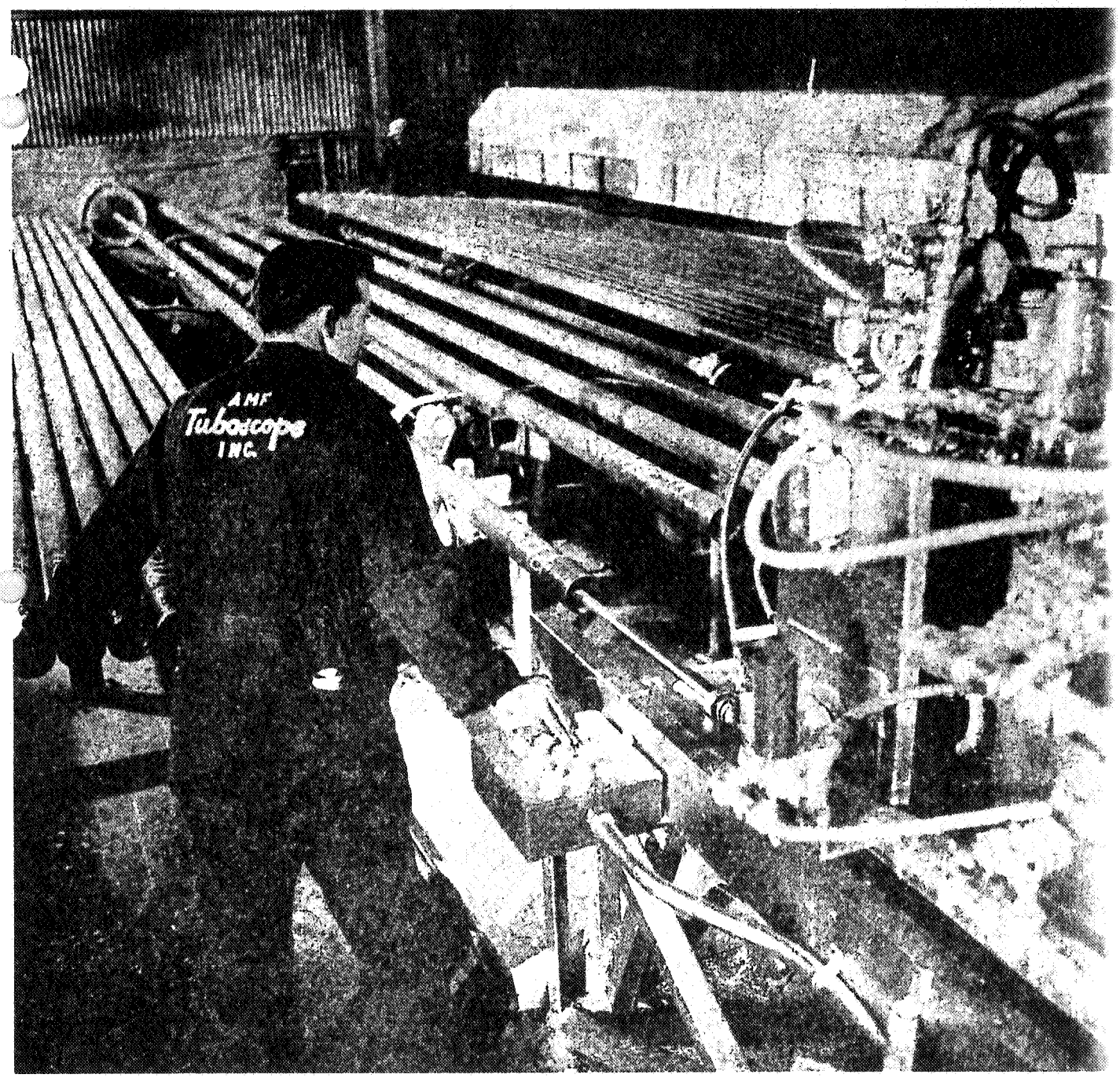




Coating flows into irregularities of pipe surface. Successive layers produce a desired coating thickness.

Final baking polymerizes separate films into one uniform coating, permanently fused to the pipe surface.




AMF
Tuboscope
INC.

SALES OFFICES

U. S. SALES

TUBOSCOPE AND TUBE-KOTE OFFICES
General Offices
Box 808—Houston, Texas 77001
Phone: —713-RI 8-1300

CALIFORNIA
Long Beach, P. O. Box 8254
Phone: 213/424-0435

COLORADO
Denver, 80202—360 Denver Club Bldg.
Phone: 303/825-0773

ILLINOIS
Carmi, 62821—Rt. 1 West, Box 161
Phone: 618/384-5921

KANSAS
Great Bend, 67530—W. 10th Street, Box 580—Phone: 316 GL 3-9571

LOUISIANA
Harvey, 70058 (Coating)—First Ave., Box 172—Phone: 504 341-1612
Harvey, 70058 (Inspection)—2000 8th St., Box 231—Phone: 504 367-1420
Houma, 70361—1311 Daspit St., Box 207
Phone: 504/UP 2-0610
Lafayette, 70503—304 Broadmoor
Phone: 318/CE 2-4083
New Iberia, 70561—Hwy. 90 E., Box 142
Phone: 318/EM 4-4161
Shreveport, 71105—376 Sandefur
Phone: 318/424-2491

MISSISSIPPI
Laurel, 39441—E. 16th St., Box 2325
Choctaw Station—Phone: 601/428-0626
Natchez, 39121—1005 Westwood Rd., Box 716—Phone: 601/442-0341

MONTANA
Glendive, 59330—307 N. River St., Box 1166—Phone: 406/365-2665

NEBRASKA
Sidney, 69162—1629 Manor Rd., Box 84
Phone: 308/254-3431

NEW MEXICO
Farmington, 87401—2006 E. 16th St., Box 1671—Phone: 505/325-3371
Hobbs, 88240—1215 N. Llano
Phone: 505/EX 3-7478

OKLAHOMA
Oklahoma City, 73117—5900 N. Eastern
Phone: 405/GA 7-2491
Pauls Valley, 73075—314 Terrace Dr.
Phone: 405/BE 8-6754
Tulsa, 74103—724 Kennedy Bldg.
Phone: 405/LU 2-8782

PENNSYLVANIA
Beaver Falls, 15010—Shenango Rd., Box 59
Phone: 412/846-2968

TEXAS
Abilene, 79604—P. O. Box 2762
Phone: 915/OR 3-6521
Beaumont, 77707—5704 College St.
Phone: 713/TE 2-6645
Corpus Christi, 78403—311 Westchester Dr., Box 1753—Phone: 512/TU 3-1193
Dallas, 75202—714 Davis Bldg., 1309 Main St.—Phone 214/RI 8-3227
Graham, 76046—Breckenridge Hwy., Box 626—Phone: 817/LI 9-0550
Houston, 77001 (Home Office)—2919 Holmes Rd., Box 808—
Phone: 713/RI 8-1300
Kilgore, 75662—Laird Hill Rd., Box 1391
Phone: 214/984-3477
Midland, 79702—Tower Rd., Box
Phone: 915/MU 3-4278
Odessa, 79762—4710 Andrews H
Box 6407—Phone: 915/EM 6
(Midland Line 915/LO
Pampa, 79066—1816 N. Dwight,
Phone: 806/MO 5-3421

WYOMING
Casper, 82602—101 River Cross
Box 2248—Phone: 307/234-15

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Calgary—7024 Farrell Rd., Box 6
Phone: 403/252-4421
Edmonton (Coating)—9515 58 Av
Box 4035, Alta.—Phone: 403/
Edmonton (Inspection)—9605 63
Box 55, Alta.—Phone: 403/43

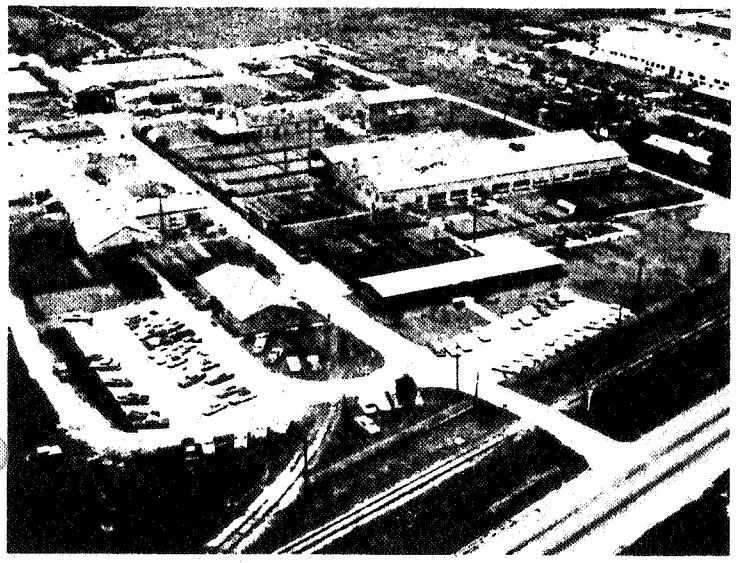
MEXICO
Tuboscope de Mexico, S.A.
Sierra Madre 325, Lomas Chapult
Mexico 10, D.F.—Phone: 20-01
Apdo. 32-705, Mexico 1, D.F.
Other service points in Europe,
East, North Africa, South Am
Australia.

Tube-Kote coatings by

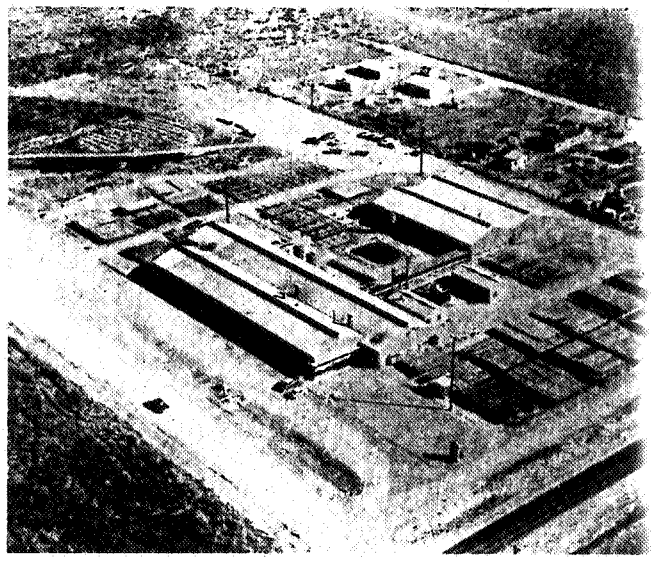
TUBOSCOPE, INC.

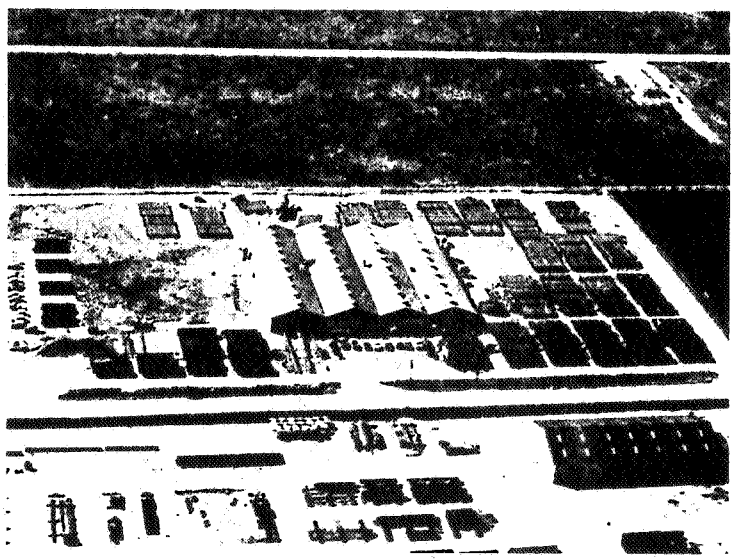
P. O. Box 808 / Houston, Texas 77001 / 713—RI 8-1300

HOUSTON, TEXAS • 2727 HOLMES ROAD

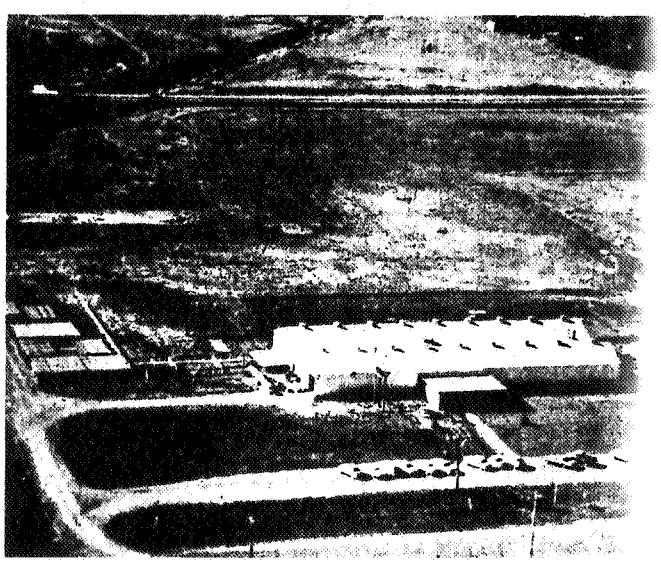


MIDLAND, TEXAS • TOWER ROAD





EDMONTON, ALBERTA, CANADA •



I B A

INTER-OFFICE CORRESPONDENCE

CIBA PRODUCTS COMPANY
Division of CIBA Corporation
Summit, N.J.

258

From: Henry T. Blekicki
Product Co-Ordinator

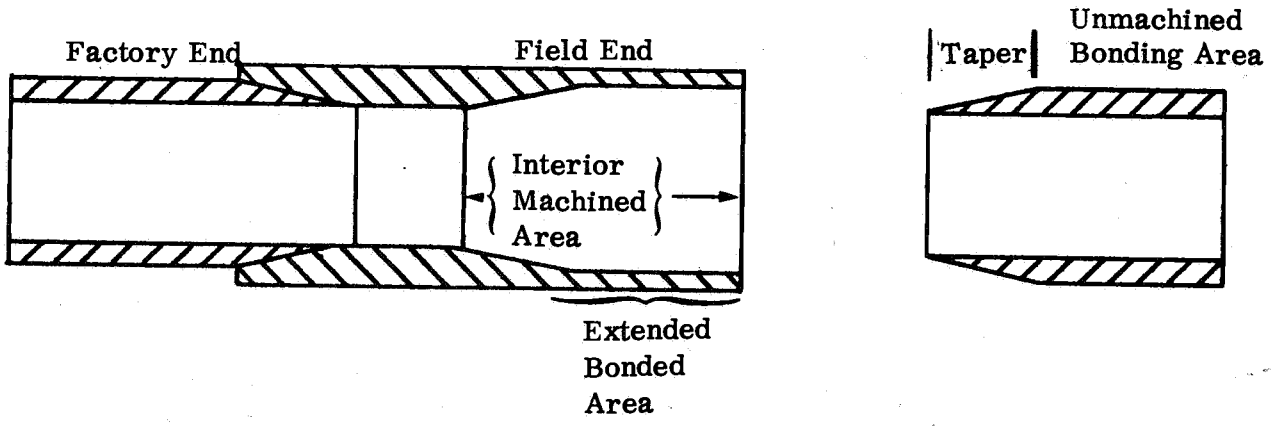
Date: May 24, 1967

To: Field Force (See below)

Bulletin No: Marketing Bulletin No. 13

Subject: NEW DEEP SOCKET COUPLING

CIBA has recently developed a superior sleeve coupling which is now being supplied with every new joint of pipe. This new coupling has an extended bonding area which provides improved burst capabilities. Also the greater length of the coupling insures that the bond will not be disturbed while it is curing. A schematic diagram below shows how the field end of the pipe has been extended:



When pipe is to be installed in the field, the entire interior machined area should be coated with the CIBA-20MW adhesive. Also the spigot end of the pipe should be coated in the following manner:

Pipe Diam. In.	
2	Taper + 1 1/2" unmachined bonding area(1)
3	Taper + 2 1/4" unmachined bonding area(1)
4	Taper + 2 3/4" unmachined bonding area(1)
6	Taper + 4" unmachined bonding area(1)

Applying the adhesive to the unmachined area of the pipe will allow a strong bond to be made even if the pipe is not perfectly locked into the coupling.

(1) See schematic diagram.

This is just one more indication of CIBA's continuing effort to improve the handling and performance characteristics of the best line pipe in the oil and gas fields.

Henry T. Blekicki
Product Co-Ordinator

HTB:grh

TO: Mr. R. C. DuFrane
Mr. R. G. Foss
Mr. J. D. Holland
Mr. W. D. Lutke
Mr. R. P. Nelson, Jr.
Mr. J. W. Scott
Mr. E. A. Stewart
Mr. J. E. Weems

cc: Mr. J. H. Causey - Wilson Supply Company
Mr. J. D. Gilmer - Mountain Iron & Supply Company

SPECIFICATIONS
CIBA-300 LINE PIPE

SECTION 1 - SCOPE:

1.1 - General: This specification covers requirements for CIBA-300 fiberglass epoxy line pipe manufactured for use in carrying fluids and gases in oil and gas production.

SECTION 2 - GENERAL REQUIREMENTS:

2.1 - Sizes: CIBA-300 pipe shall be manufactured to IPS 2, 3, 4, and 6 in. diameters.

2.2 - Classes: CIBA-300 pipe shall be manufactured for use in service at maximum operating pressures and temperatures as follows:

IPS	Steady Pressure Rating, psi (1)	Cyclic Pressure, psi (2)	°F Temperature
2	450	300	200
3	450	300	200
4	450	300	200
6	450	300	200

(1) flowing wells, triplex, quintuplex, centrifugal pumps,
(2) duplex pumps, pumping jacks.

2.3 - Lengths:

2.31 - Standard Lengths: CIBA-300 pipe will be supplied in 33 ft. nominal lengths. A maximum of 5% joiners may be included in any one shipment, at manufacturers option, bundled separately.

2.32 - Other Lengths: Shorter or longer lengths available on special order. Longer lengths; such as, 40 ft. joints, will be one continuous length.

2.4 - Couplings: Each length of pipe is to be supplied with a factory-joined deep insertion coupling and one tapered end.

2.5 - Materials and Construction:

2.51 - Materials: CIBA-300 pipe shall consist of cured epoxy materials and fiberglass.

2.511 - Dual-Epoxy System: Interior of pipe to consist of flexible epoxy chemically cross-linked to structural winding epoxy. Integral flexible liner to have minimum thickness of .010 in. Integral liner must not contain fiberglass. Exterior of pipe shall consist of a uniform weather-resistant coating of epoxy with a minimum thickness of .006 in. This external coating to be chemically cross-linked and integral to structural winding epoxy.

2.52 - Construction: CIBA-300 Pipe shall be manufactured on a continuous process, incorporating dual-angle fiberglass reinforcements consisting of high and low angles.

SECTION 3 - DETAIL REQUIREMENTS:

3.1 - Dimensions:

Diameter	O.D.	I.D.	Thickness	Wt./Ft.
2	2-3/8	2.235	.07	.4
3	3-1/2	3.360	.07	.6
4	4-1/2	4.360	.07	.8
6	6-5/8	6.425	.10	1.7

3.2 - Burst: CIBA-300 pipe shall have the following minimum short-term burst values:

IPS	Burst, psi	IPS	Burst, psi
2	4000	4	2200
3	2700	6	2200

Pipe shall burst and not weep.

3.3 - General Properties: CIBA-300 pipe shall have the following mechanical and physical properties:

MECHANICAL PROPERTIES

PROPERTY	UNITS	VALUES	TEST METHOD	
			ASTM	CTM*
Tensile stress, longitudinal	psi x 10^3	31.5	D2105-62t	161
Tensile modulus, longitudinal	psi x 10^6	4.0	D2105-62t	161
Flexural stress	psi x 10^3	35.0	–	160
Flexural modulus	psi x 10^6	3.8	–	160
Compressive stress, longitudinal	psi x 10^3	30.0	–	142
Compressive modulus, longitudinal	psi x 10^6	2.7	–	142
Girth stress (hoop)	psi x 10^3	90.0	D1599-62t	152
Girth modulus (hoop)	psi x 10^6	4.6	–	151, 152
Longitudinal tensile elongation, ultimate	%	3.0	D2105-62t	161

*CTM—CIBA Test Method

PHYSICAL PROPERTIES

PROPERTY	UNITS	VALUE	TEST METHOD	
			ASTM	CTM*
Specific gravity	dimensionless	1.81	D792-60t	–
Density	lb/cu in	.065	D792-60t	–
Thermal conductivity	BTU/hr/ft^2/in/°F	1.7	D-177	163
Thermal expansion, linear	10^{-5} in/in/°F	0.69	D-696-44	163.21A
Flow factor	Hazen-Williams coefficient	150	–	156
Rockwell hardness	M scale	> 90	–	–
Barcol hardness	–	> 80	–	–

*CTM—CIBA Test Method

SECTION 4 - FITTINGS AND ACCESSORIES:

4.1 - Adhesives: Only CIBA-300 adhesive kits are to be used with CIBA-300 pipe. Maximum continuous operating temperature of adhesive is 200°F.

4.2 - Fittings: Only CIBA-300 fittings and adapters to be used with CIBA-300 pipe. CIBA-300 fiberglass/epoxy fittings have maximum continuous operating temperature of 200°F.

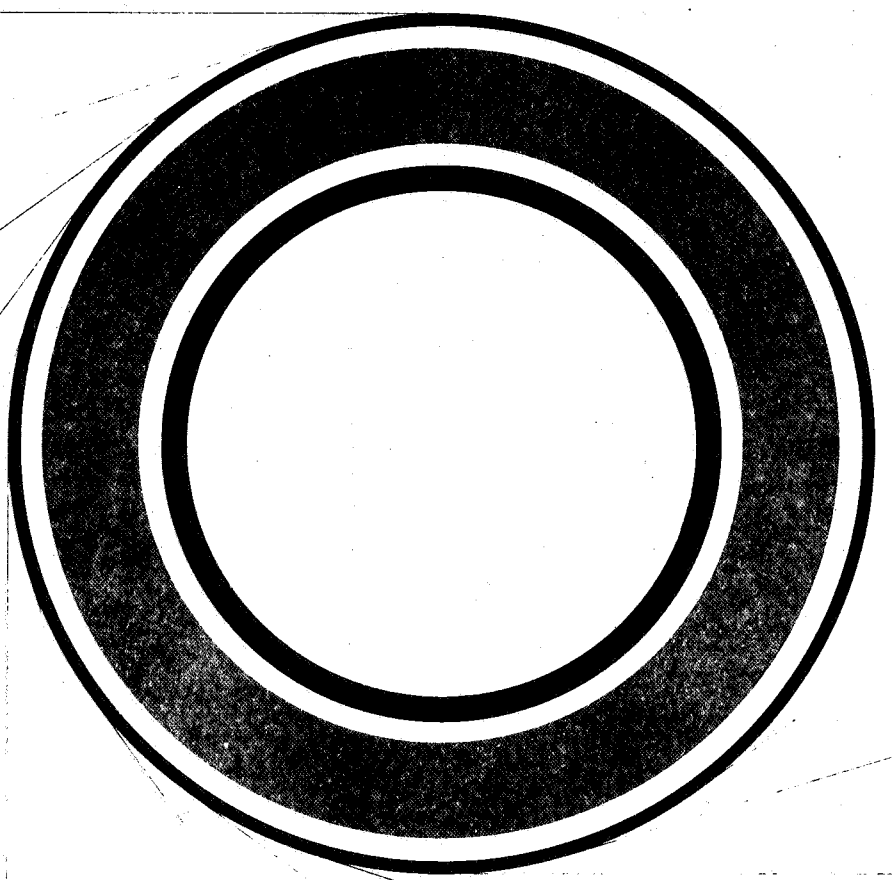
4.21 - CIBA-300 Fittings Pressure Rating, psi:

Pipe Size (IPS)	45° El	90° El	Tee	Flanges, Couplings Adapters
2"	300	300	300	300
3"	300	300	240	300
4"	300	250	200	300
6"	275	200	200	300

C I B A

FIBERGLASS REINFORCED EPOXY
FOR OIL AND GAS FIELD USE

CIBA-300 LINE PIPE SYSTEMS



C I B A

CIBA-300 LINE PIPE SYSTEMS

FIBERGLASS REINFORCED EPOXY FOR OIL AND GAS FIELD USE

CIBA-300 Line Pipe is a tough, durable, corrosion-resistant pipe for use in oil and gas field installations. CIBA Piping Systems are manufactured by the CIBA Products Company, the originators of epoxy resin technology with over 20 years of epoxy know-how.

USES

CIBA Pipe Systems are recommended for use where corrosive fluids and gases are to be handled in field production operations, or where highly corrosive soil conditions exist. CIBA Pipe Systems may be buried or laid on the surface. Service operating temperatures are rated at 200°F and cyclic pressures up to 300 psi, steady state pressures up to 450 psi.

Typical Applications are:

1. Crude oil flow and gathering lines
2. Distribution lines
3. Gas gathering lines
4. Gun barrel siphons
5. LACT unit piping
6. Line insulators
7. Manifolding
8. Portable water lines
9. Salt water disposal lines
10. Tank battery hookups
11. Transmission lines
12. Tubing
13. Vent lines
14. Water flood supply lines

"BALANCED PERFORMANCE" CONSTRUCTION

The "Dual System" performance characteristics of CIBA Piping Systems offer higher value and safety than any other reinforced pipe. CIBA Pipe Systems have an exclusive dual-reinforcement and dual-epoxy resin system to meet the broad demands of the oil and gas industries.

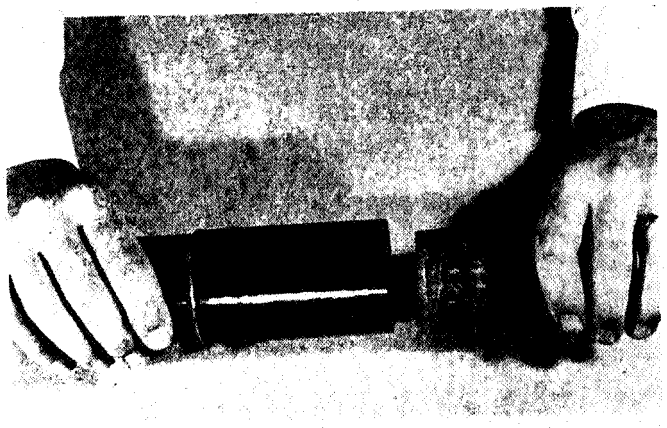
DUAL-ANGLE REINFORCEMENT WINDING FOR HIGHER PERFORMANCE EFFICIENCIES

The reinforcement in CIBA Piping Systems is balanced to handle mechanical loads—both internal and external. This is accomplished by a continuous dual-angle winding process with the high angle reinforcement engineered to resist crushing and external loads. The lower angle winding imparts: mechanical strength for outstanding resistance to tensile, flexural, and longitudinal buckling loads. The precise angles and orientation of the fiberglass windings provide a pressure balanced reinforcement with the highest strength and safety factor.

DUAL-EPOXY RESIN SYSTEMS TO IMPROVE CORROSION RESISTANCE AND FLOW CHARACTERISTICS

CIBA Piping Systems are lined with a specially formulated epoxy lining that is flexible and smooth. The exterior is uniformly coated with a hard, tough, corrosion- and weather-resistant epoxy. The two epoxy systems combine with the fiberglass reinforcement to form a monolithic wall with exterior toughness and interior flexibility.

SIMPLE, FAST JOINING SYSTEM



CIBA Pipe and Fittings are joined together with an epoxy adhesive. The factory applied double-strength coupling is tapered to receive the tapered male end of the pipe to form a strong leak-proof joint. No threading or welding required. Field cuts and tapers are made with simple tools—hacksaw and tapering tool.

RATING

CIBA-300 Line Pipe is manufactured for use at the following maximum pressures and temperatures:

IPS	Steady Pressure Rating, psi (1)	Cyclic Pressure, psi (2)	°F Temperature
2	450	300	200
3	450	300	200
4	450	300	200
6	450	300	200

(1) Flowing wells, triplex, quintuplex, centrifugal pumps.
(2) Duplex pumps, pumping jacks.

C I B A

CIBA-300 LINE PIPE SYSTEMS

FIBERGLASS REINFORCED EPOXY FOR OIL AND GAS FIELD USE

264

SPECIFICATIONS

Nom. Diam.	O.D.	I.D.	Wall Thickness	LB/FT	Burst-psi
2	2 3/8	2.235	.07	.4	4000
3	3 1/2	3.360	.07	.6	2700
4	4 1/2	4.360	.07	.8	2200
6	6 5/8	6.425	.10	1.7	2200

The pipe is supplied in 33′ lengths with integral bell and spigot joints. Epoxy adhesive kits are available to join the pipe. A complete line of elbows, tees, flanges, reducers, and adapters are also available. The molded fittings are produced from fiberglass epoxy molding compounds with identical corrosion-resistance to the pipe.

FLOW CHARACTERISTICS

CIBA-300 Line Pipe has a 36.5% lower friction loss compared to steel pipe in the turbulent region. It has a Hazen-Williams flow factor rated at 150.

CHEMICAL RESISTANCE

The CIBA-300 Pipe and Fittings are completely inert to the oil field environment. Hot brine, sweet and sour crude, alkaline soils, acid soils, dissolved gases, aromatic frictions, electrolysis, tuberculation, chlorides, sulfates, and carbonates do not affect the pipe and it is anticipated that high pipe-salvage value from abandoned fields will prolong the economic use of CIBA-300 Line Pipe indefinitely.

MECHANICAL PROPERTIES

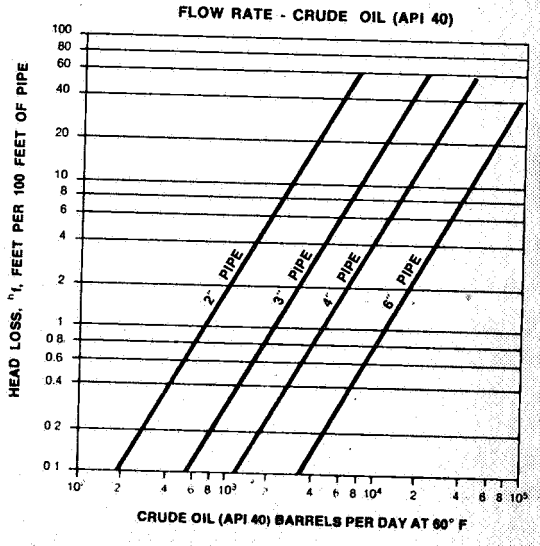
PROPERTY	UNITS	VALUES	TEST METHOD	
			ASTM	CTM*
Tensile stress, longitudinal	psi x 10^3	31.5	D2105-62t	161
Tensile modulus, longitudinal	psi x 10^6	4.0	D2105-62t	161
Flexural stress	psi x 10^3	35.0	–	160
Flexural modules	psi x 10^6	3.8	–	160
Compressive stress, longitudinal	psi x 10^3	30.0	–	142
Compressive modulus, longitudinal	psi x 10^6	2.7	–	142
Girth stress (hoop)	psi x 10^3	90.0	D1599-62t	152
Girth modulus (hoop)	psi x 10^6	4.6	–	151, 152
Longitudinal tensile elongation, ultimate	%	3.0	D2105-62t	161

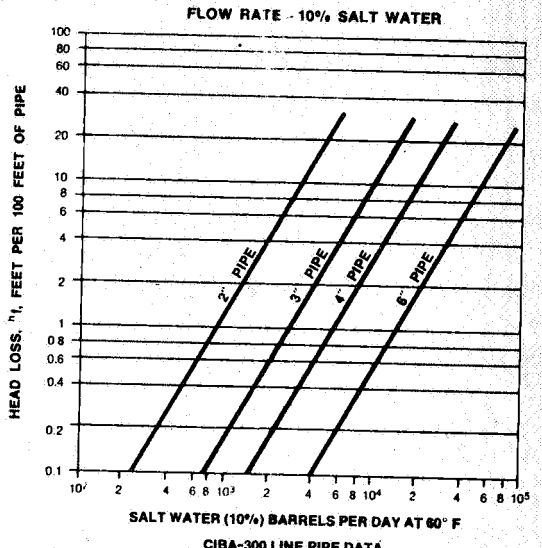
*CTM–CIBA Test Method

PHYSICAL PROPERTIES

PROPERTY	UNITS	VALUE	TEST METHOD	
			ASTM	CTM*
Specific gravity	dimensionless	1.81	D792-60t	–
Density	lb/cu in	.065	D792-60t	–
Thermal conductivity	BTU/hr/ft²/in/°F	1.7	D-177	163
Thermal expansion, linear	10^{-5} in/in/°F	0.69	D-696-44	163, 21A
Flow factor	Hazen-Williams coefficient	150	–	156
Rockwell hardness	M scale	> 90	–	–
Barcol hardness	–	> 80	–	–

*CTM–CIBA Test Method

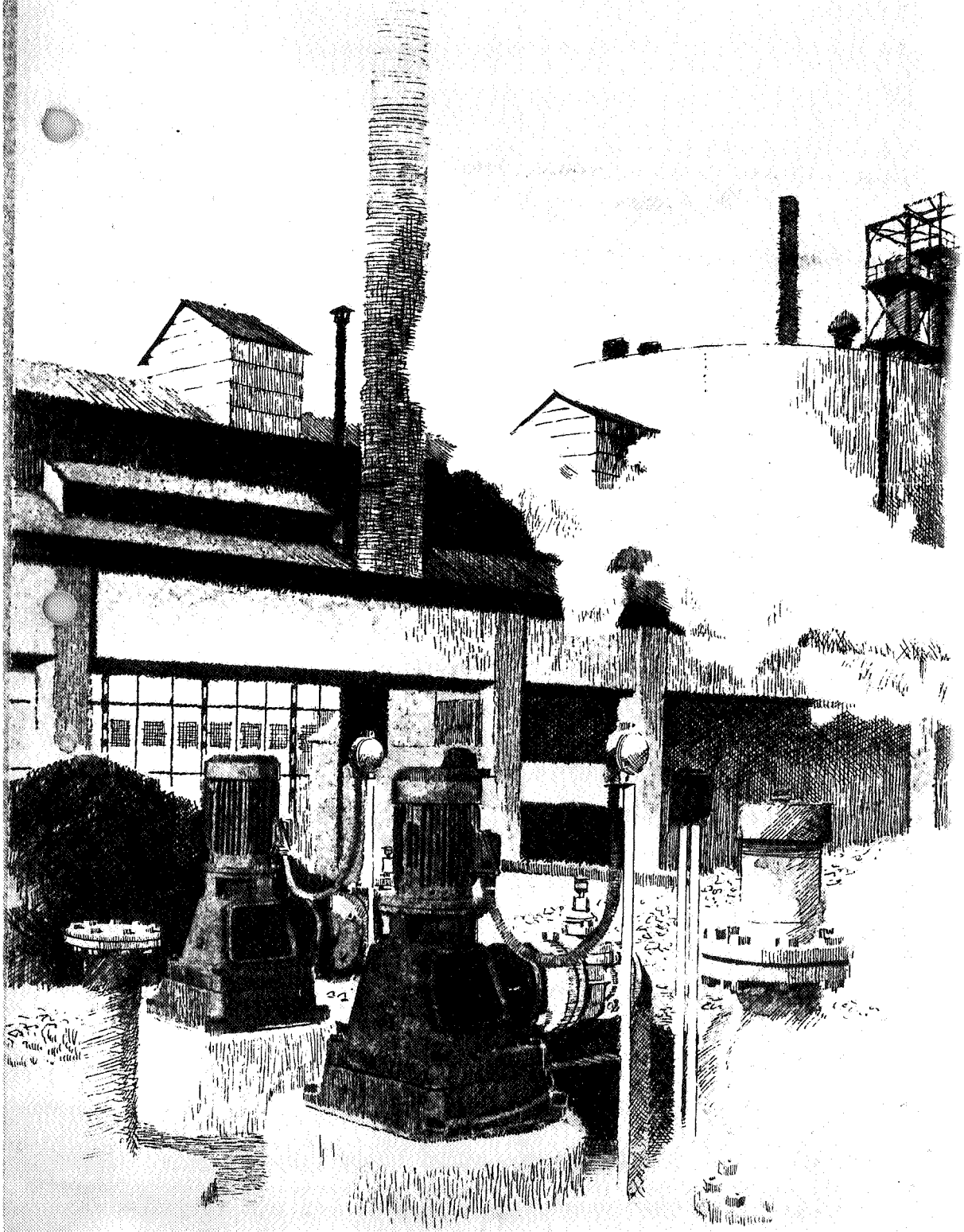




CIBA-300 LINE PIPE DATA
HAZEN-WILLIAMS FLOW FACTOR–150 (R_e = 10^4 – 10^7 RANGE)
R_e = REYNOLDS NUMBER

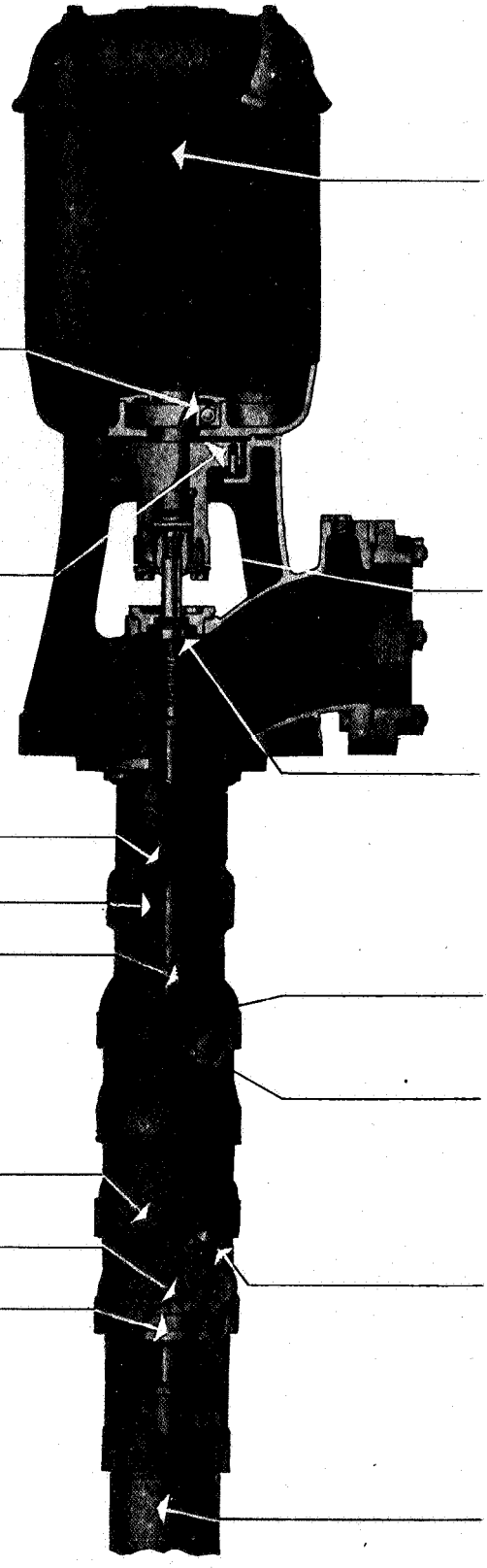
GRUNDFOS

FLANGE MOUNTED PUMPS BP. RANGE



SPECIFICATION

MODELS BP 105 - BP 135 - BP 165 - BP 190



PRIME MOVER
Drip proof, totally enclosed fan cooled or flame proof Class II electric motors. Alternative drive through flat belt pulley or right angle gear box also available.

HEAVY-DUTY ANGULAR CONTACT THRUST BEARING

ROTATION SAFETY RACHET

PUMP HEAD
Cast iron

MECHANICAL SHAFT SEAL
Diamond polished tungsten carbide surfaces on stainless steel mounting or crane ceramic surface seals.

DRIVE SHAFT
Centreless ground, stainless steel drive shafts to EN1.4057 BS 57

PUMP BEARINGS
Natural rubber or zinc free bronze to EN 2.1176 BS 1400 LB 2

BOWL HOUSINGS
Standard bronze to EN 2.1096 BS 1400 LG 2 or zinc free bronze to EN 2.1176 BS 1400 LB 2

IMPELLOR TAPER BUSH AND LOCK NUTS
Zinc free bronze to EN 2.0400

DIFFUSOR
Polished Stainless Steel

IMPELLORS
Fabricated stainless steel to EN 1.4301 BS 58 E

IMPELLOR NECKRINGS
Natural rubber or bronze to EN 2.1176 BS 1400 LB 2

SUCTION PIPE and DELIVERY TUBING
solid drawn steam piping to EN 1.0030

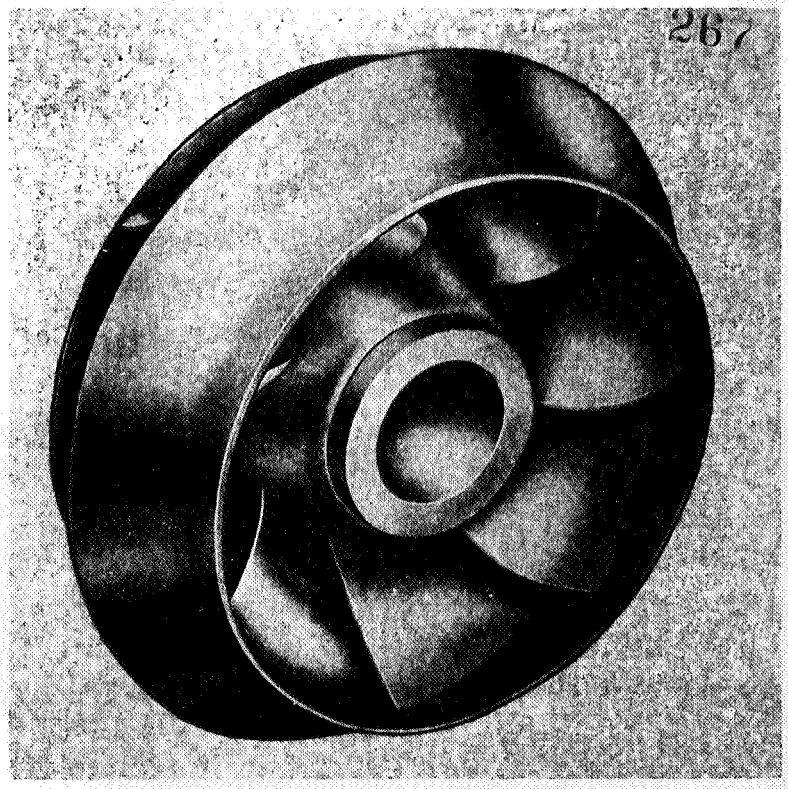
BELLMOUTH OR FOOT VALVE: These range of Pumps are available with either Bellmouth, manufactured from cast iron or bronze, or Foot Valves that can be provided with cast iron or bronze bodies.

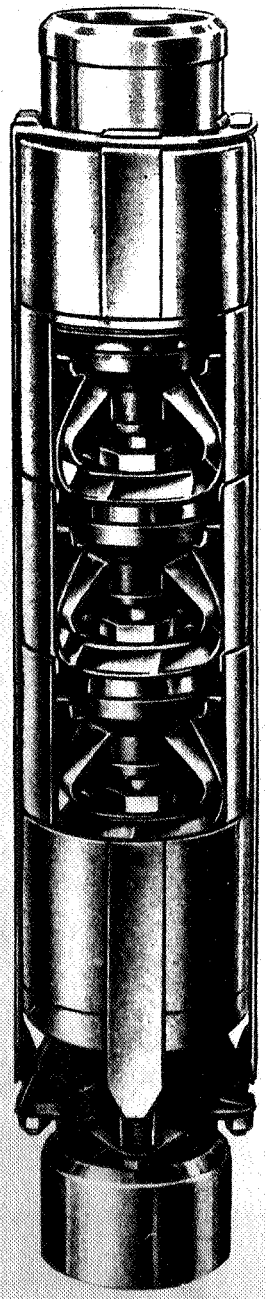
The above mentioned specifications are for quidance purposes and must be confirmed with the manufacturers when necessary.

PUMP ASSEMBLY

MODELS
BP 90 and BP 125

STAINLESS STEEL
used for Impellor, Diffusor,
Pump Shaft,
and Stage Chamber.





IMPELLOR

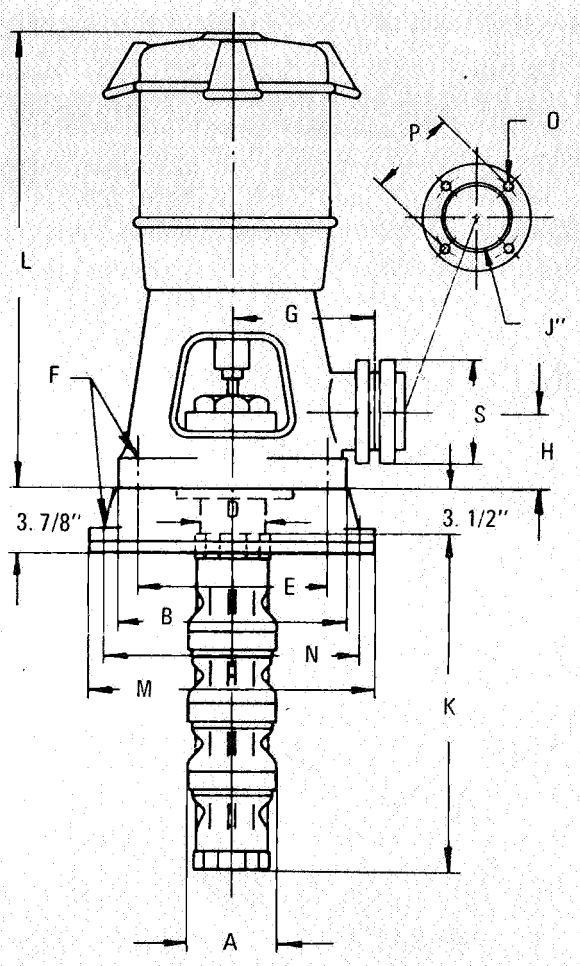
ONE OF THE UNIQUE FEATURES COMMON TO ALL FLANGE MOUNTED PUMPS ARE THE GRUNDFOSS HIGH EFFICIENCY FABRICATED STAINLESS STEEL IMPELLOR

GRUNDFOSS B P RANGE OF FLANGE MOUNTED PUMPS ARE AVAILABLE FOR PUMPING FLUIDS DIRECT FROM A STORAGE TANK OR WITH INTERMEDIATE COLUMN SECTIONS FOR PUMPING FROM DEPTHS OF UP TO 150 FT.

DOUBLE SHAFT SEAL ASSEMBLY

THE ENTIRE RANGE OF GRUNDFOSS FLANGE MOUNTED PUMPS ARE AVAILABLE WITH DOUBLE MECHANICAL SHAFT SEAL ASSEMBLIES FOR USE IN THE OIL AND ALLIED INDUSTRIES. THE SURFACES OF THESE SEAL ASSEMBLIES CAN EITHER BE OF TUNGSTEN CARBIDE OR CRANE CERAMIC.

Type	A inch / mm	D inch / mm	B inch / mm	E inch / mm	F Ø inch / mm	G inch / mm	H inch / mm	K inch / mm	L inch / mm	M inch / mm	N inch / mm	O Ø inch / mm	P Ø inch / mm	S Ø inch / mm	J
BP 90-1/BP 90-16 BP 90-17/BP 90-30	3 25/32 = 96 3 25/32 = 96	2 = 60 2 = 60	9 7/16 = 240 11 13/16 = 300	7 7/8 = 200 9 7/8 = 250	5/8 = 15 11/16 = 18	8 27/32 = 160 7 1/2 = 190	3 1/2 = 88 4 3/8 = 112	basic: 7 1/16 = 196 each stage: 1 5/8 = 42	22 = 550 30 = 750	BASE NOT AVAILABLE 15 7/16 = 390	13 3/8 = 340	4 x 5/8 /15 4 x 11/16 /18	4 11/32 = 110 5 29/32 = 150	5 1/2 = 140 7 1/2 = 190	2 2
BP 105-1/BP 105-15 BP 105-16/BP 105-28	4 3/16 = 106 4 = 106	2 1/2 = 76 2 1/2 = 76	11 13/16 = 300 13 3/4 = 350	9 1/2 = 250 11 13/16 = 300	11/16 = 18 11/16 = 18	7 1/2 = 190 9 1/2 = 240	4 3/8 = 112 4 = 120	basic: 7 3/16 = 182 each stage: 3 = 76	30 = 760 34 = 830	15 3/8 = 390 17 3/16 = 440	13 3/8 = 340 15 3/8 = 390	4 x 11/16/18 4 x 11/16/18	5 29/32 = 150 7 3/4 = 190	7 1/2 = 190 9 1/16 = 230	2 1/2 2 1/2
BP 125-1/BP 125-7 BP 125-8/BP 125-15	5 1/16 = 128 5 1/16 = 128	3 = 80 3 = 80	11 13/16 = 300 13 3/4 = 350	9 1/2 = 250 11 13/16 = 300	11/16 = 18 11/16 = 18	7 1/2 = 190 9 1/2 = 240	4 3/8 = 112 4 = 120	basic: 7 1/2 = 190 each stage: 3 1/2 = 90	30 = 750 34 = 850	15 3/8 = 390 17 3/16 = 440	13 3/8 = 340 15 3/8 = 390	4 x 11/16/18	5 29/32 = 150 7 1/2 = 190	7 1/2 = 190 9 1/16 = 230	3 3
BP 135-1/BP 135-5 BP 135-6/BP 135-20	5 3/8 = 138 5 3/8 = 138	4 = 114 4 = 114	11 13/16 = 300 13 3/4 = 350	9 7/8 = 250 11 13/16 = 300	11/16 = 18 11/16 = 18	7 1/2 = 190 9 1/2 = 240	4 3/8 = 112 4 3/4 = 120	basic: 7 33/32 = 180 each stage: 3 3/8 = 86	30 = 750 34 = 850	15 3/8 = 390 17 3/16 = 440	13 3/8 = 340 15 3/8 = 390	4 x 11/16/16	5 29/32 = 150 7 1/2 = 190	7 1/2 = 190 9 1/16 = 230	4 4
BP 165-1/BP 165-9	6 5/32 = 156	5 = 130	13 3/4 = 350	11 13/16 = 300	3/4 = 18	9 1/2 = 240	5 1/2 = 140	basic: 6 9/16 = 246 each stage: 4 3/16 = 110	38 = 950	17 3/16 = 440	15 3/8 = 390	8 x 11/16/18	8 1/4 = 210	9 1/2 = 250	5
BP 190-1/BP 190-4 BP 190-5/BP 190-9	7 1/8 = 200 8 11/16 = 220 7 1/8 = 200 8 11/16 = 220	5 = 130 6 = 150 5 = 130 6 = 150	13 3/4 = 350 13 3/4 = 350 19 11/16 = 500 19 11/16 = 500	11 13/16 = 300 11 13/16 = 300 17 15/16 = 440 17 15/16 = 440	11/16 = 18 11/16 = 18 7/8 = 22 7/8 = 22	9 1/2 = 240 9 1/2 = 240 11 13/16 = 300 11 13/16 = 300	5 1/2 = 140 5 1/2 = 140 7 1/2 = 190 7 1/2 = 190	basic: 8 1/16 = 205 each stage: 6 5/16 = 160	38 = 950 38 = 950 59 = 1500 59 = 1500	12 15/16 = 440 12 15/16 = 440 — —	15 3/8 = 390 12 15/16 = 440 — —	8 x 11/16/18 8 x 7/8 /22 8 x 7/8 22 8 x 7/8 /22	8 1/4 = 210 9 5/16 = 240 8 1/4 = 210 9 5/16 = 240	9 1/2 = 250 11 1/2 = 285 9 1/2 = 250 11 1/4 = 285	5 6 5 6



SWITCHGEAR

GRUNDFOSS ARE ALWAYS VERY PLEASED TO ADVISE OR QUOTE SUITABLE SWITCHGEAR CONTROL METHODS FOR USE IN CONJUNCTION WITH THEIR **FLANGE MOUNTED PUMPS**

The dimensions and weights given on these tables are provided to act as a guide, and should be confirmed with Manufacturers in each case.

APPROX. WEIGHTS OF PUMPS

MOTOR			PUMP ASSEMBLY													
HP	KOS	LBS	NO. OF STAGES	BP 90 KOS	BP 90 LBS	BP 105 KOS	BP 105 LBS	BP 125 KOS	BP 125 LBS	BP 135 KOS	BP 135 LBS	BP 165 KOS	BP 165 LBS	BP 190 KOS	BP 190 LBS
1	16	35	1	3	7	5	12	7	15	10	22	20	44	24	53
2	25	56	2	4	9	8	18	9	20	14	31	25	55	35	77
3	36	80	3	4	9	10	22	12	26	18	40	31	68	46	102
4	38	84	4	5	12	12	26	15	33	22	48	37	82	58	128
5	59	130	5	5	12	14	31	18	40	26	57	43	95	69	152
6	59	130	6	6	13	17	38	20	44	30	66	49	108	81	178
7,5	59	130	7	6	13	19	42	23	51	34	75	55	122	92	205
10	81	179	8	7	15	21	46	26	57	38	84	61	134	103	228
15	111	245	9	8	18	23	51	28	62	42	92	68	150	115	255
20	138	305	10	8	18	26	57	31	68	46	101	73	161	126	277
25	162	358	11	8	20	28	62	34	75	50	110	79	174	138	303
30	174	384	12	9	20	30	66	36	79	54	119	84	185	149	329
35	204	450	13	10	22	32	71	39	86	58	128	90	198	160	353
40	237	523	14	10	22	35	77	42	92	62	136	96	212	172	379
50	256	564	15	11	24	37	82	45	100	66	145	102	225	183	402

PUMP HEAD, with discharge flange, base plate, short upper column section, and suction pipe.

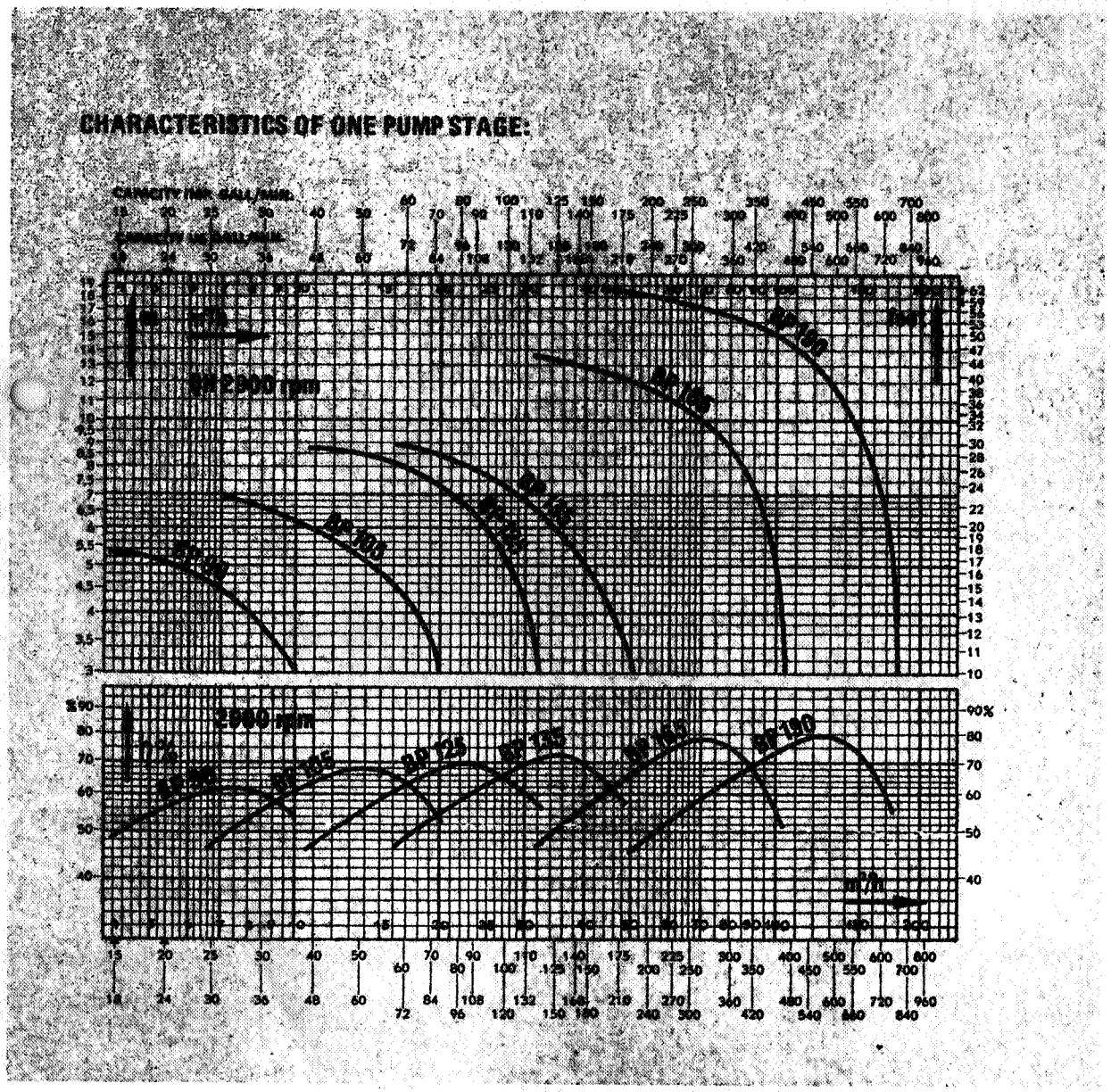
		kos.	lbs
Model No. 90,2"	BP 90-1/BP 90-16	22	48
Model No. 105 2",2.1/2",3",4"	BP 90-17/BP 90 BP 105-1/BP 105-15 BP 105-16/BP 105-28 BP 125-1/BP 125-7 BP 135-1/BP 135-4	55	122
Model No. 135 2.1/2",3",4"	BP 105-16/BP 105-30 BP 125-8/BP 125 BP 135-5/BP 135	75	165
Model No. 165 5",6"	BP 165-1/BP 165 BP 190-1/BP 190-4	97	215
Model No. 190 5",6"	BP 190-5/BP 190	150	330

15 to 600 g.p.m.

10 to 300 p.s.i.g.

THE BP RANGE OF FLANGE MOUNTED PUMPS HAVE BEEN ESPECIALLY DEVELOPED FOR APPLICATIONS CALLING FOR A VERY HIGH DEGREE OF RELIABILITY AND EFFICIENCY. THE BASIC PUMP DESIGN NOT ONLY ENSURES EASE OF INSTALLATION AND MAXIMUM ECONOMY OF SPACE, BUT ALSO GUARANTEES THAT THE PUMPS THEMSELVES ARE SIMPLE TO STRIP FOR ROUTINE MAINTENANCE WHEN NECESSARY.
SUITABLE FOR A VERY WIDE SPECIALIST RANGE OF APPLICATIONS THE PUMPS ARE BUILT TO THE HIGHEST SPECIFICATIONS.

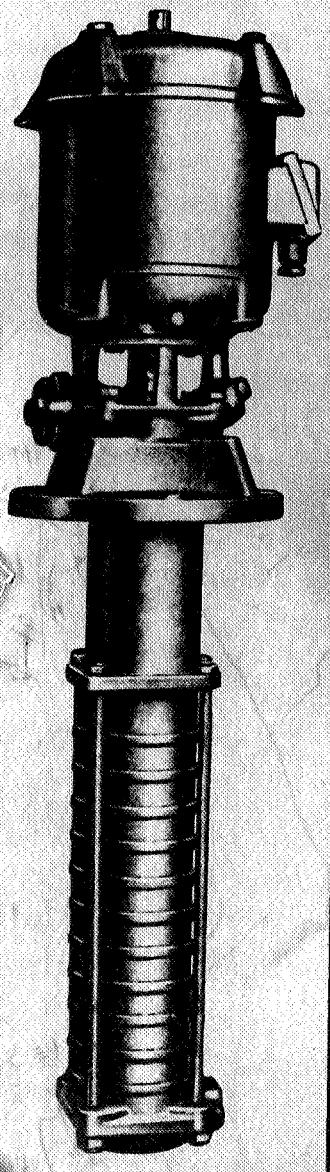
CHARACTERISTICS OF ONE PUMP STAGE:



FLANGE MOUNTED PUMPS

MODEL CP3L & CP8L

RANGE 5 gpm - 45 gpm

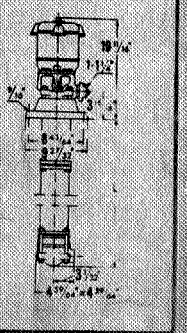


CP 3 L & CP 8 L

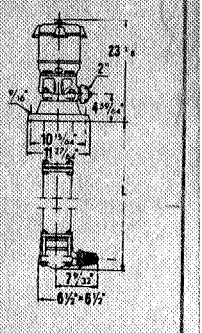
FOR THE SMALLER APPLICATION GRUNDFOSS ALSO MANUFACTURE A FLANGE MOUNTED VERSION OF THEIR CP 3 - CP 8 MULTISTAGE CENTRIFUGAL PUMPS. THESE UNITS WHICH ARE BUILT TO THE SAME HIGH STANDARDS ARE AVAILABLE WITH INTERMEDIATE TUBE LENGTHS UP TO 5'0" AND CAN BE USED FOR COLD AND HOT WATER IN THE "KS" EXECUTION.

FOR FURTHER DETAILS OF THIS RANGE SEE LEAFLETS 1811 E3 AND 1311 E3.

PUMP MODEL	LENGTH OF COLUMN PIPE 9.7/8 INCH	19.3/4 INCH	29.1/2 INCH	39.3/8 INCH	49.1/4 INCH	59.1/16 INCH
CP 3-10 L	13	22.7/8	32.1/2	42.3/8	52.1/8	62
CP 3-20 L	14.1/4	24.1/8	33.7/8	43.3/4	53.3/8	63.1/4
CP 3-30 L	15.5/8	25.1/2	35.1/8	45	54.3/4	64.5/8
CP 3-40 L	16.7/8	26.3/4	36.1/2	46.5/8	56	65.7/8
CP 3-50 L	18.1/4	28	37.3/4	47.5/8	57.3/8	67.1/8
CP 3-60 L	19.1/2	29.3/8	39.1/8	48.7/8	58.5/8	68.1/2
CP 3-80 L	22.1/8	31.7/8	41.5/8	51.1/2	61.1/4	71.1/8
CP 3-100 L	24.3/4	34.1/2	44.1/4	54.1/8	63.7/8	73.5/8
CP 3-120 L	27.1/4	37.1/8	46.7/8	56.3/4	66.3/8	76.1/4



PUMP MODEL	LENGTH OF COLUMN PIPE 9.7/8 INCH	19.3/4 INCH	29.1/2 INCH	39.3/8 INCH	49.1/4 INCH	59.1/16 INCH
CP 8-10 L	14	23.3/4	33.1/2	43.1/4	53.1/8	62.3/4
CP 8-20 L	15.3/4	25.1/2	35.1/4	45	54.7/8	64.5/8
CP 8-30 L	17.1/2	27.1/4	37.1/8	46.7/8	56.5/8	66.3/8
CP 8-40 L	19.1/4	29	38.7/8	48.1/2	58.3/8	68.1/8
CP 8-50 L	21.1/8	30.3/4	40.5/8	50.3/8	60.1/4	69.7/8
CP 8-60 L	22.7/8	32.1/2	42.3/8	52.1/8	62	71.5/8
CP 8-80 L	26.3/8	36.1/8	45.7/8	55.5/8	65.1/2	75.1/4
CP 8-100 L	29.7/8	39.5/8	49.1/2	59.1/4	69.1/8	78.3/4
CP 8-120 L	33.1/2	43.1/4	53	62.3/4	72.5/8	82.1/4



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INVESTIGATION OF THE DOLOMITE RESERVOIR OF THE LOWER CAMBRIAN PARARA-KULPARA SEQUENCE SOUTHERN YORKE PENINSULA

by

D. I. Rutledge

of

Cundill, Meyers & Associates Pty. Ltd.

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I INTRODUCTION

This investigation was undertaken at the request of Geosurveys of Aust Pty. Ltd. The object of the investigation was to review all known information concerning the thickness, extent, porosity and reservoir properties of the Parara-Kulpara dolomite sequence and to relate them to the possible extraction of brine for salt production.

The general stratigraphy of the area is reviewed in this report and correlations between wells are shown on a cross section (Plate 1). An isopach map has been drawn of the Parara-Kulpara dolomite to show its extent and thickness in the sub surface. The reservoir characteristics of the dolomite sequence are discussed and calculations made to indicate possible production rates for Stansbury West No. 1 using various permeabilities and drawdown figures.

II STRATIGRAPHY

(a) General

Yorke Peninsula is essentially a broad ridge of Archaean rocks separating Spencers Gulf and St.Vincent's Gulf. The cover of younger rocks is generally thin, except for the Cambrian sediments of the Dalrymple Basin and a broad valley in the south and centre, infilled with Permian glacigene sediments.

The Archaean metasediments and intrusives are overlain by a relatively thin sequence of conglomerates and quartzitic sandstones which are equivalent to the shield Upper Proterozoic. Cambrian rocks outcrop in the north and centre of the peninsula, and extend in the subsurface to the south east where maximum thicknesses are developed in the Dalrymple Basin. Permian glacigene sediments are present in most of the southern part of the Peninsula. Tertiary sediments are mostly less than 200 feet thick and are generally restricted to a strip along the eastern coast. Quaternary deposits are very thin, but cover over 90% of the peninsula. They include kunkar, desert and coastal dunes, lacustrine and alunitic clays.

The Cambrian section is best developed in the subsurface, and the most complete section is present in the Stansbury West No. 1 Well. Correlation with the original type sections in outcrop is usually difficult, particularly in the Lower Cambrian, where extensive time-transgressive dolomitization has occurred.

Rock units have been established for the subsurface section in previous well completion reports and these units are used throughout this report. The units used are shown in the table below, with equivalent formation names where possible. The unit 3A-3B contact has been taken at the top of the Lower Cambrian (Parara-Kulpara) dolomite and has no time significance. The Parara Limestone-Kulpara limestone contact cannot be distinguished lithologically in the subsurface due to secondary dolomitization.

Age	Formation Name	Unit No.	Lithology
Quaternary			Kunkar, sand, alluvium
Tertiary			Limestone, sandstone
	Unconformity		
Permian (Salmarian)	Unnamed unit		Glagigene, marine sediments
	Unconformity		
MIDDLE CAMBRIAN	Upper Red Beds	1	Sandstone
	Dalrymple and Stansbury Limestones	2A	Limestone, minor shale.
	Unnamed Unit	2B	Sandstone and minor shale.

Age	Formation	Unit No.	Lithology
MIDDLE CAMBRIAN	Ramsay Limestone	2C	Limestone and minor shale.
	Lower Red Beds	2D	Sandstone and shale
?	Minlaton Conglomerate	2E	Conglomerate
	Unconformity		
LOWER CAMBRIAN	Parara - Kulpara Carbonates	3A	Limestone
		3B	Dolomite
	Transitional Beds	4	Sandstone, minor dolomite
	Unconformity		
Archean			Metasediments and intrusives

(b) Unit 3B Dolomite of the Parara-Kulpara Sequence

The Unit 3B Dolomite is the reservoir unit being considered in this report.

It is white to grey, generally microcrystalline to very fine crystalline, with the original texture almost completely obliterated by dolomitisation. The unit outcrops in the north and central part of the peninsula and occurs in the subsurface beneath the eastern half of the southern peninsula. The thickness of dolomite encountered in wells on the Peninsula varies considerably, from 470' at Stansbury Town No. 1 Well to 1149' at Stansbury West No. 1 Well, and appears to be thickest to the south east (see Plate II), both onshore and offshore.

The rapid fluctuations in thickness are due mainly to prolonged erosion on the Middle-Lower Cambrian unconformity and the stripping of most of the Parara-Kulpara sequence from 'basement high' areas. To the west and north, the dolomite appears to wedge out normally against the basin edge, but lack of information could conceal a more complex picture. The extent of secondary dolomitization is also not known. All subsurface sequences have had significant dolomite sections, particularly Stansbury Town No. 1 and Edithburgh No. 1, where dolomite comprises all or most of the preserved Lower Cambrian section. At Minlaton, the ratio of dolomite to limestone was somewhat less and outcrops to the north generally show less dolomitization. This may be related to either differing original depositional conditions as the basin edge was approached, or a lesser degree of subsequent dolomitization, or both.

It seems probable that a significant thickness of Unit 3B dolomite extends over most of the eastern part of the southern peninsula, the thickest section being preserved in a belt trending south from Stansbury West No. 1.

III RESERVOIR PROPERTIES OF THE UNIT 3B DOLOMITE

(a) Porosity and Permeability

Poor to fair porosity has been found in the Unit 3B dolomite wherever it has been encountered in the subsurface. Log determined porosities vary from an aggregate of 252' averaging 14% at Stansbury West No. 1 to 243' averaging 9.7% at Edithburgh No. 1 and 209' averaging 4.7% at Stansbury Town No. 1. No values are available for Minlaton No. 1 or outcrop sections, but they are reported to be porous (Watts, 1967).

Watts considers porosity in the Unit 3B dolomite to be largely due to epigenetic dolomite recrystallisation in a pre-existing syngenetic dolomite, initiated and controlled by mild tectonic movement.

Figure 1 shows the amount, thickness and distribution of porosity in the Stansbury West, Stansbury Town and Edithburgh wells. Porosity distribution within the 3B dolomite varies widely from being mainly in the upper half at Stansbury West to being mainly in the lower half at Stansbury Town and to being fairly evenly distributed at Edithburgh. Porosity may ultimately be found to be more consistent along structural trends, but no predictions can be made with the information available at this stage.

Porosity is mainly vughular and intercrystalline, with some fracture, pin point and solution cavity porosity. The pores are generally associated with solution and fracture features, and vughs are often parallel to the same features. Some permeability is associated with intercrystalline porosity, but most is due to fracture and solution channels, and its extent and continuity for any one porous zone are unknown.

(b) Volume of Brine in Place - Possible total in the Unit 3B Reservoir

The extent of useful Unit 3B reservoir on-shore, has been taken as that area bounded by the coastline and the 400 foot Kulpara isopach. The 400 foot value is an arbitary limit, but it is considered that thinner Unit 3B sections may contain insufficient permeable reservoir to be significant.

Results from the three Beach Petroleum wells drilled on the Peninsula indicate that the net aggregate porosity thickness of Unit 3B is remarkably consistent (i.e. 252', 243', 209' - see previous section), although the total Unit 3B thickness varies widely (i.e. from 470' to 1149').

An average net porosity thickness figure of 200 feet has been used in the calculations and it is felt that this is a reasonably conservative estimate. Average porosity was calculated from log analysis figures from the three Beach Petroleum wells, which provide a widely spaced coverage of the area of interest. The calculation for volume of brine in place is shown below:

On-shore area of Unit 3B reservoir = 90.8 sq. miles

= 58,112 acres

Assumed thickness of porous section = 200 feet

Average porosity = 10%

i.e. 20 porosity feet.

Thus possible total volume of brine in place in on-shore area of Unit 3B reservoir = 58,112 x 20 acre feet

= 1,162,240 acre feet

= 316,420 x 10^6 gallons.

(c) Probable reserves, maximum pumping rate, drawdown and production life in the Stansbury West No. 1 Well.

(i) Probable Reserves in Stansbury West No. 1 Well.

The thickness of the Unit 3B porous reservoir and the average porosity in the Stansbury West No. 1 well are known with some accuracy from well logs. Assumptions must however be made concerning the radius of influence for the well, i.e. the area of reservoir one well could be

expected to effectively drain. Assumed values of 1000 feet and 2500 feet have each been used in the calculations, resulting in 2 values for probable reserves as follows:

(a) For 1000 foot radius of influence:

Area = πr^2 (where r = radius of influence)

= $\frac{22}{7} \times \frac{1000}{1} \times \frac{1000}{1}$

= 3,142,857 square feet

= 72.4 acres

Average porosity = 14%

Thickness of porous section = 252 feet

i.e. 35.28 porosity feet.

Probable volume of brine = 72.4 x 35.28

= 2554.3 acre feet

= 695.4 x 10^6 gallons

(b) For 2,500 foot radius of influence:

Area = $\frac{22}{7} \times \frac{2500}{1} \times \frac{2500}{1}$

= 19,640,000 square feet

= 450.9 acres

Thus probable volume of brine = 450.9 x 35.28

= 15,907.7 acre feet

= 4,330 x 10^6 gallons.

(ii) Pumping Rate in Stansbury West No. 1 Well.

It is possible to calculate theoretically the maximum amount of water that can be pumped from a well for a given drawdown, from the equation:

$$q = \frac{2\pi \; Pm \; (D-d)}{2.3 \log_{10} \frac{R}{r}}$$

where q = quantity of water in gallons per day
P = permeability coefficient
m = thickness of reservoir
(D-d) = drawdown (below static water level)
r = radius of well
R = radius of area of influence, or cone of pressure relief.

In the case of Stansbury West No. 1 well, it is necessary, in the present state of knowledge, to make assumptions about the value of P, (D-d) and R. To give an idea of the range of figures which could be obtained, the following tables have been prepared, which show maximum pumping rates using different combinations of these variables.

DST No 4 R = 217'
No 5 R = 56'
No 6 R = 253'
No 7 R = 177'

Assuming R = 1000 feet:

Permeability Coefficient	Drawdown 250 feet	500 feet	750 feet
10	482,000 gals/day	964,000 gals/day	1,446,000 gals/day
25	1,205,000 gals/day	2,410,000 gals/day	3,615,000 gals/day
50	2,410,000 gals/day	4,821,000 gals/day	7,230,000 gals/day
100	4,821,000 gals/day	9,642,000 gals/day	14,463,000 gals/day

Assuming R = 2500 feet:

Permeability Coefficient	Drawdown 250 feet	500 feet	750 feet
10	433,125 gals/day	866,250 gals/day	1,299,375 gals/day
25	1,082,810 gals/day	2,165,620 gals/day	3,248,430 gals/day
50	2,165,625 gals/day	4,331,250 gals/day	6,496,875 gals/day
100	4,331,250 gals/day	8,662,500 gals/day	12,993,750 gals/day

It should be emphasized that these amounts are theoretical maximums, and they would be considerably reduced under actual field conditions. However, the theoretical amounts are quite high, and providing permeabilities are good, it should be possible to produce water at the quantity apparently required for the salt operation (stated to be approx. 336,000 galls/day) without any serious drawdown difficulties. Low permeability or lack of continuity of the permeability appear to be the most important unknown factor which could adversely influence production rates.

(iii) Production Life of Stansbury West No. 1.

It is neither possible at this stage to determine whether the reservoir at Stansbury West will be replenished in a reasonable time after sustined pumping, nor to determine the amount and rate of any such replenishment. It thus seems better to calculate the useful life of Stansbury West No. 1 assuming no replenishment takes place. It seems reasonable however to assume a recovery factor of about 70% .

Thus: Probable volume of recoverable brine for 1000' radius

$$= 6954 \times 10^6 \times \frac{70}{100} \text{ gallons}$$

$$= 486.8 \times 10^6 \text{ gallons}$$

Probable volume of recoverable brine for 2,500' radius

$$= 4330 \times 10^6 \times \frac{70}{100} \text{ gallons}$$

$$= 3031 \times 10^6 \text{ gallons}$$

Projected production rate required for salt production is 122.6×10^6 gallons per year (Sprigg, 1968)

Thus: life of Stansbury West No. 1 well if radius of influence is 1000'

= 4 years

" " " " " " 2,500' = 24.5 years

(iv) Drive - Replenishment at Stansbury West No. 1 Well.

It is not possible at this stage to determine the type of drive for the Unit 3B reservoir at Stansbury West No. 1 Well.

The brine appears to be concentrated connate water derived from associated evaporitic sections (e.g. Red Bed sequence). Pressures measured in drill stem tests may be due to overburden pressure in the case of a closed reservoir or hydrostatic pressure if the reservoir permeability is extensive and connected with outcrop sections, either onshore or offshore. Intake of either rainwater or seawater should lead to dilution of the brine towards the intake area, and this could be the case at Stansbury Town No. 1 well where the brine is significantly more dilute than Stansbury West No. 1 (104,000 ppm salts versus 163,000 ppm salts). Some evidence for continuity of permeability is seen by the drill stem test results from the three Beach Petroleum wells, which indicate that individual porous zones in each well have similar potentiometric surfaces, implying connection between the zones. The extent of this connection away from the wells is an unknown factor. Calculations in the preceding section have been based on the assumption of no replenishment and probably indicate a theoretical minimum for the life of the Stansbury West No. 1 well, if the volumetric and yield assumptions are correct. This conservative approach could be more than justified however, if permeabilities away from the immediate vicinity of the well, are lower than at the well itself.

IV CONCLUSIONS AND RECOMMENDATIONS

The Unit 3B dolomite appears to occur in the subsurface over most of the eastern half of the southern Yorke Peninsula and probably thickens to the southeast offshore. Results from wells drilled to date indicate the presence of zones with good porosity and suggest zones of effective permeability are present within the dolomite reservoir, and also that individual zones appear to be connected vertically in the vicinity of each well.

The Stansbury West No. 1 well has the best reservoir development. It theoretically could supply brine at the required rate (122.6×10^6 gallons per year) for a period of 4 years if the radius of influence of the well were 1000' and 24 years if the radius of influence of the well were 2500', and if permeability were reasonably continuous. The life of the well would be considerably extended if there was significant replenishment by sea or rain water although some eventual dilution could be expected in these cases.

Should reservoir permeability be restricted, it would probably not be possible to maintain the required production rate. Reservoir depletion would be associated with lower pressures and greater drawdown, and a larger number of more closely spaced wells would then be necessary to produce the same amount of brine.

Prediction of production rates and amounts given in this report can only be mostly hypothetical at this stage and an extended testing programme for Stansbury West No. 1 is recommended to properly evaluate the Unit 3B reservoir potential. Measurements of porosity and permeability should be made on the existing Stansbury West No. 1 cores to allow comparison of porosity values with log calculations and to establish actual permeability values.

In conclusion, the Unit 3B dolomite appears to be continuous over a large area and to contain zones of good porosity and effective permeability although with an unknown degree of continuity. It should be theoretically possible to produce 365 million gallons of brine per year from 3 wells with 640 acre spacing providing permeability is consistently effective and continuous enough to allow rapid replenishment of the zones immediately adjacent to the wells.

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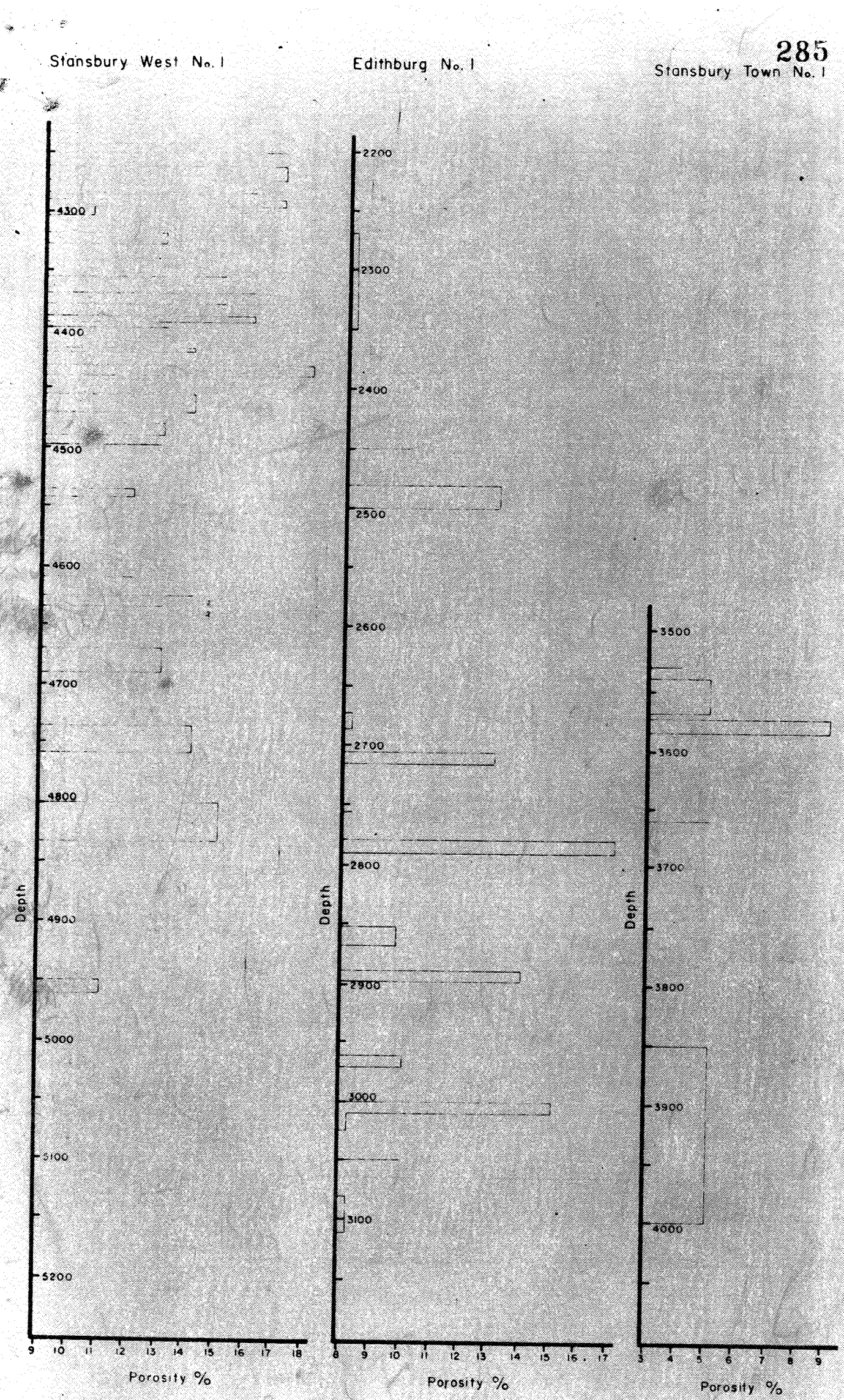


Fig. 1 Amount & Thickness of Porosity, UNIT 3B Dolomites

N.

S.

A

A1

Carramulka

Minlaton Stratigraphic Bore

Stansbury West No. 1

Stansbury Town No. 1

Edithburg No. 1

Sea Level

Sea Level

TERTIARY

PERMIAN

2E

1

2A

2B

2C

2D

3B

4

PRE-CAMBRIAN METASEDIMENTS

TERTIARY

GLACIGENES

1

2A

2B

2C

3B

2E

4

PRE-CAMBRIAN METASEDIMENTS

INDEX MAP

Scale 1:1,000,000

0 5 10 20 30 40 50 miles

137°00' 138°00' 35°00'

A Carramulka

Minlaton 1

Stansbury West 1

Stansbury Town 1

Edithburg 1 A1

ADELAIDE

ST VINCENTS GULF

NIL

2000

4000

LEGEND

2000' Yorke Comerson Isopach

Lines of Cross Section

Cambrian Outcrop Area

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CROSS-SECTION A - A1

Carramulka - Edithburg No. 1

Horizontal Scale 1" = 1 mile

Vertical Scale 1" = 500 feet

To Accompany Report on Investigation of the Dolomite Reservoir of the Lower Cambrian Parara-Kulpara Sequence, Southern Yorke Peninsula by

CUNDILL, MEYERS & ASSOCIATES PTY. LTD.

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SUMMARY

OF THE

SALT POTENTIAL

OF

YORKE PENINSULA

by

GEOSURVEYS OF AUSTRALIA PTY. LTD.

1969/8

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1. BRINE ANALYSES
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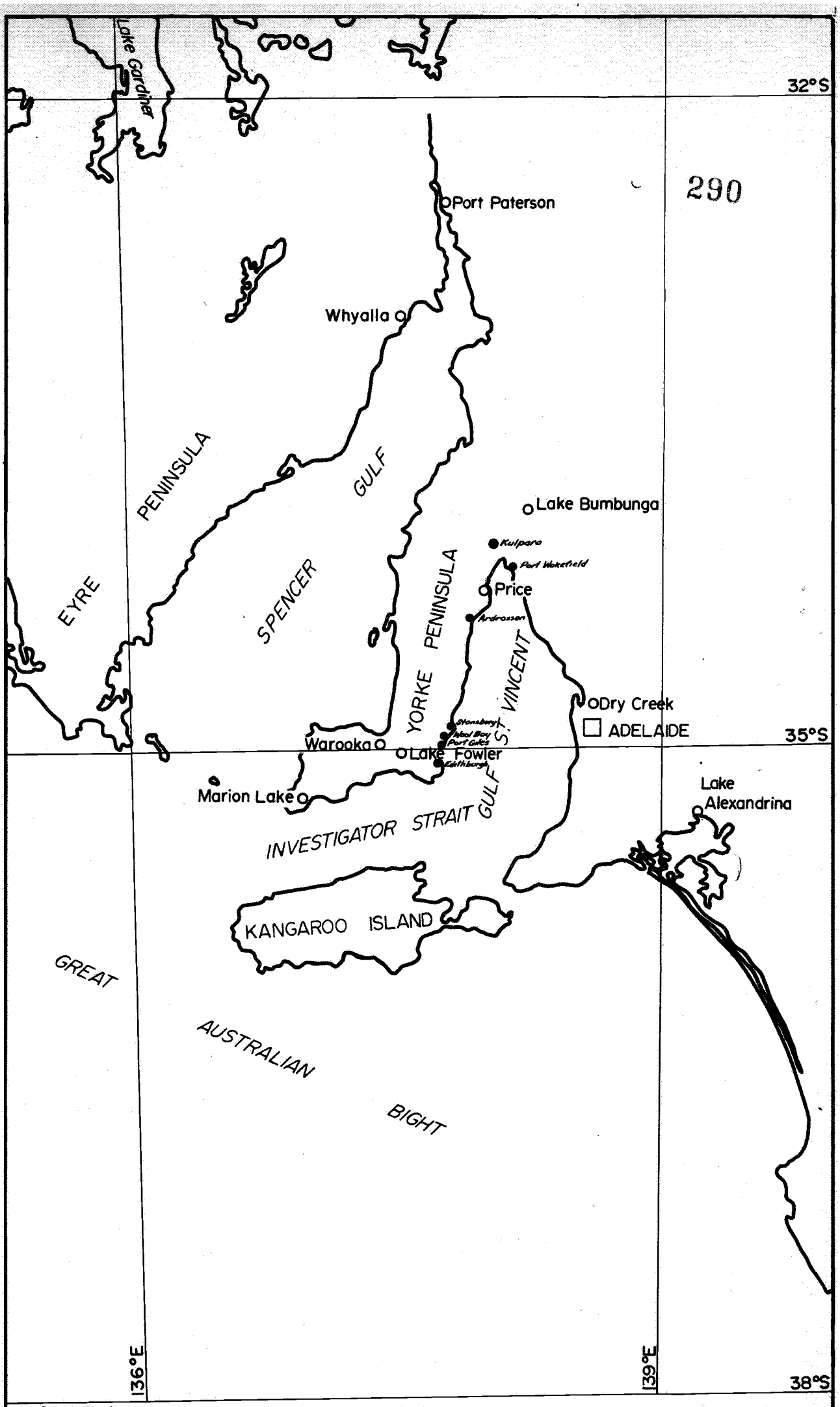
1.	LEASE MAP	Scale 1:100,000	GEO.565
2.	ELEVATION MAP	Scale 1:100,000	GEO.566
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5.	SHEETS 1 AND 2 STANSBURY WEST NO. 1 COMPOSITE LOG	Vertical Scale 100 feet = 1 inch	B.P. 379 1 and 2

1. ABSTRACT

Geosurveys of Australia Pty. Ltd. holds two Special Mining Leases for evaporite minerals totalling 552 square miles over southern Yorke Peninsula. Two main sources of brine are considered, together with two potential evaporating areas. Deep brines from the Kulpara Limestone at approximately 4,000 feet below ground level are calculated to yield 158,000 tons of 98% NaCl per annum using Weavers Lagoon as a ponding and harvesting area. Shallow Tertiary to Recent brines of the Peesey Swamp area are as yet relatively unknown in reserves and salinity, but could possibly produce in excess of 400,000 tons of 98% NaCl per annum from an evaporating area situated in the swamp itself.

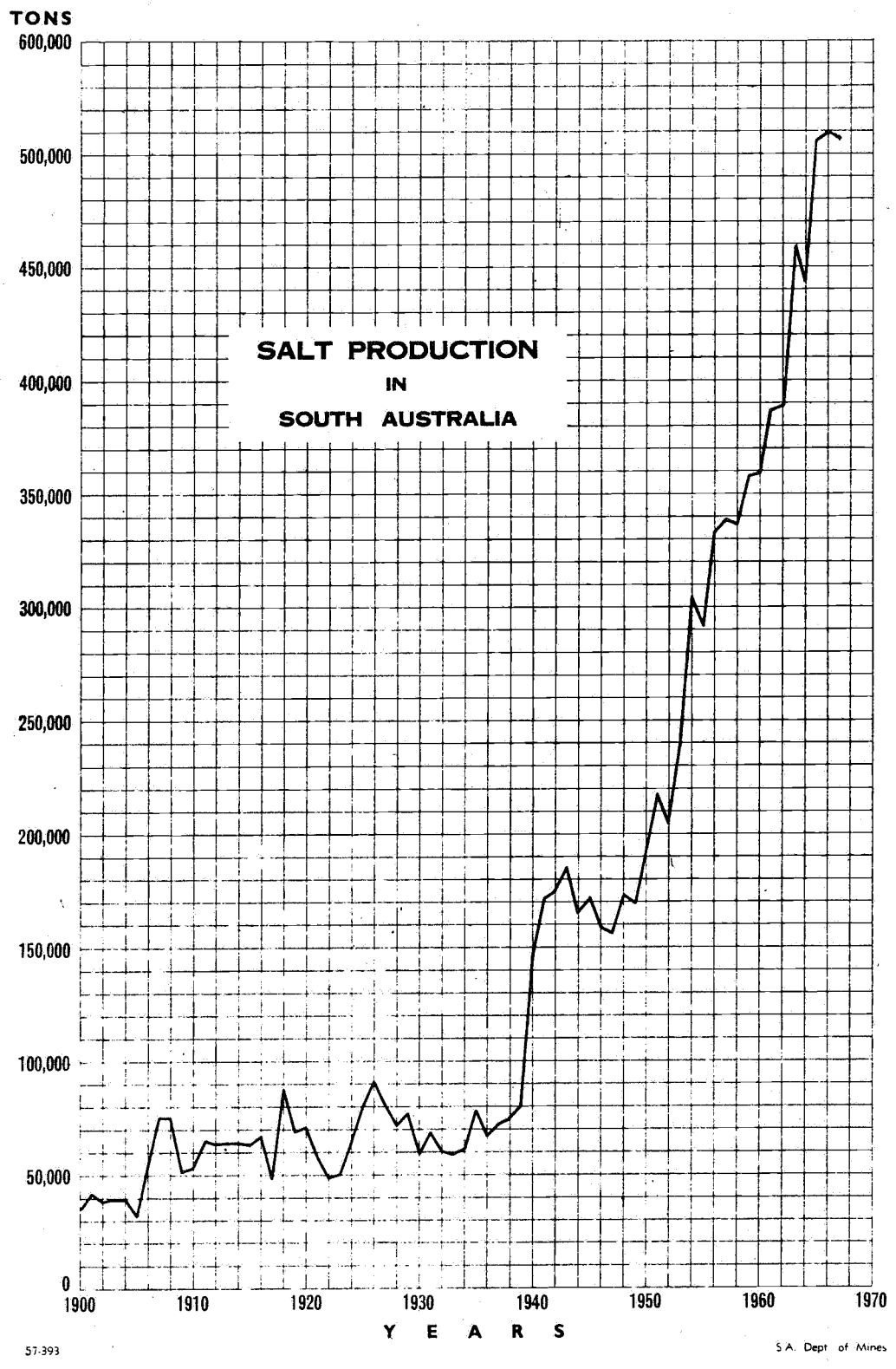
Transport, communications, climate and port facilities are all quite adequate to handle well over 400,000 tons of NaCl per year.

A programme of further exploration of Peesey Swamp is recommended with the aim of establishing a viable large scale salt harvesting industry in the area.



LOCALITY MAP

SUMMARY OF THE SALT POTENTIAL
OF YORKE PENINSULA


TONS
600,000
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
SALT PRODUCTION
IN
SOUTH AUSTRALIA
1900
1910
1920
1930
1940
1950
1960
1970
Y E A R S
57-393
S.A. Dept of Mines

2. HISTORY

A. Brief History of the South Australian Salt Industry

The first recorded production of salt was in 1829, seven years before the establishment of the colony, when 20 tons of salt were garnered on Kangaroo Island. This was harvested from natural lake deposits, probably in the Hundred of Haines, near the present site of operations by the Colonial Sugar Refining Company who are working a gypsum deposit. Salt was gathered on a small scale for strictly local requirements from a number of localities for many years. It was not until 1891, when 7,505 tons were produced, that the scale of production became notable. From this time on, a number of companies were interested in salt production, both from saline lakes, and from the sea.

The very great advantages offered by the indented coastline of Spencer and St. Vincent Gulfs for the production of salt by the evaporation of sea water, were recognised some 40 years ago. The availability of sites close to cheap sea transport, combined with high net evaporation and abnormal salinity of sea water led to the establishment of solar salt works at the head of Spencers Gulf, near Port Augusta and at Whyalla, at Price on the eastern shore of Yorke Peninsula, and in 1940 at Dry Creek near Adelaide. In addition several operators recover salt from shallow salt lakes on Yorke Peninsula.

At the present time, the principal solar salt operations are at Dry Creek (I.C.I. Alkali (Aust.) Pty. Ltd.); Price (Ocean Salt (Extended) Pty. Ltd.); Whyalla (B.H.P. Co. Pty. Ltd.); and Port Patterson (Augusta Salt Ltd.). The Australian Salt Co. Ltd. is the major operator in a number of salt lake deposits, including Lake MacDonnell, Lake Bumbunga, and others. Waratah Gypsum Pty. Ltd. operates on Marion Lake, at Stenhouse Bay; while Olsson Industries salt works are based near Warooka, both utilising the highly saline groundwater brines as a source of solar salt.

Note Waratah Gypsum has ceased salt production at Marion Lake but is producing up to 120,000 tons per annum from Lake MacDonnell.

See Figure 1 for the location of all the South Australian salt producing areas, and see Figure 2 for a graph of salt production in South Australia since the turn of the century. In 1965, the last year for which all figures are available, South Australia supplied 81% of the total Australian salt production.

B. Outline of Geosurveys Involvement

In 1966 Beach Petroleum N.L. drilled Stansbury West No. 1 Well during a programme of oil exploration on Yorke Peninsula. Drill stem tests of the Cambrian Kulpara Limestone (in reality a dolomite) revealed highly saline ($\geq$16% NaCl) connate water associated with good formation porosities (14% average over a total effective reservoir thickness of 252 feet) and high permeabilities (40 to 337 Millidarcies from core analysis). In close proximity to the above wellsite occur numerous salt lakes, one of which has an area of 560 acres, and which displays high potential as a salt harvesting area. The supposed lack of markets for salt at the time of drilling the oil exploration well, limited further work in the area, except for brief feasibility studies.

In 1968, after Beach Petroleum had drilled a further two wells in the area, both revealing high salt concentrations within the Kulpara Limestone, Special Mining Lease No. 187 was taken out over much of Southern Yorke Peninsula (see Enclosure 1). This was done on the recommendations of a further brief feasibility study (Sprigg, 1968).

On the granting of the S.M.L. by the South Australian Department of Mines, International Technical Services were commissioned to prepare a study on Australian and World salt marketing, and a proposed study programme on the feasibility of salt production from the Kulpara Limestone. Concurrently with this, Australian Mineral Development Laboratories undertook a study on chemical engineering. These reports were combined in International Technical Services (1968).

Cundill, Meyers and Associates also investigated the Kulpara Limestone reservoir and presented their results in Rutledge (1968).

The results of the above reports indicated that development of an

industry based on pumping brine from the deep (4,000 feet) reservoirs in the Stansbury West vicinity would require a large amount of capital and high development costs. It was considered that it would be more sound to initially establish a salt industry using other brine sources, before outlaying the capital needed to develop the Stansbury brines.

As a consequence, an investigation was commenced on the feasibility of using as a brine source, the shallow saline aquifers of Peesey Swamp. A further Special Mining Lease was acquired to enable research to continue unhindered in this area.

3. SUMMARY OF THE GEOLOGY

Enclosure 4 comprises a composite geological map of Yorke Peninsula prepared by the South Australian Geological Survey.

Yorke Peninsula is essentially a broad ridge of "Archaean" rocks generally thinly covered by younger deposits. There are two areas of thicker cover. In the southeast, a deep basin of Cambrian rocks occurs (the Dalrymple Basin): and in the same area, but extending northwestwards and westwards, Permian erosion has removed both the Cambrian and Pre-Cambrian rocks to well below present sea level, and replaced them by glacial deposits.

Outcrops of "Archaean" rocks are limited to about one-tenth of the total area of the peninsula. The known exposures show that the rocks are mostly gneissic metasediments--containing amphibolites--some of which may originally have intruded into much of the outcropping rock.

Cambrian sandstones and carbonates outcrop around Curramulka, and plunge to the south, reaching their maximum known thickness of 4,553 feet in Stansbury West No. 1 Well. The Cambrian sediments were deposited in a near shore environment possibly partly deltaic, tidal flat and coastal plain for the sandstones and shales, and lagoonal to shallow restricted marine for the carbonates.

Deposition commenced in the Lower Cambrian, with marine transgression and the deposition of the Transition Beds - interbedded multicoloured fine sandstones, shales and argillaceous dolomites. Conditions then became very stable with negligible detrital sediment influx, and carbonate deposition of the Kulpara and Parara Limestones occurred on shallow marine banks.

This was followed by faulting, uplift and subsequent erosion of part to whole of this sequence in the upper portion of the Lower Cambrian together with deposition of the Minlaton Conglomerate. Conditions again stabilised and red-beds, carbonates and black shales were deposited (Unit 2 of the accompanying stratigraphic table).

Uplift of the source areas followed the laying down of Unit 2, leading to the widespread deposition of red-bed sandstones and shales under deltaic and near shore environments.

A long period of stability and erosion followed the orogeny which marked the close of Cambrian deposition. The orogeny had little effect on the Cambrian of Yorke Peninsula, merely folding the sediments into large broad anti and synclinoria.

Deposition was re-initiated in the Lower Permian when glacial to fluvioglacial rudaceous sandstones and grey shales were laid down in a trough which extended southeast across the foot of Yorke Peninsula. The Permian was probably originally laid down over most, if not all of Yorke Peninsula, but much has been removed by erosion before Tertiary times.

Another long period of non-deposition followed the Permian. This was concluded in the Eocene with the deposition of freshwater lignitic sands up to 400 feet thick.

A widespread marine transgression followed, culminating in the Oligocene and Miocene when hard dense shelly calcarenites were deposited, overlying soft porous bryozoal calcarenites of Oligocene age. The Oligocene may lie with a minor disconformity on the ?Eocene, with unconformity on the Permian, and with major unconformity on the Cambrian or on the "Archaean" crystalline basement. Weathering and erosion in the late Miocene developed a karst topography on the calcarenites and limestones. Limestones outcropping

near Edithburgh previously thought to be Pliocene, and mapped as such on Enclosure 4, are probably of Middle Miocene age on faunal evidence.

Pleistocene deposits although thin, are widespread. They include various shelly "coquina" beds, red sandy clays, and thick masses (+200 feet) of "aeolianite" (a semi-consolidated, porous and calcareous dune sand). During the late Pleistocene the "Bakara" calcrete was formed during arid climatic conditions. The calcrete is a dense and nodular to loose and rubbly limestone, and forms a capping to older sediments over much of the peninsula.

Recent units comprise unconsolidated "terra rossa" soils, coastal dunes, and gypseous "lunettes" marginal to salt lakes. The rock gypsum of Stenhouse Bay, was also formed at this time by crystallisation in lagoons floored by black muds containing seaweed and post-Pleistocene molluscs. These black muds probably underlie much of Peesey Swamp, but the inland salt lakes such as Lake Fowler and Weavers Lagoon are floored by impervious Permian clays, through removal of the overlying calcrete.

The unusual thickness of 138 feet of Recent shelly marine clays and sands noted at Peesey Swamp in Peninsula Oil Bore No. 1 (drilled in 1933) is probably Pleistocene, with the impervious Pleistocene calcrete lying not too far below the swamp bottom.

STRATIGRAPHIC TABLE

SOUTHERN YORKE PENINSULA

AGE	UNIT NO.	FORMATION	LITHOLOGY	MAXIMUM KNOWN THICKNESS (feet)
RECENT - PLEISTOCENE (or QUATERNARY)		Undifferentiated but includes Molyneaux Sand, Loveday and Bakara Soils, and St. Kilda and Glanville Formations.	Sands, clays, calcrete.	?60
—UNCONFORMITY—				
MIOCENE - OLIGOCENE		Port Willunga Beds.	Soft marly limestone	119
—DISCONFORMITY—				
?EOCENE		Undifferentiated	Lignitic sands	238
—UNCONFORMITY—				
PERMIAN		Unnamed	Fluvioglacial shales and sandstones	1,359
—UNCONFORMITY—				
MIDDLE CAMBRIAN	1	"Upper Red Beds"	Red-brown to purple sandstones	1,800
	2A	Dalrymple and Stansbury Limestones.	Oolitic limestones and shales	367
	2B	Unnamed	Sandstones and shales	220
	2C	Ramsay Limestone	Dark grey-brown limestone	290
	2D	Unnamed	Multicoloured shales & limestone	362
	2E	Minlaton Conglomerate	Limestone & gneiss conglomerate	88
—UNCONFORMITY—				
LOWER CAMBRIAN	3A	Parara Limestone	Massive blue-grey argillaceous limestone	1,006
	3B	Kulpara Limestone	White to purple vugular dolomite	1,640
	4	"Transition Beds"	Sandstones, shales, dolomites	404
—UNCONFORMITY—				
"ARCHAEAN"		Moonta Porphyry and other undifferentiated formations	Highly folded metasediments and intrusives	Unknown

4. OUTLINE OF THE GEOMORPHOLOGY.

Yorke Peninsula is a leg shaped land mass, 80 miles from north to south and 40 miles from west to east on the southern "foot", its widest part. The low unrelieved surface of the peninsula is a mature peneplain (in a non-genetic sense), virtually without drainage. From the south, the peninsula rises very gradually to a maximum altitude of just over 700 feet near Arthurton, while from the western coast of the "foot" it rises to an altitude of just over 300 feet. Near Warooka the land mass falls to near sea level across Peesey Swamp, and rises again to about 100 feet near Yorketown.

The outline of the peninsula is controlled by meridional faults bounding the "leg" which is therefore a low lying horst tilted to the south, while the "foot" is a west tilted fault block, separated from the rest of the peninsula by the north-east facing scarp of Warooka Fault and the low-land of Peesey Swamp.

Although the peninsula was undoubtedly tilted and peneplained more than once during the Tertiary, the present peneplain surface is formed by a calcrete sheet, formed as a 'B' horizon in soils overlying all older rocks during the final stage of the Pleistocene.

The calcrete sheet bears a very thin "terra rossa" soil formed by weathering of the calcrete, and is now highly cultivated, although formerly covered by dense mallee scrub, of which remnants may still be found over the poor sandy soils between Warooka and Cape Spencer.

Changes in geomorphology since the formation of the calcrete sheet are restricted to seif dune fields built upon the calcrete surface, and depressions where the calcrete has either been removed by erosion or has passed below sea level.

Near Tickera in the north of the peninsula, and near Yacca Trig, in the south, extensive fields of seif dunes occur. The seif dunes are orientated from northwest to southeast, are semi-consolidated and are no longer active, being stabilised by vegetation, either naturally or by cultivation. Such fields of seif dunes could not form in the present

climate, and belong to a past period of post-Pleistocene aridity.

Probably the most striking geomorphologic feature of Yorke Peninsula is the Yorketown salt lake district. In this area of about 160 square miles, over 120 salt lakes occur, ranging in size from only a few acres to 560 acres over Weavers Lagoon and a maximum of 2,400 acres over Lake Fowler, and with a total area of probably 9,000 acres for all of the lakes.

The salt lakes are normally slightly oval in shape, some such as Weavers Lagoon and Munkowurlie Lagoon are elongate along east-northeast to west-southwest axes, which are parallel to the residual drainage. Lake Fowler, the largest of all the lakes, has an irregular outline, but in common with all of the other lakes, has a smoothly concave southeastern shore with a marginal lunette dune of fine floury gypsum, which is time correlatable with the seif dune fields.

The salt lakes are not restricted to any topographic contour related to present sea level. Lake Fowler has an altitude of 50 feet above mean sea level, while Weavers Lagoon is about 160 feet above sea level, and some small lakes near Minlaton stand at an altitude of just over 200 feet. All of these salt lakes are flat bottomed, with a floor of impervious Permian clay, and sometimes carry Permian glacial erratics near their shores.

The ubiquitous calcrete sheet is very rarely present on the salt lakes and their genesis is considered to be due to the removal of this calcrete by chemical solution and wind deflation down to the ground-water table, thereby exposing the Permian clays. Winter rains, falling on the surrounding country, percolate downward and eventually flow into the lakes as shore line springs. This spring water is sometimes nearly fresh, but one spring near Weavers Lagoon contains approximately 1% of salt, which possibly originates in the underlying Permian or Cambrian brine aquifers, although diluted by the annual rainfall.

Quite distinct from the Permian clay-floored lakes of Yorketown are the gypsum-floored lakes near Stenhouse Bay, which have flat, smooth, level floors of coarsely crystallised gypsum. This gypsum at Marion Lake overlies shelly marine muds with seaweed, which in turn rest upon calcreted Pleistocene shell beds of the Glanville Formation. The gypsum lakes invariably occur

near the coast and close to present day sea level. They are old marine-barred back shore lagoons, in which water loss by evaporation caused tidal inflow which exceeded outflow, and water salinity rose to the point where calcium sulphate was precipitated, in beds up to 6 feet thick.

Peesey Swamp is a very large area of 12,650 acres of near sea level clay pans and swamps which is partly covered by salt tolerant plants such as samphire. Peesey Swamp is elongated northwest to southeast and is bounded to the west by the rather abrupt scarp of the Warooka Fault, and to the east by the gently west sloping calcrete surface of the late Pleistocene peneplain. To north and south, Peesey Swamp is separated from the sea by high coastal dune belts.

Peesey Swamp looks very much like an emerged marine strait, as was suggested by Crawford (1965), but Crawford's concept of the Swamp as a deep Quaternary semi-graben is not now regarded as valid, as his concept is based on a report of 138 feet of Recent marine sediments, and no Tertiary overlying the Permian in Peninsula Oil Bore, sunk just east of Peesey Swamp in 1931-1933. This bore was never logged palaeontologically, but the concept of such a thickness of Recent marine sediments is quite untennable in terms of modern Quaternary stratigraphy for this area. Calcreted Pleistocene shelly limestones outcrop on the site of the Beach Petroleum Borehole Peesey No. 1, and brines are pumped from a shallow well sunk through calcrete on Salt Lease 658, on the swamp itself. The floor of Peesey Swamp is of soft black or grey clay, with a thin veneer of coarse sand, which being well drained is covered by samphire and grasses, whereas the clays are too salty and water-logged to support any vegetation.

Much work needs to be done on this swamp to determine the nature of the underlying sediments and the source of its brines, but in the present state of knowledge it can be confidently stated that the swamp itself is not of Recent tectonic origin, but is a recently emerged shallow marine strait, in which only a thin layer of Recent marine muds may be found above the hard calcrete capping of the marine Pleistocene.

5. GEOGRAPHY

A. Climate

Temperature: Average monthly maxima and minima are available from the South Australian Bureau of Meteorology, for Kadina, Maitland and Warooka. The average summer and winter figures for January and July respectively, for these localities, are shown below:-

	JANUARY			JULY		
	Max. (°F)	Min. (°F)	Mean (°F)	Max. (°F)	Min. (°F)	Mean (°F)
KADINA (Northern Yorke Pen.)	88.0	58.5	73.3	61.0	42.0	51.5
MAITLAND (Central Yorke Pen.)	84.5	58.0	71.3	58.5	43.5	51.0
WAROOKA (Southern Yorke Pen.)	80.6	57.3	69.0	57.5	44.3	50.9

It can be seen from the above figures that there is a slight rise in summer and winter temperatures from south to north, the southern portion of the peninsula having a more maritime climate.

TABLE 1

WAROOKA 1951 - 1957 (6 YEARS)

	TEMPERATURE			HUMIDITY
	Max. (°F)	Min. (°F)	Mean (°F)	%
January	80.6	57.3	69.0	50
February	79.7	59.2	69.5	54
March	77.9	57.2	67.6	59
April	70.2	52.8	61.5	69
May	63.8	49.1	56.5	83
June	59.1	45.8	52.5	86
July	57.5	44.3	50.9	85
August	58.7	44.5	51.6	78
September	63.1	46.2	54.7	68
October	68.1	49.1	58.6	61
November	71.7	50.3	61.0	54
December	77.4	55.2	66.3	49
Average per annum	69.0	50.9	60.0	66

Rainfall: Average rainfall exceeds 20 inches over the areas of the peninsula having greatest relief and decreases towards the coasts, more rapidly on the eastern side. (See Figure 3).

The majority of rain falls between April and October with the number of wet days ranging from 70 to 120 per annum over the peninsula. The rain is mostly confined to shower activity with occasional thunderstorms.

TABLE 2

RAINFALL

	1861 - 1968 WAROOKA		1875 - 1964 EDITHBURGH		1888 - 1964 YORKETOWN	
	Rainfall (Pts.)	Days	Rainfall (Pts.)	Days	Rainfall (Pts.)	Days
January	55	3	53	4	52	3
February	67	4	66	4	65	4
March	58	4	70	4	63	4
April	136	9	135	9	130	9
May	221	13	196	13	201	11
June	263	14	235	14	251	14
July	261	17	216	16	229	16
August	235	16	209	16	220	14
September	179	13	167	12	173	11
October	147	10	137	11	138	9
November	91	7	92	7	89	7
December	63	5	66	6	64	5
Total per annum	1,716	120	1,642	116	1,675	107

Humidity: Readings available over a six year period for Warooka indicate high humidity between April and September which corresponds to the period of maximum precipitation. (See Table 1).

Wind: Due to the open and fairly level nature of the terrain, strong winds tend to be prevalent over most of the peninsula associated with significant sea breezes.

Wind analysis has been made for Yorketown for the period 1944 to 1948, there being no other long term records available for Southern Yorke Peninsula.

Table 3 below shows a comparison of winds for Yorketown (a) and Dry Creek (Adelaide), (b).

Adelaide figures of three hours duration used

A comparison of climatic conditions existing at Dry Creek with those of Southern Yorke Peninsula, is shown in Table 4.

The actual annual evaporation rate for Dry Creek is in the order of 80 inches. This figure is dependent on prevailing winds while the net evaporation figures given in Table 4 do not take windage into account.

As the prevailing winds on Yorke Peninsula are more intense than those at Dry Creek (Table 3), a figure of 80 inches has been assumed for purposes of calculation.

Met. Figures for Dry Ck y/e 1950
pvic Class evaporation 80·6" Rainfall 18·6" I.e. net evaporation 62·0"
and Adelaide figures 56·4" 21·1" I.e. 35·3"
There is a great difference between adelaide & Dry Ck

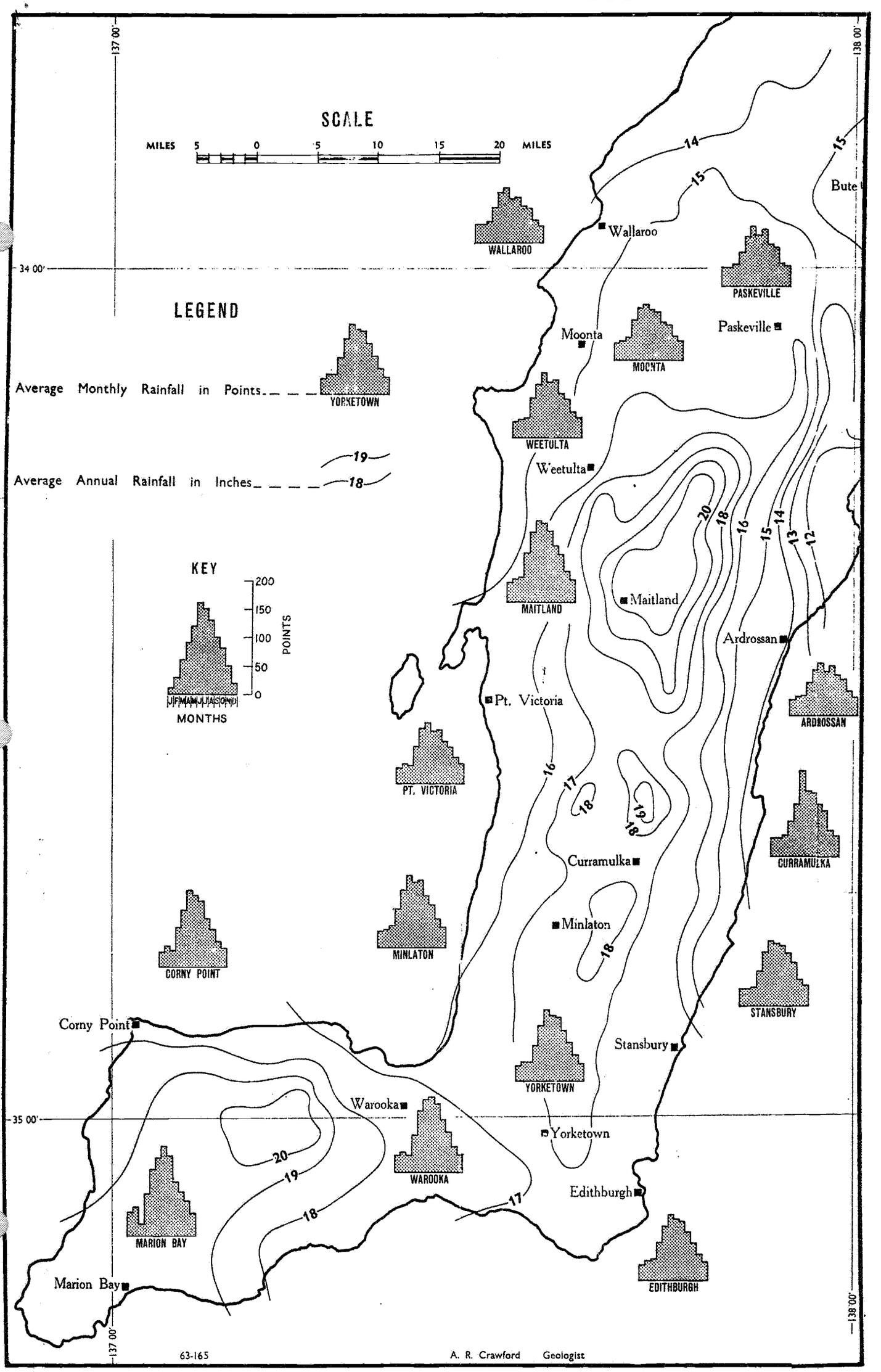


Fig.3 —Average monthly rainfall and isohyets of annual averages

TABLE 4

COMPARISON OF THE CLIMATE OF SOUTHERN YORKE PENINSULA WITH THAT OF DRY CREEK (ADELAIDE)

Month	Mean Temp. (°F) Dry Creek	Mean Temp. (°F) Warooka	Mean Rainfall (inches) Dry Creek	Mean Rainfall (inches) Warooka	Wet Days Dry Creek	Wet Days Warooka	Mean Humidity (%) Dry Creek	Mean Humidity (%) Warooka	Mean Evaporation (inches) Dry Creek	Mean Evaporation (inches) Yorketown	Net Evaporation (inches) Dry Creek	Net Evaporation (inches) Yorketown
Jan.	73.4	69.0	0.76	0.55	4	3	39 + 11	50	9.3	8.0	8.5	7.5
Feb.	73.3	69.5	0.76	0.67	4	4	43 + 11	54	7.5	6.0	6.7	5.3
Mar.	69.8	67.6	0.95	0.58	5	4	47 + 12	59	6.3	5.0	5.3	4.4
Apr.	63.7	61.5	1.72	1.36	10	9	56 + 13	69	3.8	3.5	2.1	2.2
May	58.0	56.5	2.71	2.21	13	13	67 + 16	83	2.3	2.2	-0.4	0.2
June	53.7	52.5	2.90	2.63	15	14	75 + 11	86	1.5	1.5	-1.4	-1.0
July	51.9	50.9	2.61	2.61	16	17	76 + 9	85	1.5	1.7	-1.1	-0.6
Aug.	53.8	51.6	2.44	2.35	16	16	70 + 8	78	2.1	2.3	-0.3	-0.1
Sept.	57.2	54.7	2.01	1.79	13	13	60 + 8	68	3.1	3.1	1.1	1.4
Oct.	61.7	58.6	1.74	1.47	11	10	50 + 11	61	5.0	4.6	3.3	3.2
Nov.	66.5	61.0	1.22	0.91	8	7	44 + 10	54	6.8	5.0	5.6	4.7
Dec.	70.6	66.3	1.04	0.63	6	5	40 + 9	49	8.6	6.8	7.6	6.2
AVERAGE	62.8	60.0					53 + 13	66				
TOTAL			20.86	17.16	121	120			57.7	49.7	37.0	33.4

Av 15 1950 Adelaide (Dry Ck) 21·1 (18·6)

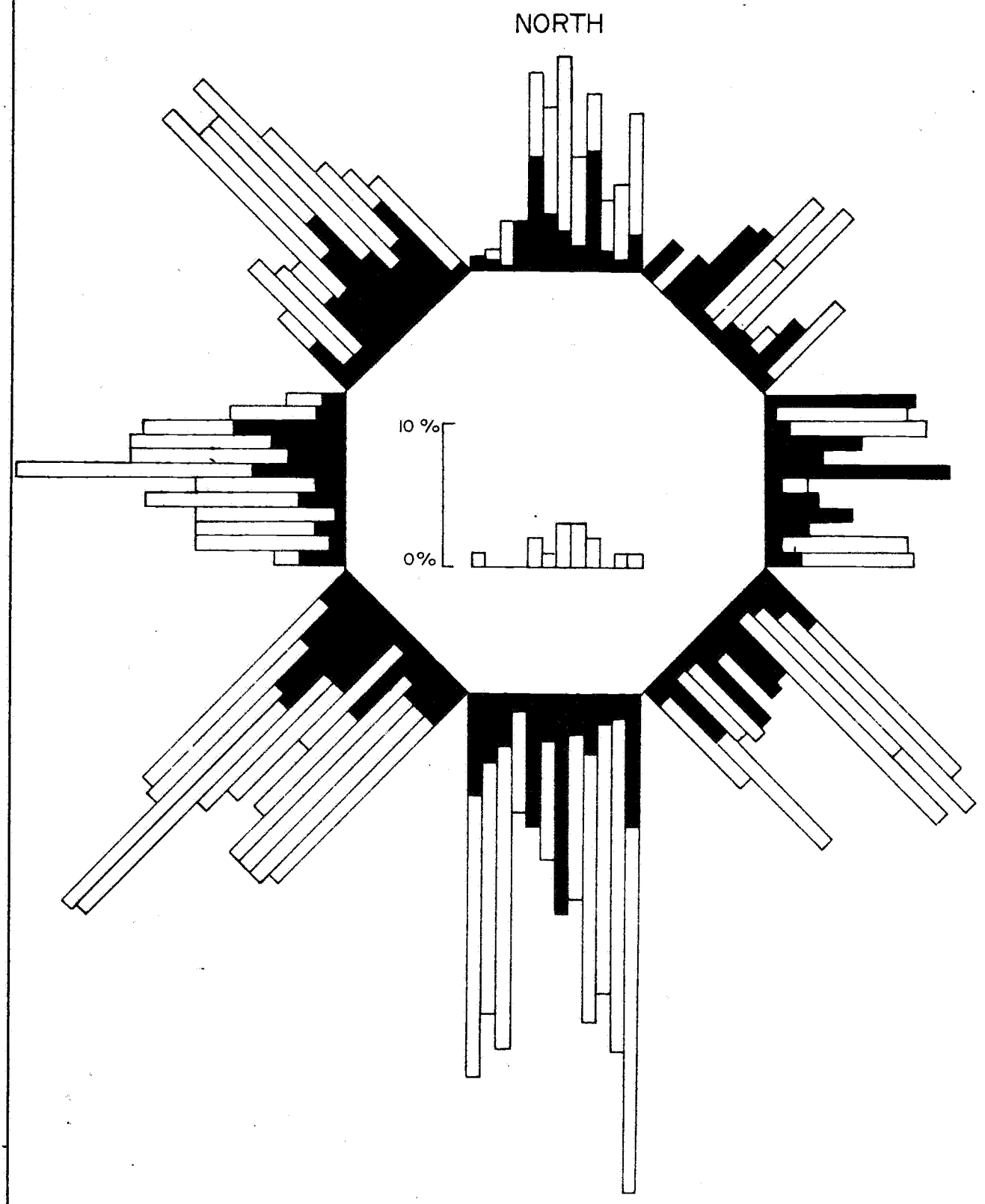
Adelaide Dry Ck 56·4 (80·6)

35·3 (62·0)

TABLE 3 (a)

WIND ROSE 307

YORKETOWN 9.00 A.M.



The wind rose represents the monthly frequency distribution of wind directions from eight points of the compass. The sides of the octagon face towards the cardinal and semi-cardinal points with north at the top. Projecting from each side are twelve columns representing the twelve months of the year, and the lengths are proportional to the percentage frequency of winds from a given direction working clockwise from January to December. The solid black part of the columns represent winds of speeds 13 miles per hour (21 kilometers per hour) and greater, and the open part, winds of speeds less than 13 miles per hour. The percentage frequency of calms in the twelve months is shown in the centre of the rose, working from left to right from January to December.

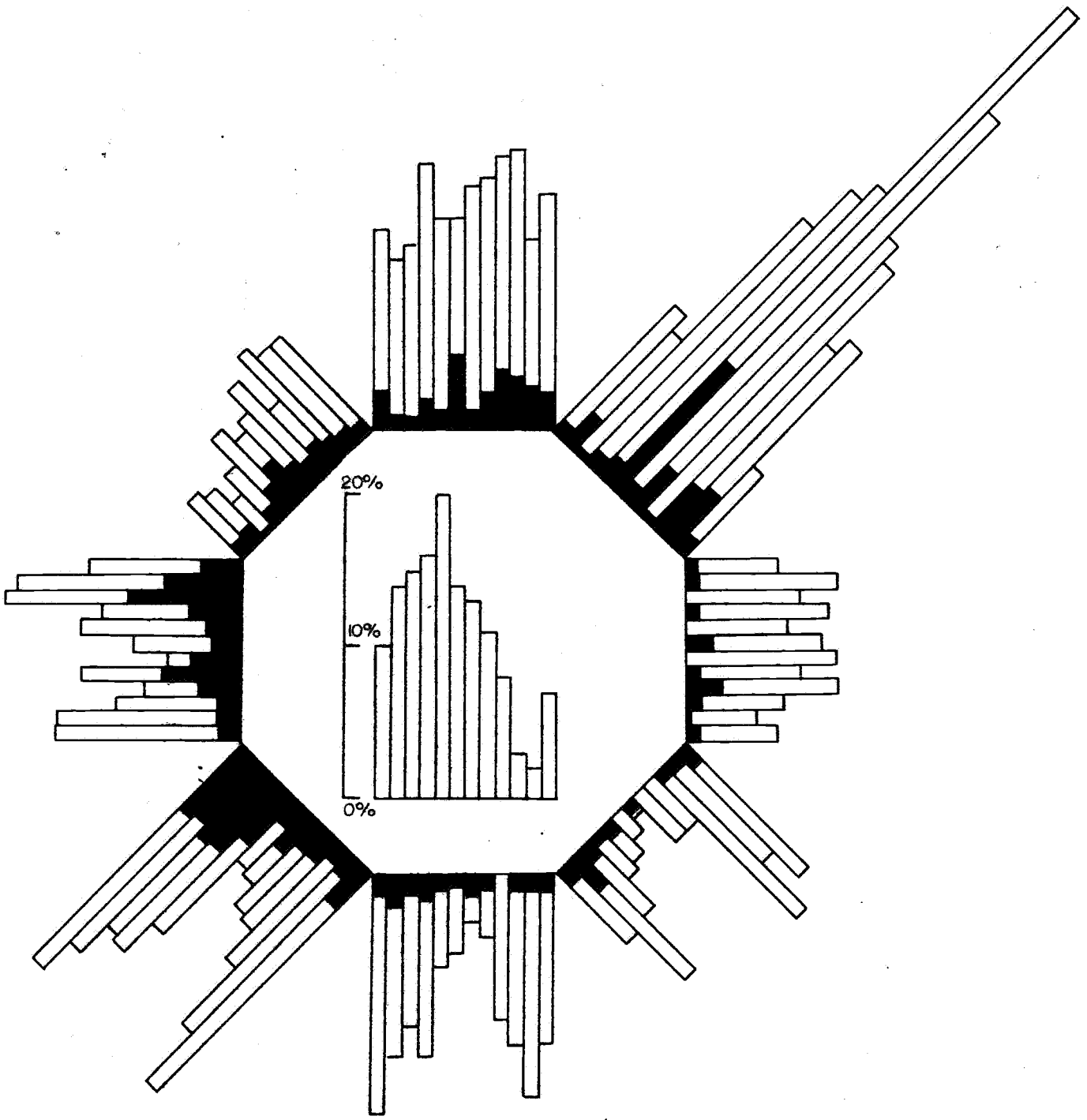
TABLE 3 (b)

WIND ROSE

ADELAIDE 9.00 A.M.

308

NORTH



The wind rose represents the monthly frequency distribution of wind directions from eight points of the compass. The sides of the octagon face towards the cardinal and semi-cardinal points with north at the top. Projecting from each side are twelve columns representing the twelve months of the year, and the lengths are proportional to the percentage frequency of winds from a given direction working clockwise from January to December. The solid black part of the columns represent winds of speeds 13 miles per hour (21 kilometers per hour) and greater, and the open part, winds of speeds less than 13 miles per hour. The percentage frequency of calms in the twelve months is shown in the centre of the rose, working from left to right from January to December.

B. Transport and Communications

Yorke Peninsula is only about 150 miles in length and between 20 and 50 miles in width. No elevations exceed 800 feet over the region.

An excellent system of sealed roads link all major towns. Access from Adelaide is made via a first grade highway to Port Wakefield, some 60 road miles from Adelaide and thence through Kulpara or Price.

Shipping facilities for shallow draft vessels exist at Stansbury, Wool Bay and Edithburgh. Facilities for deeper draft vessels exist at Ardrossan (adjacent to Price). By May 1970 it is proposed to have a deep water port developed at Giles Point.

A summary of the facilities at these two localities is as follows:-

	Ardrossan (B.H.P.)	Giles Point
Water Depth	27 feet L.W.	32 feet L.W.
Vessel Limit	15,000 tons	40,000 tons
Conveyor	Yes - Belt	Yes - Belt
Capacity	400 tons per hour	800 tons per hour
Storage	8,000 tons	-

C. Social Geography

The entire economy of Yorke Peninsula is based on primary production, which includes mixed farming, fishing, mining, and the businesses established in the small towns. These businesses depend entirely on the primary producer for a livelihood, although tourism is an increasingly important source of income.

These factors mean that the population of the towns is only a proportion of the total population, and many workers are only employed on a seasonal basis. Therefore a settled labour pool is readily available on the Peninsula.

The mining industry comprises salt production, as already stated, plus gypsum quarrying at Stenhouse Bay, and limestone production at Point Turton and Klein Point. Flotation of copper from old mine dumps at Kadina is due

to commence in the near future. These places have their own port facilities, and are fully mechanised so that limited labour is required.

The region is politically stable, and labour disputes should be no problem with locally hired employees.

6. POTENTIAL BRINE SUPPLY SOURCE

There are four potential brine supply sources available.

A. The sea.

B. The saline waters of the Cambrian Kulpara Limestone.

C. The saline waters of the Permian sands.

D. The shallow brine aquifers of the Tertiary to Recent sediments.

A. The Sea

This is not considered here due to the limited evaporating pan areas in close proximity to the coast.

B. The Saline Waters of the Cambrian Kulpara Limestone

During 1966, saline waters were encountered within the Kulpara Limestone between 4,250 feet and 5,375 feet below ground level in B.P.N.L. Stansbury West No. 1 Well. Analyses of these waters revealed between 122,000 and 164,000 p.p.m. of dissolved salts, of which over 96% was NaCl. For a full list of analyses, see Appendix I.

i) Brine reserves available

From further drilling and geophysical results the brine aquifer was shown to cover several hundred square miles, and to be commonly greater than 1,000 feet thick. A report by Cundill, Meyers and Associates (Rutledge 1968), who had all available data placed at their disposal, indicated that

the possible total volume of brine in place in the onshore area of the Kulpara Limestone is approximately 300,000 x 10^6 gallons. The probable volume of brine which could be expected to be drawn from one well for a 1,000 foot radius of influence was calculated to be approximately 700 x 10^6 gallons, and for a 2,500 foot radius, 4,330 x 10^6 gallons. Furthermore it was calculated that Stansbury West No. 1 Well could supply brine at a rate of at least 122 x 10^6 gallons per year for a period of 4 years if the radius of influence of the well was 1,000 feet, and 24 years if the radius of influence was 2,500 feet. Their report concluded:-

"It should be theoretically possible to produce 365 x 10^6 gallons of brine per year from 3 wells with 640 acre spacing, providing permeability is consistently effective and continuous enough to allow rapid replenishment of zones immediately adjacent to the wells." Subsequent measurement of porosity and permeability of cores from the Kulpara of Stansbury West has indicated high to very high permeabilities (40 to 337 millidarcies). Thus one of the first pre-requisites has been established, a sufficient supply of brines was theoretically proven to be present, and the aquifer of sufficient quality to be capable of supplying the brines at the anticipated rate.

ii) Concentration and purity of the brines

Analyses are given in Appendix I.

Australian Mineral Development Laboratories were commissioned to study the evaporation behaviour of the brines, and the following is an extraction from their report:-

"After consultation with the sponsor the composition of brine from DST 5 (4,720 - 4,832 ft.) was selected as typical of that likely to be available. The brine for evaporation tests was made up according to the analysis given for DST 5 (omitting lithium - 3 ppm.). Forty litres of brine were prepared:-

Component	ppm.
Cl	98,300
SO_4	1,187
HCO_3	93
Na	62,100
K	828
Ca	1,178
Mg	190

Assumed Composition	ppm.
$CaHCO_3$	124
$CaSO_4$	1,682
$CaCl_2$	1,806
$MgCl_2$	744
NaCl	157,926
KCl	1,579
	163,861

The specific gravity of the brine was 1.113 at 20° C and the initial pH was 7.0.

Two separate tests were conducted:-

(a) Direct Evaporation

A 500-ml portion of brine was evaporated under an infra-red lamp until amost dry. The salt/brine mixture was filtered under suction until the salt was as dry as possible. The salt was then washed on the filter with exactly 50 ml. of saturated sodium chloride and again sucked dry. The amount of liquid "hold up" in the solid was determined by weighing the salt, drying at 100° C and re-weighing. The solid product, the initial filtrate (bitterns) and wash liquor were analysed separately and the distribution of the components was calculated after combining the results for the filtrate and wash.

Results

	Distribution of Components, %					
	NaCl	KCl	$CaCl_2$	$CaSO_4$	$MgCl_2$	$CaHCO_3$
Solid product	87	3	3	70	3	85
Filtrate (bitterns)	13	97	97	30	97	15

The total volume of bitterns was 40 ml including 5.5 ml. of "hold up" liquor.

Approximate Composition of Solid Product

	%
NaCl	99.0
$CaSO_4$	0.7
$CaHCO_3$ (as $CaCO_3$)	0.1
KCl	0.03
$MgCl_2$	0.03
$CaCl_2$	0.03

(b) Stagewise Evaporation

Most of the brine (39 litres) was evaporated by infra-red heating under simulated natural conditions. An oscillating fan provided a constant air stream over the brine surface. The brine temperature reached 35 to 40°C during the day but was allowed to fall to approximately 20°C at night. Salt commenced to crystallise at a brine specific gravity of 1.210; the specific gravity then remained constant until approximately 80% of the salt had been crystallised, but then rose gradually to 1.220 after 94% had been crystallised.

Solid products were removed at intervals by filtration under suction and then washed by displacement with approximately 500 ml. of water. The wash water was returned to the evaporation bath with the filtrate. The final product obtained at a brine specific gravity of 1.220 was not washed after filtration, but the "hold-up" volume was determined and an adjustment was made in the composition of the solid to allow for the bitterns remaining in it.

The solid products and bitterns were analysed to enable distribution of the components to be determined. Some difficulties were experienced in obtaining material balances for some of the components, but the figures given in Table below are regarded as reliable indications of the compositions of the various fractions. Some of the figures have been "rounded off" for the purpose of evaluating the results.

From the results of the two tests the conclusion is reached that a salt product containing 99% NaCl could be obtained only in the earlier stages of evaporation (up to 40% of the total NaCl), but that at least 80% of the NaCl could be obtained as a 98% product (assuming no contamination with foreign materials.). Most of the bicarbonate and sulphate in the brine are precipitated during the middle stages of evaporation, so there is little likelihood of reducing the level of contamination by these components except by limiting the extent of evaporation."

COMPOSITION OF SALT PRODUCTS

Fraction	NaCl		KCl		$CaSO_4$		$MgCl_2$		$CaHCO_3$		$CaCl_2$	
	%	dist. %	%	dist. %	%	dist. %	%	dist. %	%	dist. %	%	dist. %
1	99.8	31	<0.01	0.1	<0.1	2.1	<0.01	0.3	0.06	21	<0.01	0.1
2	99.5	12	<0.01	0.1	0.4	6.1	<0.01	0.3	0.08	13	<0.01	0.1
3	98.3	22	0.01	0.3	1.6	45.6	0.02	1.0	0.10	32	0.01	0.2
4	98.8	14	0.02	0.4	1.2	22.0	0.03	1.0	0.10	17	0.02	0.5
5	97.7	15	0.15	2.4	1.2	22.0	0.10	1.4	0.08	13	0.40	6.1
Bittern	-	6	-	96.7	-	2.2	-	96.0	-	4	-	93.0

iii) Proposed method of brine extraction

The programme proposed for extraction of the brines is as follows:-

a) The drilling of 3 wells on the margins of Weavers Lagoon on 640 acre spacing, designed to intersect the brine bearing dolomites at approximately 4,200 feet.

b) To drill into the dolomites approximately 100 feet.

c) In each well to run and cement approximately 4,200 feet of $8^5/8$" "Fibercast" high density epoxy resin fibreglass casing, into the top of the dolomites

d) The above holes to be equipped with air quills of epoxy resin fibreglass pipe, extending from surface to 700 feet. The purpose of the quill is to aerate the brine column to effect pumping to

surface. It is anticipated approximately 400,000 gallons of brine will be required at maximum pumping rates. To obtain this rate, a 375 c.f.m., f.a.d. compressor operating at 127 p.s.i. would be required, assuming a 150 foot drawdown.

C. The Saline Waters of the Permian Sands

Very little is known as yet on the above. A bore sunk in the search for oil near Warooka in 1933 (Peninsula Oil Bore No. 1) found saline water (74,260 p.p.m. salts) in an aquifer within the Permian. Details of aquifer thickness, flow rates etc. are not known. The sinking of a well in the Peesey Swamp area is necessary to evaluate saline aquifers within the Permian.

D. The Shallow Brine Aquifers of the Tertiary and Recent

All South Australian Department of Mines information on the salinity of shallow subsurface waters on Southern Yorke Peninsula, has been collated and contoured. The results are displayed on Enclosure No. 3.

From the contours of salinity it can be seen that above the background of 0.5 to 1.0% salinities, two anomalous areas are present. One is situated in the centre of the peninsula some 4 miles to the west of Stansbury with a maximum of 27.17% salinity at its centre. From geophysical evidence it is very possible that the saline water arises from deep Cambrian brines, which have migrated up along fault zones.

The second anomalous area is that of Peesey Swamp with maximum values of 20.30% salinity.

In view of the above considerations, it is highly possible that the strongly saline brines of Peesey Swamp also arise from deep Cambrian brines percolating up through the Permian.

It must be realised that the information available in the Peesey Swamp area especially, is sparse and the contours shown based on very few control points. Further analyses should alter the picture considerably.

Full analyses of these brines are not available. One analysis quoted in Lockhart Jack (1921), is reproduced

Rock	Sample No	Hole	Depth	Est. Salinity	Recd	Sampler	Date
Mid Lough Upper Red unit 1.	DST No 1	BP Skerne W No 1	1161-1221 (520 ohm-mtr)	15,677	12,546	Wallis	11/5/66
"	DST No 1	"	"	(970 ohm-mtr) 13,143	10,780	"	"
Lower Coash Limestone 2 & unit 3B	DST 4 (1)	"	4191-4251	(17,293)	118,149	"	10/6/66
	DST 5 (4)	"	4720-4837	(12,671)	157,928	"	14/6/66
"	DST 6	"	5720-5836	(153,549)	149,052	"	24/6/66
"	DST 7	"	5280-5315	(12,210)	157,451 (and 150,857)	"	27/6/66
"	DST 1	BP Skerne Town No 1	3558-3671	(104,475)	79,568 mg/l (and 82,000)	Lawrence	[illegible]
"	DST 2	"	4048-4112	102,890	77,207 mg/l (and 79,000)	"	" 10/5/67
Lower Coash transit Red unit 4	DST 1	BP Eskdalemuir No 1	1701-1783'	41,847	42,410 (and 43,200) mg/l (and 3,550)	"	11/9/66 - 12/9/66
Mid Lough upper Red unit 3	DST 1	"	2726-2800	41,407	69,680 and 70,000 mg/l 9,200	"	17/9/66
unit 3B	DST 2	"	2830-2877	(101,204)	90,200 and 92,700 mg/l 5,120	"	20/9/66
	DST 3	"	3028-3116	(118,535)	87,206 and 88,974 mg/l 6,760 ca	"	23/9/66
	DST 4	"					

Av of DST 4(1) DST 5(4), DST 6 & DST 7 in Unit 3B = 14.5% Nacl

in Appendix No. I. The total salt content of this brine was 202,000 p.p.m., with calcium and magnesium content less than found in normal sea water.

A recent analysis of brine at present being pumped at Peesey Swamp by Aldenhoeven, is also shown in Appendix I, and indicates a salinity of 156,900 p.p.m.

The brines in the Peesey Swamp area are found from 2 to 20 feet below ground level in porous aquifers of Recent to Pleistocene age. The present method of developing the brines involves the sinking of a well to a depth of about 8 feet, and installing simple pumping equipment. Pumping rates of 20,000 g.p.h. are common, and higher rates can be expected in selected areas.

A field and laboratory study of the feasibility of extracting and harvesting large volumes of salt in Peesey Swamp is at present in the planning stages.

7. POTENTIAL EVAPORATING AREAS

Two main potential evaporating areas are considered:

A. Salt lakes of the Yorketown-Stansbury area.

B. Peesey Swamp.

A. Salt Lakes of the Yorketown-Stansbury Area.

Enclosure 2 shows relevant salt lakes and their areas.

Weavers Lagoon is 560 acres in area and has been made the subject of a detailed report and recommendations (International Technical Services 1968) which are summarised below. All calculations have been made assuming an inlet brine of 1.113S.G. i.e. 14.2% NaCl, as available from the Kulpara Limestones.

Peggy Swamp
12,42 acres } 15 @ $54.61

Lois Fowler
2,400 acres

total 15,000 acres if we'd sold our whole yield @ 60 bu/acre
= 900,000 bu yield

i) Layout of Weavers Lagoon

Area of Weavers Lagoon	560 acres
Area of proposed concentrating ponds	302 acres
Concentrating area divided into 3 ponds,	
the first	173 acres
the second	86 acres
and the third	43 acres

Area of proposed crystallising ponds 274 acres comprising 5 x 49 acre crystallising ponds and 1 x 29 acre pickle pond.

ii) Annual pumping, production, and harvesting rates

Maximum pumping rate of inlet brine	8,500 g.p.m.
Maximum pumping rate of pickle to crystallisers	2,500 g.p.m.
Annual production	158,000 s. tons
Mean Annual salt production per acre	576 s. tons
Required capacity of harvester	200 s. tons/hour.

The above figures are taken from International Technical Services (1968).

iii) Nature of Weavers Lagoon

Weavers Lagoon occurs in the salt lake district of the Yorketown area. Within this area of approximately 160 square miles in extent occur between 120 and 130 lakes in which salt may crystallise during summer.

Weavers Lagoon itself covers 560 acres, is flatbottomed and floored by impervious Permian clays. For a more detailed description of the salt lake district, see Section 4, "Summary of the Geomorphology."

B. Peesey Swamp

The nature of Peesey Swamp is described above in Section 4, "Summary of the Geomorphology."

The exact area available for the purposes of evaporating brines, is at present unknown. A total area which may possibly be able to be developed after grading and removal of samphire bush, is in the order of 12,642 acres. At present 2,743 acres are available for crystallising pans of which 1,243

[redacted]

[redacted]

1,975 Salt consumed annually at 1700 cc

+ 80% of salt lost annually at the 2nd [illegible]

100 lbs [illegible] contain 15 lbs salts + 85 lbs water

yield 11.7 lbs salt from a cost of $3.5 of consumed

" 11.7 lbs salt 22.6 of water consumed

or 11.7 lbs of salt from 100 lbs of brine = 1 lb salt from 8.6 lbs of brine

[illegible]

acres are presently held under lease and being worked by various companies.

In order to investigate the potential of this area, both as a source of brines and as a locus for brine harvesting, recommendations are outlined under Section 8, "Recommendations".

A number of calculations have been made relevant to using Peesey Swamp as a locus for salt harvesting. These are presented below.

A. Preliminary Calculations re Peesey Swamp

Assumptions

Mean annual evaporation at Peesey (including windage affect)	80"
Mean annual rainfall at Peesey	17"
Net evaporation at Peesey	63"
Evaporation rate from brines at Peesey	45"
Brine leakage	40%
Washing loss	10%
Brine inlet density	S.G. 1.115 (15% NaCl)
Density brine to crystalliser	S.G. 1.210
Density discharged bitterns	S.G. 1.261
NaCl yield at S.G. 1.261	78% total available

i) Total H_2O evaporated/acre/year

$\Rightarrow$ 100 tons/acre x 45"/year

= 4,500 tons/acre/year (for total system)

ii) Yield NaCl/ton H_2O evaporated (for total system)

$$= \frac{85 \times 0.85}{15 \times 0.78} = 1 : 6.2$$

or 1 ton of salt/8 tons water evaporated.

iii) Yield NaCl/acre (for total system)/year, correcting for leakage and washing loss

$$= \frac{4,500}{8} \times 0.6 \times 0.9$$

= 300 tons/acre/year.

145 lbs/sq inch = 20 lbs/sq ft

120 lbs/sq inch = 91 kg/sq cm

120 lbs/sq inch = 20 lbs/sq ft

iv) Total acreage required for 400,000 tons NaCl

$$= \frac{400,000}{300} = 1,350 \text{ acres (approximately)}$$

to which must be added 250 acres for a brine holding area between the concentrating area and the crystallisers.

Total area required = 1,600 acres.

v) Subdivision of Ponds:

Assume 50" net evaporation over concentrating area.

Assume 40" net evaporation over crystallisers.

Therefore ratio of concentrating area to crystallisers becomes

$$\frac{60}{50} : \frac{25}{40} = 1.2 : 0.675$$

or approximately 5:3

Therefore area crystallisers

$$= \frac{1,350}{8} \times 3$$

$$= 500 \text{ acres approximately}$$

and concentrating area = 850 acres.

vi) Yield/acre from crystallisers

Yield from total system = 300 tons/acre

Yield from crystallisers = 800 tons/acre approximately

Assuming salt deposited has a bulk density of 90 lbs./cu.ft.

One acre = 43,560 square feet

Therefore salt crust $= \frac{12 \times 800 \times 2,240}{90 \times 43,560}$

$= 5\frac{1}{2}$"

vii) Brine to be pumped annually

$$= \frac{400,000 \times 2,240 \text{ gallons}}{11.14}$$

with washing and seepage loss

$$= \frac{400,000 \times 2,240}{11.14} \times \frac{100}{15 \times 0.6 \times 0.9} = 10^9 \text{ gallons}$$

$$= 450,000 \text{ tons.}$$

B. Brief Precis of Operating Details

Harvesting of the salt would be performed by space-frame, ultra light rubber tyred vehicles. A minimum of two vehicles having a harvesting capacity of 800 tons/hour would be necessary.

Crystallisers would be positioned in areas which are both water tight and having the bearing strength of the pond surface sufficiently high to carry the harvesting machines. Harvesting would be carried out as late in the season as possible, but probably during the months of March and April. Washing would be carried out on site, and the wash brine returned to the concentrating area.

A minimum of one seasons harvest would be stacked on site, and as the present load limit for roads in the area is $38\frac{1}{2}$ tons, a large stockpile at Port Giles would also be maintained to enable rapid loading in the event of short intervals between shipments.

8. RECOMMENDATIONS

A. General

i) Investigate the shallow subsurface brines in the Peesey Swamp area to determine salinity, reserves, supply rates and chemical engineering properties etc. of these brines.

ii) Concurrently with i) above, delineate the areas suitable for construction of brine evaporating ponds, and investigate surface permeabilities and bearing strengths of these areas.

iii) Undertake a preliminary investigation to determine pertinent factors regarding pan layout, construction of ponds and dykes, material and equipment needed, purchase and acquisition of land, handling equipment, harvesting machines and various other materials needed to establish a viable salt industry at this location.

iv) If factors prove favourable after the completion of iii), to initiate a study programme to form a basis for broad planning decisions, to enable a detailed examination of all major aspects of the project to be carried out. Pilot experimentation will be carried out at this stage.

It is considered that a minimum period of 6 months will be necessary to complete stage iii) above.

v) To investigate the high salinity values to the north of Weavers Lagoon.

B. Proposed Programme

i) Plan a drilling, field testing and mapping programme in the Peesey Swamp area to commence at the end of May 1969.

ii) Commence field operations with the drilling of a minimum of 5 wells on favourable locations as indicated from the previously prepared brine salinity contour plan. Flow rates and salinities of the brines encountered to be investigated and monitored on a 24 hour basis, care being taken to eliminate the possibility of re-circulation.

iii) Draw down of fluid during pump testing to be monitored in pilot holes drilled for that purpose.

iv) Extended pump testing operations to be undertaken, with sampling and analysis of fluids obtained, performed at regular intervals.

v) Representative lithologic samples from all wells to be collected at 5 foot intervals, described, bagged and stored.

vi) Surface geological and geomorphological mapping to be undertaken in the field using large scale aerial photographs to determine areas of highest potential with regard to future pond areas, and to aid in predicting the distribution of aquifers in the subsurface.

vii) Surface samples to be taken with auger and piston tube sampler to determine permeability and load bearing strength of potential pond areas.

viii) Field investigation of bearing strength and permeability of areas displaying pond potential using cone penetrometers and field tests of surface permeabilities.

ix) Undertake studies of the broad engineering and economic factors involved.

x) Undertake office compilation of data re the high salinities of the shallow brines north of Weavers Lagoon.

9. REFERENCES

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APPENDIX I

BRINE ANALYSES

SOUTHERN YORKE PENINSULA

WATER ANALYSIS

Drill Hole Name . . . PIT ON M.L.134 . . . .

Location . . Peesey . . . . . Section . . . BK. B . . Hundred . . . Moorowie . . .

Latitude . 35° 01' 00" S . . . . . Longitude . . 137° 27' 40" E . . . . .

Depth . . 2 feet . . . . . .

Formation . . . Pleistocene = ? Glanville Formation . . . . . .

Sample No. . . . . Sampler . . . . . Date . . .

	Parts per Million	Assumed Composition of Salts	Parts per Million
Chloride (Cl)	117,080	Calcium bicarbonate	143
Sulphate (SO_4)	10,120	Calcium sulphate	5,691
Bi-carbonate (HCO_3)	86	Calcium chloride	
Nitrate (NO_3)	---	Magnesium bicarbonate	
Sodium (Na))	66,377	Magnesium sulphate	7,627
Potassium (K))		Magnesium chloride	19;576
Calcium (Ca)	1,731	Sodium bicarbonate	
Magnesium (Mg)	6,469	Sodium sulphate	
Silica (SiO_2)	140	Sodium chloride) Potassium Chloride)	168,836
TOTAL	202,013	TOTAL	

Laboratory . . . . . .

Analyst . . . . . Date . . . . . .

Comments . . . Information from Lockhart Jack, R, 1921, The Salt and Gypsum Resources of South Australia: Geol. Survey of S. Aust. Bull. 8 P.61 . . . . . .

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WATER ANALYSIS

Drill Hole Name . . . ALDENHOVEN PUMP WELL . . . . . .

Location . . Peesey Swamp . . .Section . . . 95. . .Hundred . . . Moorowie . .

Latitude . 35°, 01' 10" S . . . . . Longitude . 137° 29' 45" E. . . . . .

Depth . . Approx. 8 feet . . . . . .

Formation . . . . . .

Sample No. . . . . Sampler . . . . . .Date . . .

	Parts per Million	Assumed Composition of Salts	Parts per Million
Chloride (Cl)	88,000	Calcium bicarbonate	
Sulphate (SO4)	10,930	Calcium sulphate	
Bi-carbonate (HCO3)	210	Calcium chloride	
Nitrate (NO3)	---	Magnesium bicarbonate	
Sodium (Na)	51,430	Magnesium sulphate	
Potassium (K)	---	Magnesium chloride	
Calcium (Ca)	1,325	Sodium bicarbonate	
Magnesium (Mg)	5,025	Sodium sulphate	
		Sodium chloride	13%
TOTAL	156,920	TOTAL	

Laboratory . . . . . .

Analyst . . . . . Date . May, 1969 . . . . . .

Comments . . . . . .

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WATER ANALYSIS

Drill Hole Name . . . BEACH PETROLEUM STANSBURY WEST No. 1 . . . . . .

Location . STANSBURY . . . . . .Section . 332 . . . .Hundred . Dalrymple . . .

Latitude . 34°. 54'. 02". S. . . . . Longitude . 137°. 42'. 46". E. . . . .

Depth . . . 1161 . - 1221 feet . . . . . .

Formation . Middle Cambrian "Upper Red-Beds" (Unit 1) . . . . . .

Sample No. . D.S.T. No. 1 . . . Sampler . . . T. R. Watts . . . . . .Date . 16/5/66

	Parts per Million	Assumed Composition of Salts	Parts per Million
Chloride (Cl)	7,940	Calcium bicarbonate	90
Sulphate (SO4)	1,860	Calcium sulphate	1,865
Bi-carbonate (HCO3)	54	Calcium chloride	---
Nitrate (NO3)	---	Magnesium bicarbonate	---
Sodium (Na)	4,938	Magnesium sulphate	682
Potassium (K)	----	Magnesium chloride	446
Calcium (Ca)	585	Sodium bicarbonate	---
Magnesium (Mg)	252	Sodium sulphate	---
		Sodium chloride	12,546
TOTAL	15,629	TOTAL	

Laboratory . Australian Mineral Development Laboratories . . . . . .

Analyst . . . . . Date . . . . 31/5/66 . . . .

Comments . A.M.D.L. Report No. AN.2688/66 Sample 520 feet above test tool. . .

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WATER ANALYSIS

Drill Hole Name . . BEACH PETROLEUM STANSBURY WEST No. 1 . . . . . .

Location . . . Stansbury . . . . Section . . 332 . . . Hundred . . Dalrymple . . .

Latitude . 34° 54' 02" S. . . . . Longitude . 137° . . 42' 46" E . . . .

Depth . . 1161 . - 1221 feet . . . . . .

Formation . . Middle Cambrian "Upper Red-Beds" (Unit 1) . . . . . .

Sample No. D.S.T. No. 1 . . . . Sampler . . . T. R. Watts . . . . . Date 16/5/66

	Parts per Million	Assumed Composition of Salts	Parts per Million
Chloride (Cl)	6,540	Calcium bicarbonate	87
Sulphate (SO4)	1,679	Calcium sulphate	1,454
Bi-carbonate (HCO3)	52	Calcium chloride	---
Nitrate (NO3)	----	Magnesium bicarbonate	---
Sodium (Na)	4,248	Magnesium sulphate	797
Potassium (K)	----	Magnesium chloride	---
Calcium (Ca)	463	Sodium bicarbonate	---
Magnesium (Mg)	161	Sodium sulphate	25
		Sodium chloride	10,780
TOTAL	13,143	TOTAL	

Laboratory . . Australian Mineral Development Laboratories . . . . . .

Analyst . . . . . Date . . . . 31/5/69 . . . .

Comments A.M.D.L. Report AN.2688/66 Sample 770 feet above test tool. . . . . .

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WATER ANALYSIS

Drill Hole Name . BEACH PETROLEUM STANSBURY WEST NO. 1 . . . . . .

Location . . Stansbury . . . . Section . . . 332 . . Hundred . . Dalrymple . . .

Latitude . . 34° 54' 02" S . . . . . Longitude . . 137° 42' 46" E . . . .

Depth . . . . Interval Tested 4191 - 4251 ft. . . . . .

Formation . . Lower Cambrian Kulpara Limestone (Unit 3B) . . . . . .

Sample No. . D.S.T. 4 (1) . . . Sampler . . . . T.R. Watts . . . . . Date . 10/6/66

	Parts per Million	Assumed Composition of Salts	Parts per Million
Chloride (Cl)	73,420	Calcium bicarbonate	124
Sulphate (SO4)	823	Calcium sulphate	1,166
Bi-carbonate (HCO3)	93	Calcium chloride	1,382
Nitrate (NO3)	Nil	Magnesium bicarbonate	----
Sodium (Na)	46,500	Magnesium sulphate	----
Potassium (K)	408	Magnesium chloride	682
Calcium (Ca)	873	Sodium bicarbonate	----
Magnesium (Mg)	174	Sodium sulphate	----
Lithium (Li)	2	Sodium chloride	118,149
		Potassium chloride	778
TOTAL	122,293	TOTAL	

Laboratory . . Australian Mineral Development Laboratories . . . . . .

Analyst . . . . . Date . . 1/7/66 . . . . . .

Comments . . A.M.D.L. Report AN.2953/66 . . . . . .

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WATER ANALYSIS

Drill Hole Name . . BEACH PETROLEUM STANSBURY WEST NO. 1 . . . . . .

Location . . Stansbury . . . . . Section . . 332 . . . Hundred . Dalrymple . . .

Latitude . . 34° 54' 02" S . . . . . Longitude . . 137° 42' 46" E . . . .

Depth . . . Interval tested 4720 - 4832 feet . . . . . .

Formation . Lower Cambrian Kulpara Limestone (Unit 3B) . . . . . .

Sample No. . D.S.T. 5 (4) . . Sampler . . . T. R. Watts . . . . . Date 14/6/66

	Parts per Million	Assumed Composition of Salts	Parts per Million
Chloride (Cl)	98,300	Calcium bicarbonate	124
Sulphate (SO4)	1,187	Calcium sulphate	1,682
Bi-carbonate (HCO3)	93	Calcium chloride	1,806
Nitrate (NO3)	nil	Magnesium bicarbonate	---
Sodium (Na)	62,100	Magnesium sulphate	---
Potassium (K)	828	Magnesium chloride	744
Calcium (Ca)	1,178	Sodium bicarbonate	----
Magnesium (Mg)	190	Sodium sulphate	----
Lithium (Li)	3	Sodium chloride	157,926
		Potassium Chloride	1,579
TOTAL	163,879	TOTAL	

Laboratory . Australian Mineral Development Laboratories . . . . . .

Analyst . . . . . Date . . 1/7/66 . . . . . .

Comments . . A.M.D.L. Report AN.2953/66 . . . . . .

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WATER ANALYSIS

Drill Hole Name . . BEACH PETROLEUM STANSBURY WEST NO. 1

Location . Stansbury . . . . Section . . 332 . . Hundred . Dalrymple . . .

Latitude . 34° 54'02" S. . . . . Longitude 137° 42' 46" E. . . . . .

Depth . . . . Interval tested 5724 - 5636 feet . . . . . .

Formation . Lower Cambrian Kulpara Limestone (Unit 3B) . . . . . .

Sample No. D.S.T. No. 6. . . Sampler . . . T. R. Watts . . . . . Date 26/6/66

	Parts per Million	Assumed Composition of Salts	Parts per Million
Chloride (Cl)	92,400	Calcium bicarbonate	267
Sulphate (SO4)	874	Calcium sulphate	1,239
Bi-carbonate (HCO3)	201	Calcium chloride	2,273
Nitrate (NO3)	---	Magnesium bicarbonate	---
Sodium (Na)	58,635	Magnesium sulphate	---
Potassium (K)	---	Magnesium chloride	732
Calcium (Ca)	1,252	Sodium bicarbonate	---
Magnesium (Mg)	187	Sodium sulphate	---
		Sodium chloride	149,038
TOTAL	153,549	TOTAL	

Laboratory . Australian Mineral Development Laboratories . . . . . .

Analyst . . . . . Date . 12/7/66 . . . . . .

Comments . A.M.D.L. Report AN.3071/66 . . . . . .

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WATER ANALYSIS

Drill Hole Name . . . . . BEACH PETROLEUM STANSBURY WEST No. 1 . . . . . .

Location . . . Stansbury . . . . Section . . 332 . . . . Hundred . . Dalrymple . .

Latitude . . . 34° 54' 02" S . . . . . Longitude . . 137° 42' 46" E . . . .

Depth . . Interval tested 5290 - 5315 feet . . . . . .

Formation . Lower Cambrian Kulpara Limestone (Unit 3B) . . . . . .

Sample No. D.S.T. No. 7 . . . . Sampler . . . T. R. Watts . . . . . Date . 27/6/66

	Parts per Million	Assumed Composition of Salts	Parts per Million
Chloride (Cl)	97,800	Calcium bicarbonate	205
Sulphate (SO4)	776	Calcium sulphate	1,100
Bi-carbonate (HCO3)	154	Calcium chloride	2,628
Nitrate (NO3)	---	Magnesium bicarbonate	---
Sodium (Na)	61,945	Magnesium sulphate	---
Potassium (K)	---	Magnesium chloride	826
Calcium (Ca)	1,324	Sodium bicarbonate	---
Magnesium (Mg)	211	Sodium sulphate	---
		Sodium chloride	157,451
TOTAL	162,210	TOTAL	

Laboratory . Australian Mineral Development Laboratories . . . . . .

Analyst . . . . . Date . . . 12/6/66 . . . . .

Comments . . A.M.D.L. Report AN. 3071/66 . . . . . .

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WATER ANALYSIS

Drill Hole Name . BEACH PETROLEUM STANSBURY TOWN NO. 1 . . . . . .

Location . Stansbury . . . . . Section 332 . . . . . Hundred . Melville . . . .

Latitude . 34° 54' 24" S . . . . . Longitude . 137° 46' 46" E . . . . .

Depth . . 3,558 to 3,671 feet. . . . . .

Formation Lower Cambrian Kulpara Limestone (Unit 3 B) . . . . . .

Sample No. DST No. 1 . . . . . Sampler R. A. Laws . . . . . Date . . .

	Parts per Million	Assumed Composition of Salts	Parts per Million
Chloride (Cl)	63,100	Calcium bicarbonate	100
Sulphate (SO4)	1,900	Calcium sulphate	2,693
Bi-carbonate (HCO3)	75	Calcium chloride	15,457
Nitrate (NO3)	nil	Magnesium bicarbonate	-
Sodium (Na)	31,300	Magnesium sulphate	-
Potassium (K)	-	Magnesium chloride	6,657
Calcium (Ca)	6,400	Sodium bicarbonate	-
Magnesium (Mg)	1,700	Sodium sulphate	-
		Sodium chloride	79,568
TOTAL	104,475	TOTAL	

Laboratory . . . Australian Mineral Development Laboratories . . . . . .

Analyst . . . . . Date . . . 20/6/67 . . . . .

Comments . A.M.D.L. Report AN.3092/67 . . . . . .

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WATER ANALYSIS

Drill Hole Name . . BEACH PETROLEUM STANSBURY TOWN NO.1 . . . . . .

Location . Stansbury . . . . .Section . .332. . . .Hundred . Melville. . ..

Latitude . .34°.54'.24".S. . . . . Longitude . 137°.46'.46".E. . . . .

Depth . . . 4049 to 4162 feet . . . . . .

Formation .Lower Cambrian Transitional Beds (Unit 4). . . . . .

Sample No. D.S.T. No. 2 . . . . Sampler . . . . . R.A. Laws. . . .Date . . .

	Parts per Million	Assumed Composition of Salts	Parts per Million
Chloride (Cl)	62,200	Calcium bicarbonate	153
Sulphate (SO4)	1,750	Calcium sulphate	2,480
Bi-carbonate (HCO3)	115	Calcium chloride	16,980
Nitrate (NO3)	Nil	Magnesium bicarbonate	---
Sodium (Na)	30,375	Magnesium sulphate	---
Potassium (K)	----	Magnesium chloride	6,070
Calcium (Ca)	6,900	Sodium bicarbonate	---
Magnesium (Mg)	1,550	Sodium sulphate	---
		Sodium chloride	77,207
TOTAL	102,890	TOTAL	

Laboratory . Australian Mineral Development Laboratories. . . . . .

Analyst . . . . . Date . 20/6/67 . . . . . .

Comments . A.M.D.L. Report AN3092/67 . . . . . .

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WATER ANALYSIS

Drill Hole Name . BEACH PETROLEUM EDITHBURGH No. 1 . . . . . .

Location . Edithburgh . . . . Section . 113 . . . Hundred . Melville . . .

Latitude . . 35°.06'.10".S. . . . . Longitude 137°.38'.40".E. . . . . .

Depth . 1701 - 1783 feet . . . . . .

Formation Middle Cambrian "Upper Red Beds" (Unit 1). . . . . .

Sample No. D.S.T.1 . . . . . Sampler . . R.A. Laws . . . . . Date 14/9/66

	Parts per Million	Assumed Composition of Salts	Parts per Million
Chloride (Cl)	36,900	Calcium bicarbonate	198
Sulphate (SO4)	1,720	Calcium sulphate	2,438
Bi-carbonate (HCO3)	149	Calcium chloride	13,290
Nitrate (NO3)	Nil	Magnesium bicarbonate	---
Sodium (Na)	16,700	Magnesium sulphate	----
Potassium (K)	----	Magnesium chloride	3,556
Calcium (Ca)	5,570	Sodium bicarbonate	---
Magnesium (Mg)	908	Sodium sulphate	---
		Sodium chloride	42,460
TOTAL	61,947	TOTAL	

Laboratory . . . . . Australian Mineral Development Laboratories . . . . . .

Analyst . . . . . M.R. Hanckel . . . . . Date . . . 12/10/66. . . . .

Comments . Australian Mineral Development Laboratories. Report AN810/67. . . .

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WATER ANALYSIS

Drill Hole Name . BEACH PETROLEUM EDITHBURGH No. 1 . . . . . .

Location . . Edithburgh . . . Section . . 113 . . . Hundred . . Melville . . .

Latitude . 35°. 06'. 10". S. . . . . Longitude . 137°. 38'. 40". E. . . . .

Depth . . . 2206 - 2298 feet . . . . . .

Formation . Lower Cambrian. Kulpara. Limestone. (Unit. 3B). . . . . .

Sample No. . D.S.T. No. 2 . . Sampler . . . R. A. Laws. . . . . .Date 17/9/66

	Parts per Million	Assumed Composition of Salts	Parts per Million
Chloride (Cl)	58,600	Calcium bicarbonate	118
Sulphate (SO4)	1,350	Calcium sulphate	1,913
Bi-carbonate (HCO3)	89	Calcium chloride	20,690
Nitrate (NO3)	Nil	Magnesium bicarbonate	---
Sodium (Na)	27,200	Magnesium sulphate	---
Potassium (K)	----	Magnesium chloride	4,700
Calcium (Ca)	8,060	Sodium bicarbonate	---
Magnesium (Mg)	1,200	Sodium sulphate	---
		Sodium chloride	69,080
TOTAL	96,499	TOTAL	

Laboratory . Australian Mineral Development Laboratories . . . . . .

Analyst . . . M.R. Hanckel . . . . . Date . . 12/10/66 . . . . .

Comments . . A.M.D.L. Report 810/67. . . . . .

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WATER ANALYSIS

Drill Hole Name . . BEACH PETROLEUM EDITHBURGH No. 1

Location . . Edithburgh . . . Section . 113 . . . Hundred . . Melville

Latitude . 35° 06' 10" S . . . . . Longitude . 137° 38' 40" E. . . . .

Depth . . 2630 - 2827 feet . . . . . .

Formation . Lower Cambrian Kulpara Limestone (Unit 3B) . . . . . .

Sample No. D.S.T. No. 3 Sampler . R.A. Laws Date 20/9/66

	Parts per Million	Assumed Composition of Salts	Parts per Million
Chloride (Cl)	73,800	Calcium bicarbonate	138
Sulphate (SO4)	1,290	Calcium sulphate	1,826
Bi-carbonate (HCO3)	104	Calcium chloride	23,780
Nitrate (NO3)	Nil	Magnesium bicarbonate	---
Sodium (Na)	35,500	Magnesium sulphate	---
Potassium (K)	---	Magnesium chloride	5,290
Calcium (Ca)	9,160	Sodium bicarbonate	.---
Magnesium (Mg)	1,350	Sodium sulphate	---
		Sodium chloride	90,200
TOTAL	121,204	TOTAL	

Laboratory . . Australian Mineral Development Laboratories . . . . . .

Analyst . . M.R. Hanckel . . . . . Date . . . . . 12/10/66 . .

Comments . . . A.M.D.L. Report AN810/67 . . . . . .

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WATER ANALYSIS

Drill Hole Name . . BEACH PETROLEUM EDITHBURGH No. 1 . . . . . .

Location . Edithburgh . . . .Section . . 113 . . .Hundred . . Melville . . .

Latitude . 35° 06' 10" S . . . . . Longitude . . 137° 38' 40" E . . .

Depth . . . 3028 - 3216 feet . . . . . .

Formation . Lower Cambrian Kulpara Limestone (Unit 3B). . . . . .

Sample No. . . D.S.T. No. 4 . Sampler . . R. A. Laws . . . . . .Date 23/9/66

	Parts per Million	Assumed Composition of Salts	Parts per Million
Chloride (Cl)	72,500	Calcium bicarbonate	174
Sulphate (SO4)	994	Calcium sulphate	1,409
Bi-carbonate (HCO3)	131	Calcium chloride	23,902
Nitrate (NO3)	nil	Magnesium bicarbonate	---
Sodium (Na)	34,500	Magnesium sulphate	---
Potassium (K)	---	Magnesium chloride	5,404
Calcium (Ca)	9,090	Sodium bicarbonate	---
Magnesium (Mg)	1,380	Sodium sulphate	---
		Sodium chloride	87,706
TOTAL	118,595	TOTAL	

Laboratory . . . Australian Mineral Development Laboratories. . . . . .

Analyst . . M.R. Hanckel. . . . . Date . . . . . 17/11/66 . .

Comments . . . A.M.D.L. Report AN874/67 . . . . . .

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APPENDIX II

LEASE DETAILS

APPENDIX II

A. LIST OF MISCELLANEOUS LEASES OVER SOUTHERN YORKE PENINSULA.

(To Accompany Enclosure 1)

Miscellaneous Lease No.	Company	Aquired	Expires
15	Australian Salt	1.1.64	31.12.84
19	Australian Salt	1.4.65	31.3.86
20	Australian Salt	1.4.65	31.3.86
30	Australian Salt	1.7.66	30.6.87
31	Australian Salt	1.7.66	30.6.87
32	Sharpe K.J.	1.10.66	30.9.71
34	Australian Salt	1.1.61	31.12.81
35	Australian Salt	1.1.61	31.12.81
38	Colonial Sugar Ref. Co.	1.7.48	30.6.69
42	Australian Salt	1.7.49	30.6.70
45	Maas W. & R.	1.7.50	30.6.71
134	Olsson Ind. Pty. Ltd.	1.1.62	31.12.82
240	Colonial Sugar Ref. Co.	1.7.62	30.6.83
296	Giles R.H., F.N. & M.	1.1.54	31.12.74
297	Australian Salt	1.1.54	31.12.74
307	Estate Bishop H.J.	1.1.54	31.12.74
310	Giles R.H., F.N. & M.	1.1.54	31.12.74
382	Jenzen A.E.	1.7.55	30.6.76
424	Page E.A.	1.4.58	31.3.79
453	Olsson Ind. Pty. Ltd.	1.7.59	30.6.80
517	Jenzen A.E.	1.10.67	30.9.72
539	Jarvis J.H.	1.10.48	30.9.69
550	Estate Schulz E.P.	1.7.50	30.6.71
599	Colonial Sugar Ref. Co.	1.10.55	30.9.76
614	Colonial Sugar Ref. Co.	1.4.57	31.3.78
619	Peter Cameron Sales and Aldenhoven F. & R.E.	1.4.57	31.3.78
658	Olsson Ind. Pty. Ltd.	1.1.60	31.12.80
685	Adelaide Cement Co.	1.1.63	30.6.80
(G) 689	Aldenhoven F. & Fitch L.R.	1.10.63	30.9.84
(G) 690	Aldenhoven F. & Fitch L.R.	1.10.63	30.9.84
(G) 691	Aldenhoven F. & Fitch L.R.	1.10.63	30.9.84
703	Aldenhoven F. & Fitch L.R.	1.7.64	30.6.85
705	Australian Salt	1.10.64	30.9.85
726	Science Aids (Aust.) Pty. Ltd.	1.4.68	31.3.73
736	Aldenhoven F. & Fitch L.R.	1.10.68	30.9.71

(G) = Gypsum
Remainder Salt.

Appendix II

B. LIST OF SPECIAL MINING LEASES OVER SOUTHERN YORKE PENINSULA

	Company	Aquired	Expires	Area
S.M.L. 187	Geosurveys of Aust. Pty. Ltd.	7.5.68	31.3.70	460 square miles
S.M.L. over Peesey Swamp (Number not yet allotted)	Geosurveys of Aust. Pty. Ltd.	1.5.69	1.11.69	92 square miles

YORKE PENINSULA

GENERALISED GEOLOGICAL MAP OF PRE-QUATERNARY ROCKS

REFERENCE

CAINOZOIC

TERTIARY

PLIOCENE

Tp — *HALLETT COVE SANDSTONE*: *Thin sandy limestones with oysters.*

MIOCENE

Tm — *MELTON LIMESTONE*: *Gritty and conglomeratic bryozoal limestones.*

OLIGO-MIOCENE

To-m — *PORT WILLUNGA BEDS*: *Soft bryozoal sandy limestones.* *POINT TURTON LIMESTONE.*

EOCENE

Te — *BLANCHE POINT MARLS*: *Pink silicified sandstone.* *MULOOWURTIE CLAYS*: *Coarse lignitic sands.*

PERMIAN

P — *Boulder till with erratics derived from the south-east, fluvioglacial sands, claystones with marine foraminifera.*

PALAEOZOIC

CAMBRIAN

MIDDLE

€mr — *RAMSAY LIMESTONE*: *Mottled dark blue and buff limestone.*

€lc — *Red bed clastics, evaporites, conglomerates, arkose.*

LOWER

€lp — *PARARA LIMESTONE*: *Mottled dark blue and buff limestone.*

€lk — *KULPARA LIMESTONE*: *Grey and blue-grey limestones.*

PROTEROZOIC

Ps — *Dark blue-grey or green-grey tillite of overthrust remnant.* (*? STURT TILLITE*)

P — *Coarse and medium grained conglomeratic and arkosic sandstone.* (*Shield Proterozoic*)

ARCHAEAN

MOONTA PORPHYRY: *Felspar porphyry.* (*Age uncertain*)

A — *Undifferentiated paragneisses, schists and calc-silicate rocks. Granites, pegmatites, aplite shown by + where known. Hornblendite.*

GEOLOGICAL BOUNDARIES

NORMAL FAULTS, DOWN THROW ON EAST SIDE

POST-CAMBRIAN PRE-PERMIAN THRUST

BEDDING

STRIKE AND DIP

HORIZONTAL

FOLIATION OF PARAGNEISSES

SYNCLINE

ANTICLINE

ROADS

RAILWAY

SALT LAKES AND LAGOONS, SWAMP

SUBMARINE FORM LINES (FATHOMS)

CONTOURS (100 FEET INTERVAL)

Geology by A. R. CRAWFORD, M.Sc.
Department of Mines, South Australia.

Prepared by R.C.K.

SCALE
8 MILES TO 1 INCH

MILES 4 2 0 4 8 12 16 20 24 28 32 MILES

KILOMETRES 10 0 10 20 30 40 KILOMETRES

H. J. WALL, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.

ENV 1063(1)-1

MAITLAND

GEOLOGICAL SURVEY OF SOUTH AUSTRALIA
DEPARTMENT OF MINES ADELAIDE

AUSTRALIA 1:253,440
Map Corners from data available at publication.

4 MILE GEOLOGICAL SERIES SHEET I 53-12 ZONE 5

FIRST EDITION 1960

SECTION A—A'
Vertical scale 2000 feet to 1 inch

SECTION B—B'
Vertical scale 2000 feet to 1 inch

SECTION C—C'
Vertical scale 2000 feet to 1 inch

SECTION D—D'
Vertical scale 2000 feet to 1 inch

SECTION E—E'
Vertical scale 4000 feet to 1 inch

REFERENCE

CAINOZOIC — QUATERNARY — PLEISTOCENE—RECENT
- Qr — *Alluvium and low angle slope deposits.*
- Qrs — *Saline swamps, often with sheet kunkar. Salt flats. Salt lakes with gypsum dunes.*
- Qrd — *Beach sand and back shore dunes. Older dunes of former marine strait in Peesey Swamp. Redistributed sand spreads and low dunes.*
- Qrw — *Downwash. High angle slope deposits and fault scarp debris.*
- Qrr — *Raised beaches and marine shelly limestones. Beach dune ridges.*
- Qrk — *Older alluvial clays with ferruginous pisolites and felspathic and quartz grit.*
- Qre — *Older fixed desert veif dunes, often strongly kunkarised internally. Associated sand spreads.*
- *Kunkar, undifferentiated according to age and origin, including crusts, sheets, calcareous loess with concretions and reworked, recemented material. Coastal aeolianite.*

CAINOZOIC — PLEISTOCENE
- Qpm — *Red current-bedded often gravelly sandy clays with thin alunite seams of coastal cliffs. ARDROSSAN CLAYS AND SANDROCK. Indurated gritty sandy mottled clays and silts with gravel bands.*

CAINOZOIC — TERTIARY — PLIOCENE
- Tp — *HALLETT COVE SANDSTONE. Thin sandy limestones with abundant pelecypods.*

CAINOZOIC — TERTIARY — LOWER MIOCENE
- Tm — *MELTON LIMESTONE. Sandy red gritty limestones and conglomeratic cross-bedded bryozoal limestones with Lepidocyclina.*

CAINOZOIC — TERTIARY — OLIGO-MIOCENE
- To-m — *PORT WILLUNGA BEDS. Soft bryozoal sandy limestones of the east coast, overlying PORT JULIA GREENSAND. Limestone at Uramia. POINT TURTON LIMESTONE with Victoriella.*

CAINOZOIC — TERTIARY — UPPER EOCENE — MIDDLE EOCENE
- Te — *BLANCHE POINT MARLS. Yellow and pink silicified sandstone with Turritella aldinga of the Ardrossan-Price area. Quartzitic sandstone of Rocky Point. MULOOWURTIE CLAYS. Ochreous sandy clays with lenses of shelly limestone. Cross-bedded coarse sands with lignite of Kulpara, Price and Ardrossan.*

UPPER PALAEOZOIC — PERMIAN
- P — *Boulder till with erratics derived from the south-east. Deltaic sandy claystones. Fluvioglacial sands.*

LOWER PALAEOZOIC — CAMBRIAN — MIDDLE
- Cmr — *RAMSAY LIMESTONE. Mottled dark blue and buff argillaceous limestone with Girvanella and Redlichia.*
- Clc — *Red bed clastics and evaporites. Conglomerates, sedimentary breccias and arkose of Rocky Point and Pine Point.*

LOWER
- Clp — *PARARA LIMESTONE. Mottled dark blue and buff argillaceous limestone with Pararaia and Archaeocyatha.*
- Clk — *KULPARA LIMESTONE. Grey and blue-grey limestones with "Collenia" and Archaeocyatha in upper part. White shales at base.*

ARCHAEAN PROTEROZOIC
- P — *Massive quartz conglomerates and felspathic cross-bedded sandstones, locally passing upwards into fine-grained red sandstones and shales.*
- A — *Undifferentiated sedimentary gneisses, schists and calc-silicate rocks. Granites, pegmatite, aplite (shown by symbol +). Hornblendite. MOONTA PORPHYRY (unexposed).*

GEOLOGICAL BOUNDARIES
- OBSERVED
- APPROXIMATE
- SUB-QUATERNARY LIMIT OF TERTIARY DEPOSITS
- SUB-QUATERNARY LIMIT OF PERMIAN DEPOSITS
  - PROBABLE
  - INFERRED
- SUB-QUATERNARY BOUNDARY BETWEEN PROTEROZOIC AND CAMBRIAN
  - PROBABLE
  - INFERRED
- SUB-QUATERNARY BOUNDARY BETWEEN ARCHAEAN AND PROTEROZOIC
  - PROBABLE
  - INFERRED
- SUB-QUATERNARY OUTCROP OF MOONTA PORPHYRY
- NORMAL FAULTS, DOWN THROW ON EAST SIDE
- SCARPS FACING EAST, PROBABLY NORMAL FAULTS
- BEDDING
  - STRIKE AND DIP
  - HORIZONTAL
  - VERTICAL
- GNEISSOSITY, SCHISTOSITY
  - VERTICAL
- MAIN ROAD
- ROAD
- TRACK
- RAILWAY
- EPHEMERAL STREAM
- SWAMP
- SALT LAKES AND LAGOONS
- SUBMARINE FORM LINES 15 FATHOM INTERVAL)
- CONTOURS (50 FEET INTERVAL)
- SEIF DUNE CRESTS
- TRIANGULATION STATION
- QUARRY
- BORES WITH SEQUENCE OF STRATA
- MINE SHAFT OR PROSPECTING PIT
- GLACIAL ERRATIC
- IRON — Fe — ALUNITE — Al
- COPPER — Cu — PHOSPHATE — Ph

TECTONIC SKETCH

Middle Cambrian
Lower Cambrian (Parara Limestone clastics and red beds)
Lower Cambrian (Kulpara Limestone)
Proterozoic
Archaean
Moonta Porphyry (Intrusive)
Granites, Pegmatites
Bedding foliation of gneisses and schists
Coincazoic Normal Faults or Monoclines
Post-Cambrian Pre-Permian Thrust
Stratigraphic Bores

LEGEND

CAINOZOIC — QUATERNARY — PLEISTOCENE—RECENT
- Qrd — *Modern beach sand and coastal dunes.*
- Qrl — *Saline swamps, often with sheet kunkar. Salt flats. Salt and gypsum lakes. Gypsum dunes.*
- Qre — *Older dunes of former marine straits and coasts, kunkarised.*
- Qrr — *Beach dune ridges, partly kunkarised.*
- Qrk — *Kunkar undifferentiated according to age and origin, including crusts, sheets, calcareous loess, with concretions and reworked recemented material.*
- Qrc — *Aeolianite and aeolianite kunkar exposed in coastal cliffs.*

CAINOZOIC — PLEISTOCENE
- Qpm — *Red clays with thin alunite seams of Waterloo Bay Cliffs. ARDROSSAN CLAYS AND SANDROCK: Red gravelly sandy clays mottled by laterisation exposed in Giles Point Cliffs.*

CAINOZOIC — TERTIARY — PLIOCENE
- Tp — *HALLETT COVE SANDSTONE: Thin sandy limestones with abundant pelecypods. Thin oyster beds of Giles Point and De Mole Point.*

CAINOZOIC — TERTIARY — OLIGO-MIOCENE
- To-m — *PORT WILLUNGA BEDS: Soft Bryozoal sandy limestones of the east and south coast, exposed only in cliffs.*

UPPER PALAEOZOIC — PERMIAN
- P — *Boulder till with erratics derived from the south- east. Deltaic sandy claystones with marine foraminifera. Fluvioglacial sands.*

ARCHAEAN PROTEROZOIC
- A — *Undifferentiated sedimentary gneisses with mainly con-cordant amphibolites, graphic granite, and pegmatite.*

GEOLOGICAL BOUNDARIES
- SUB-QUATERNARY LIMIT OF OLIGO-MIOCENE (INFERRED)
- SUB-QUATERNARY LIMIT OF PLIOCENE (INFERRED)
- BEDDING
  - STRIKE AND DIP
  - VERTICAL
- GNEISSOSITY, SCHISTOSITY
- MAIN ROAD
- ROAD
- TRACK
- SALT LAKES AND LAGOONS
- SWAMP
- FORM LINES (50 FEET INTERVAL)
- SUBMARINE FORM LINES (5 FATHOM INTERVAL)
- TRIANGULATION STATION
- BORES WITH SEQUENCE OF STRATA
- GLACIAL ERRATIC
- MINERAL WORKINGS
- GYPSUM — Gp — NATURAL WHITTING — Wh

Geology by A. R. CRAWFORD, M.Sc.
B. P. Webb, M.Sc., Senior Geologist in charge of Regional Mapping.
E. S. O'Driscoll, B.Sc., Chief Geologist.

Topography supplied by Photogrammetric Section, Department of Lands, South Australia.

Cartography by Geological Drafting Section, Department of Mines, South Australia.

Compiled under the direction of T. A. Barnes, M.Sc., Government Geologist.

Issued under the authority of the Honourable Sir A. Lyell McEwin, M.L.C., Minister of Mines.

Published 1961

N. J. MALL, GOVERNMENT PHOTOLITHOGRAPHER ADELAIDE

INDEX TO ADJOINING SHEETS
Showing Magnetic Variation

KIMBA, WHYALLA, BURRA, LINCOLN, MAITLAND, ADELAIDE, KINGSCOTE, BARKER

LOCALITY

SOUTH AUSTRALIA

SCALE
4 MILES TO 1 INCH

MILES 2 1 0 2 4 6 8 10 12 14 16 18 20 MILES

KILOMETRES 5 0 5 10 15 20 25 KILOMETRES

RECEIVED 9 JUN 1969 DEPT. OF MINES N.S.W.

ENV 1063(1)-2

SUMMARY OF THE SALT POTENTIAL OF YORKE PENINSULA
Report N° 1969/8 Enclosure 4

COMPOSITE WELL LOG
BEACH PETROLEUM N. L.
STANSBURY WEST No.1

PETROLEUM TENEMENT: O.E.L. 24 | STATE: SOUTH AUSTRALIA | 4-MILE SHEET: MAITLAND | BASIN: WILDCAT | WELL STATUS: DRY and ABANDONED

LOCATION: Lat. 34° 54' 02" SOUTH; Long. 137° 42' 46" EAST

ELEVATION: G.L. 310' A.S.L.; K.B. 322' A.S.L.

Date Spudded: 12 May, 1966
Date Drilling Stopped: 24 June, 1966
Date Rig Released: 28 June, 1966

Total Depth: Driller 5724'; E.Log 5725'

Hole Size	Inches	From	To
	17½	Surface	36'
	12¼	36'	600'
	8¾	600'	5724'

Casing Size	Inches	Wt	Depth	Cmt	Cmt'd to
	13⅜	54.5 lbs	36'	15 sacks	Surface
	9⅝	36 lbs	596'	230 sacks	Surface

Cement Plugs	From	To	Sacks
	3340'	3200'	50
	1240'	1100'	50
	660'	520'	50
	Surface	30'	10

Well Head Fitting: Steel Plate Welded on Casing
Driller by: Drillcon
Logged by: Welex
Drilling Method: Rotary
Cemented by: Haliburton
Drafting by: Geodrafting Services

Geological Wellsite Supervision by: D.I. Rutledge, T.R. Watts, J. Gausden of CUNDILL, MEYERS & ASSOCIATES

	GUARD LOG DATA		FORXO – CALIPER DATA		RADIOACTIVITY LOG DATA
RUN NUMBER	1	2	1	2	1
Date	4 June, 1966	25 June, 1966	4 June, 1966	25 June, 1966	25 June, 1966
First Reading	596'	596'	596'	3700'	20'
Last Reading	3828'	5720'	3832'	5724'	5724'
Interval Measured	3232'	5124'	3236'	2024'	5704'
Casing Welex	595'	595'	595'	595'	595'
Casing Driller	596'	596'	596'	596'	596'
Depth Reached	3828'	5725'	3833'	5725'	5725'
Bottom Driller	3829'	5724'	3829'	5724'	5724'
Mud Nature	Bentonite	Bentonite	Bentonite	Bentonite	Bentonite
Density / Viscosity	10·0 / 52	10·3 / 59	10·0 / 52	10·3 / 59	10·3 / 59
Mud Resistivity	2·1 @ 68°F	1·95 @ 68°F	2·1 @ 68°F	1·95 @ 68°F	—
Mud Resistivity BHT	1·5 @ 136°F	—	1·5 @ 136°F	—	—
pH / Fluid Loss cc/30 min.	10·5 / —	10·1 / 5·5	10·5 / —	10·1 / 5·5	10·1 / 5·5
Origin of Sample	Circulation	Pit	Circulation	Pit	Pit
Rmf	1·9 @ 68°F	1·83 @ 68°F	1·9 @ 68°F	1·83 @ 68°F	1·83 @ 68°F
Rmc	2·8 @ 68°F	2·6 @ 68°F	2·8 @ 68°F	2·6 @ 68°F	2·6 @ 68°F
Bit Size	8¾"	8¾"	8¾"	8¾"	8¾"
Casing Size	9⅝"	9⅝"	9⅝"	9⅝"	9⅝"
Truck No.	7889	7889	7889	7889	7889
Recorded by	W. Carter	Myers	W. Carter	Myers	Meyers
Witness	Rutledge	Heisler – Watts	Rutledge	Heisler – Watts	Heisler – Watts

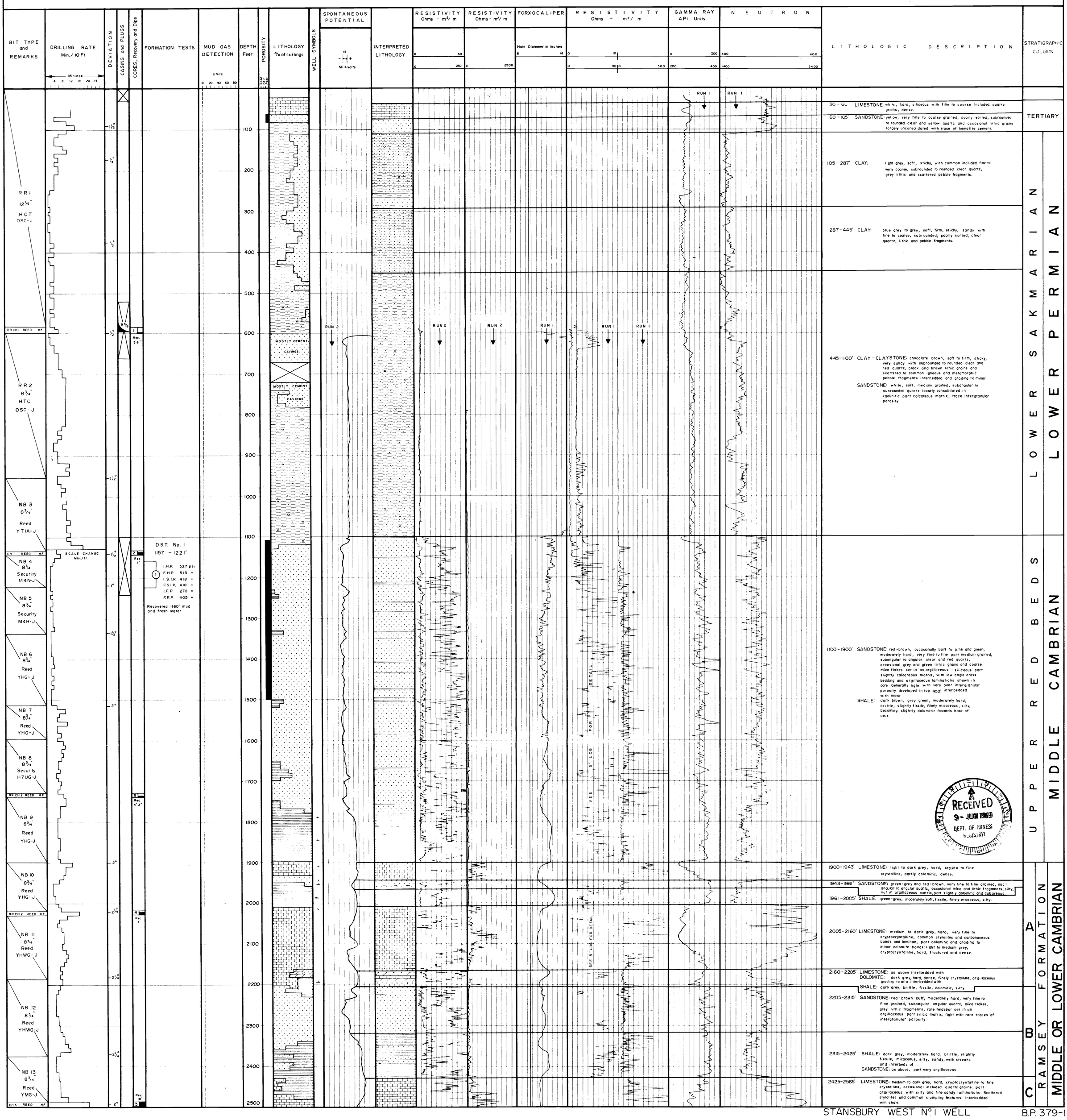
LITHOLOGIC REFERENCE

- Conglomerate, pebble
- Sandstone
- Siltstone
- Clay, claystone
- Limestone
- Dolomite
- Shale
- Granite gneiss
- Micaceous
- Carbonaceous
- Pyritic
- Calcareous
- Dolomitic
- Argillaceous

WELL SYMBOLS

- Circulation loss, partial
- Plugged interval
- Casing shoe
- Core interval, number and recovery
- Formation test, interval, number

Lithology and Composite Log by D. Rutledge T.R. Watts and J. Gausden of CUNDILL, MEYERS & ASSOCIATES



LITHOLOGIC DESCRIPTION

30 – 60' LIMESTONE: white, hard, siliceous with fine to coarse included quartz grains, dense.

60 – 105' SANDSTONE: yellow, very fine to coarse grained, poorly sorted, subrounded to rounded clear and yellow quartz and occasional lithic grains largely unconsolidated with trace of hematite cement.

105 – 287' CLAY: light grey, soft, sticky, with common included fine to very coarse, subrounded to rounded clear quartz, grey lithic and scattered pebble fragments.

287 – 445' CLAY: blue grey to grey, soft, firm, sticky, sandy with fine to coarse, subrounded, poorly sorted, clear quartz, lithic and pebble fragments.

445 – 1100' CLAY – CLAYSTONE: chocolate brown, soft to firm, sticky, very sandy with subrounded to rounded clear and red quartz, black and brown lithic grains and scattered to common igneous and metamorphic pebble fragments interbedded and grading to minor

SANDSTONE: white, soft, medium grained, subangular to subrounded quartz loosely consolidated in kaolinitic part calcareous matrix, trace intergranular porosity.

1100 – 1900' SANDSTONE: red-brown, occasionally buff to pink and green, moderately hard, very fine to fine part medium grained, subangular to angular clear and red quartz, occasional grey and green lithic grains and coarse mica flakes set in an argillaceous – siliceous part slightly calcareous matrix, with low angle cross bedding and argillaceous laminations shown in core. Generally tight with very poor intergranular porosity developed in top 400' interbedded with minor

SHALE: dark brown, grey green, moderately hard, brittle, slightly fissile, finely micaceous, silty, becoming slightly dolomitic towards base of unit.

1900 – 1943' LIMESTONE: light to dark grey, hard, crypto to fine crystalline, partly dolomitic, dense.

1943 – 1961' SANDSTONE: green-grey and red-brown, very fine to fine grained, sub-angular to angular quartz, occasional mica and lithic fragments, silty, set in argillaceous matrix, part slightly dolomitic and calcareous.

1961 – 2005' SHALE: green-grey, moderately soft, fissile, finely micaceous, silty.

2005 – 2160' LIMESTONE: medium to dark grey, hard, very fine to cryptocrystalline, common stylolites and carbonaceous bands and laminae, part dolomitic and grading to minor dolomite bands: light to medium grey, cryptocrystalline, hard, fractured and dense.

2160 – 2205' LIMESTONE: as above interbedded with
DOLOMITE: dark grey, hard, dense, finely crystalline, argillaceous grading to and interbedded with
SHALE: dark grey, brittle, fissile, dolomitic, silty.

2205 – 2315' SANDSTONE: red-brown-buff, moderately hard, very fine to fine grained, subangular angular quartz, mica flakes, grey lithic fragments, rare feldspar set in an argillaceous part silicic matrix, tight with rare traces of intergranular porosity.

2315 – 2425' SHALE: dark grey, moderately hard, brittle, slightly fissile, micaceous, silty, sandy, with streaks and interbeds of
SANDSTONE: as above, part very argillaceous.

2425 – 2565' LIMESTONE: medium to dark grey, hard, cryptocrystalline to fine crystalline, occasional included quartz grains, part argillaceous with silty and fine sandy laminations. Scattered stylolites and common slumping features. Interbedded with shale.

STRATIGRAPHIC COLUMN

TERTIARY

LOWER SAKMARIAN

LOWER PERMIAN

UPPER RED BEDS

MIDDLE CAMBRIAN

RAMSEY FORMATION

A

B

C

MIDDLE OR LOWER CAMBRIAN

RECEIVED 9 JUN 1969 DEPT. OF MINES ADELAIDE

STANSBURY WEST N°1 WELL
COMPOSITE LOG SHEET 1 of 2

B.P. 379-1

1966/16

ENV 1063(1)-3

Report N° 1969/8

Enclosure 5-1

COMPOSITE WELL LOG
STANSBURY WEST No.1
2500 – 5724'

BIT TYPE and REMARKS | DRILLING RATE Min./ft. (Minutes 4 8 12 16 20 24) | DEVIATION | CASING and PLUGS | CORES, Recovery and Dips | FORMATION TESTS | MUD GAS DETECTION (Units 0 20 40 60 80) | DEPTH Feet | POROSITY (Good Poor) | LITHOLOGY % of cuttings | WELL SYMBOLS | SPONTANEOUS POTENTIAL (15 Millivolts) | INTERPRETED LITHOLOGY | RESISTIVITY Ohms – m²/m (0 50 / 0 250) | RESISTIVITY Ohms – m²/m (0 2500) | FORXOCALIPER (Hole Diameter in Inches 6 16) | RESISTIVITY Ohms – m²/m (0 10 / 0 50 0 500) | GAMMA RAY A.P.I. Units (0 200 400 / 200 400 1400) | NEUTRON (400 1400 / 1400 2400)

BIT TYPE and REMARKS

NB 14 8¾" Security H7UG-J
NB 15 8¾" Reed YMG-J
NB 16 8¾" Reed YSG-J
NB 17 8¾" Reed YSIG-J
NB 18 8¾" Reed YSIG-J
NB 19 8¾" Reed YMG-J
CH3 RR REED HF
NB 20 8¾" Reed YHWG-J
NB 21 8¾" YHWG-J Reed
CH4 REED HF
NB 22 8¾" Reed YHG-J
NB 23 8¾ Reed YHG-J
NB 24 8¾" Reed YSIG-J
NB 25 8¾" Reed YHG-J
CH4 RR REED HF
B 26 RR YH WG-J
NB 27 8¾" Reed YCG-J
NB 28 8¾" Reed YCG-J
79 YHG-J Reed 8¾
REED HF
NB 29 8¾" Reed YHG-J
NB 30 8¾" HTC XV
NB 31 8¾" Reed YHWG-J
REED HF
NB 32 8¾" Reed YHG-J
REED HF
NB 32 8¾" Reed YHG-J
NB 33 8¾" Reed YHG-J
NB 34 8¾" H T C X7R
NB 35 8¾" Reed YHWG
NB 36 8¾" Reed YHWG
REED HF
NB 37 8¾" Reed YCG-J
NB 38 8¾" Reed YHWG-J
NB 39 Reed YHG-J
NB 40 8¾" Reed YCG-J
REED HF

DEVIATION: 2½° · 2½° · 2° · 2½° · 2½° · 2¼° · 2½° · 2° · 1½°

CORES, Recovery and Dips: 6 Rec. 6' 6" Dip 5° · 7 Rec. 4' 2" · 8 Rec. 5' 6" · 9 Rec. 6' 6" · 10 Rec. 6" · 11 Rec. 10" · 12 Rec. 5" Dip 5° · 13 Rec. 6" Dip 70°

FORMATION TESTS

D S T No 2
3637 – 3829'
Recovered 500' mud
Misrun

D S T No 3
3639 – 3848'
Recovered 2050' mud

D S T No 4
4191 – 4251'
Recovered 3781' salt water

D S T No. 5
4720' – 4832'
Recovered 3980 salt water

D S T No. 7
5290 – 5315'
Recovered 2430' salt water

D S T No. 6
5636 – 5724'
Recovered 1357' salt water

DEPTH Feet: 2600 · 2700 · 2800 · 2900 · 3000 · 3100 · 3200 · 3300 · 3400 · 3500 · 3600 · 3700 · 3800 · 3900 · 4000 · 4100 · 4200 · 4300 · 4400 · 4500 · 4600 · 4700 · 4800 · 4900 · 5000 · 5100 · 5200 · 5300 · 5400 · 5500 · 5600 · 5700

POROSITY: Py · c · v · Py · Py · Py · Py

WELL SYMBOLS: RUN 2 · RUN 2 · RUN 2 · SEE 5" LOG · SEE 5" LOG · SEE 5" LOG · gn

LITHOLOGIC DESCRIPTION

See previous sheet

2565 – 2715' DOLOMITE: light to medium grey, hard, fine crystalline, part sandy, trace pyrite with calcite veins and gypsum laminations. Interbedded with Shale and Limestone as above.

2715 – 2795' SHALE: red and purple brown, grey, green – grey moderately hard, blocky, brittle, finely micaceous, silty and part dolomitic

2795 – 2818' LIMESTONE: medium to dark grey, hard, cryptocrystalline to fine crystalline, dense, with argillaceous streaks and partings interbedded with
DOLOMITE: light to medium grey, fine crystalline, hard, shaley, dense

2818 – 3035' SHALE: as in 2715 – 2795'

3035 – 3075' LIMESTONE: white, moderately soft, brittle, part chalky, part dolomitic, with dolomite veinlets and trace gypsum.

3075 – 3108' DOLOMITE: white to pink, hard, cryptocrystalline, occasionally argillaceous, with trace calcite veinlets

3108 – 3180' LIMESTONE: dark grey, hard, cryptocrystalline, part very fine crystalline with rare fine calcite veinlets. Dense. Interbedded with
SHALE: dark grey, hard, subfissile to massive, micaceous, part silty, carbonaceous and pyritic.

3180 – 3380' LIMESTONE: light to dark grey, part dark brown, cryptocrystalline, part micro to very fine crystalline, hard, occasional argillaceous streaks and partings, trace irregular stylolites infilled with carbonaceous material, rare pyrite streaks and fractures and fine to medium crystalline calcite veins. Occasional traces intercrystalline, vugular and fracture porosity

3380 – 3610' LIMESTONE: as above, with pink and white dolomite fragments and pink calcite veins. Occasional fine to medium calcite crystals indicating traces of vugular porosity. Some streaks of poor intercrystalline porosity.

3610 – 3710' LIMESTONE: light grey, hard, crypto to occasionally fine crystalline with common fracture porosity

3710 – 3850' LIMESTONE: as above, part very fine sandy and argillaceous with rare nodules of pyrite and rare stylolites.

3850 – 3930' LIMESTONE: medium to dark grey, hard, very fine, part fine crystalline, common stylolites,

3930' – 4092' LIMESTONE: as above, cryptocrystalline with rare dolomite interbeds: medium grey, cryptocrystalline, hard, dense.

4092 – 4226' LIMESTONE: as above, slightly argillaceous, with argillaceous streaks and laminations, slightly dolomitic

4226 – 4270' LIMESTONE: medium to dark grey, cryptocrystalline with traces of fine crystalline dolomite and calcite rhombs, dolomitic, interbedded with
DOLOMITE: light grey, crypto to very fine crystalline occasional coarse calcite crystals and pyrite blobs. Common vugs lined with calcite.

4270 – 4825' DOLOMITE: light grey, crypto to very fine crystalline, part fine crystalline, part slightly calcareous with medium to very coarse euhedral to subhedral calcite crystals in part associated with vugular porosity. Occasional sub-horizontal fractures infilled with carbonaceous material, occasional stylolites, carbonaceous streaks and patches. Dense with streaks and interbeds showing poor to good intercrystalline, vugular, microvugular, pin point and fracture porosity, interbedded with minor
DOLOMITE: medium to dark grey, brown, micro to very fine crystalline, argillaceous, rare calcite microveinlets, common fractures, scattered medium to very coarse calcite and dolomite rhombs. Occasional scattered medium to very coarse quartz crystals occurring as vug lining. Generally dense with minor vuggy, fracture and pin point porosity

4825 – 5230' DOLOMITE: as above, light grey, occasionally dark grey, generally dense with poor intercrystalline porosity only.

5230 – 5314' DOLOMITE: light grey to white, micro to fine crystalline, occasional dolomite veinlets, trace carbonaceous material, part subfissile, dense with occasional isolated poor to fair intercrystalline and traces of pin point porosity. Becomes slightly pink in basal 20'.

5314 – 5375' DOLOMITE: white, very fine to fine crystalline, part poor to fair intercrystalline and occasional pin point porosity

5375 – 5420' SANDSTONE: pink, light grey, brown and mauve mottled, very fine to fine, occasionally medium to coarse subangular quartz, reddish feldspar set in a silica part dolomitic matrix, part with included shale fragments grading to and interbedded with grey sandy dolomites and pure dolomitic quartz sandstone. Tight.

5420 – 5640' SANDSTONE: light to medium grey, fine, part medium grained, subangular quartz, trace feldspar, clastic mica, green mafics (epidote?) set in a sparse silicic, slightly dolomitic, part argillaceous matrix, grading to and interbedded with minor
SILTSTONE: grey, silicous, micromicaceous, argillaceous, dolomitic, part sandy. Tight

5640 – 5653' SANDSTONE: light pink, green, grey, fine to very coarse, poorly sorted subrounded quartz, pink and white feldspar minor mica and mafics in a dolomitic part silicic matrix. Tight

5653 – 5708' SANDSTONE: as above, part subrounded to rounded quartz in sparse silicic matrix with poor to fair intergranular porosity

5708 – 5724' GRANITE GNEISS: pink to brown, medium grained, irregular interlocking quartz, feldspar and amphibole (hornblende) in minor feldspathic groundmass. Occasional opaque oxides (magnetite). Strongly foliated with folia at 75°. Fine carbonate veins.

STRATIGRAPHIC COLUMN

PROTEROZOIC
ARCHEAN
TRANSITIONAL BEDS
KULPARA DOLOMITE
PARARA LIMESTONE
FORMATION
RAMSEY
(LOWER RED BED EQUIVALENT)
MBRIAN
MIDDLE CAMBRIAN

RECEIVED 3 JUN 1969 DEPT. OF MINES REGISTRY

1966/16

STANSBURY WEST N°1 WELL
COMPOSITE LOG SHEET 2 of 2

B.P. 379-2

Report N° 1969/8

ENV 1063(1)-3

PORT CLINTON

PRICE

34° 20'

MAITLAND

ARDROSSAN

PORT VICTORIA

VICTORIA

WARDANG ISLAND

34° 30'

S P E N C E R

G U L F

PORT ALFRED

BLACK POINT

34° 40'

CURRAMULKA

MINLATON

PORT VINCENT

S T V I N C E N T

34° 50'

S. M. L. 187

STANSBURY

138° 00'

HARDWICKE BAY

POINT TURTON

WEAVERS LAGOON

WAROOKA

PEESEY SWAMP

MIS. L. 517

MIS. L. 382

MIS. (sett). L. 703

MIS. L. 134

MIS. L. 658

MIS. L. 453

MIS. L. 736

MIS. L. 619

MIS. L. 689

MIS. L. 45

MIS. L. 424

YORKETOWN

MIS. L. 296

MIS. L. 310

WOOL BAY

PORT GILES

COOBOWIE

SALT CREEK BAY

MIS. L. 726

EDITHBURGH

LAKE FOWLER

MIS. L. 307

MIS. L. 15

MIS. L. 35

MIS. L. 34

MIS. L. 42

MIS. L. 31

MIS. L. 30

MIS. L. 19

MIS. L. 685

MIS. L. 297

MIS. L. 599

MIS. L. 614

MIS. L. 38

MIS. L. 240

SCHOOL RES.

MIS. L. 32.

SULTANA POINT

TROUBRIDGE ISLAND

S. M. L.

(Number not yet alloted)

STURT BAY

WATERLOO BAY

137° 20'

137° 30'

137° 40'

137° 50'

35° 00'

35° 10'

ENV 1063

Scale 1:100,000

0 1 2 3 4 5 6 7 Miles

0 1 2 3 4 5 6 7 8 9 10 Kilometres

SUMMARY OF THE SALT POTENTIAL OF YORKE PENINSULA

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LEASE MAP

ROAD MILEAGES

Price — Ardrossan	= 12·5 Miles
Ardrossan — Port Giles	= 45·5 Miles
Weavers Lagoon — Port Giles	= 9·4 Miles
Peesey Swamp — Port Giles	= 17·8 Miles
Lake Fowler — Port Giles	= 10·5 Miles

For information regarding Miscellaneous Lease Areas, see Appendix 2.

For information regarding Port Facilities, see 5. B. Transport and Communications.

GEOSURVEYS of AUSTRALIA Pty. Ltd.

Report Nº 1969/8 Enclosure 1 GEO. 565

ENV 1063-5

PORT CLINTON
PRICE
MAITLAND
ARDROSSAN
PORT VICTORIA
WARDANG ISLAND
PORT VICTORIA
S P E N C E R
G U L F
PORT ALFRED
BLACK POINT
CURRAMULKA
MINLATON
PORT VINCENT
S T V I N C E N T
HARDWICKE BAY
STANSBURY
WEAVERS LAGOON
WAROOKA
PEESEY SWAMP
WOOL BAY
YORKETOWN
PORT GILES
COOBOWIE
S A L T C R E E K B A Y
LAKE FOWLER
EDITHBURGH
SULTANA POINT
TROUBRIDGE ISLAND
S T U R T B A Y
W A T E R L O O B A Y
34° 20'
34° 30'
34° 40'
34° 50'
35° 00'
35° 10'
137° 20'
137° 30'
137° 40'
137° 50'
138° 00'

ENV 1063

Scale 1:100,000

7 Miles
10 Kilometres

SUMMARY OF THE SALT POTENTIAL OF YORKE PENINSULA

SALINITY CONTOURS

Contours at 0·1 %
0·5%
1·0%
5·0%
10·0%
20·0% Total Soluble Salts in Brines

o Shallow Bore Data after S.A. Dept. of Mines

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GEOSURVEYS of AUSTRALIA Pty. Ltd.

Report Nº 1969/8 Enclosure 3 GEO. 567

ENV 1063(1)-6

PORT CLINTON

PRICE

34° 20'

MAITLAND

ARDROSSAN

PORT VICTORIA

WARDANG ISLAND

34° 30'

S P E N C E R

G U L F

P O R T

A L F R E D

BLACK POINT
B.P.N.L. Black Point N° IA

34° 40'

CURRAMULKA

MINLATON

PORT VINCENT

S.A.D.M. Minlaton Strat Bore N°1

S T V I N C E N T

B.P.N.L. Minlaton South N°1

34° 50'

G U L F

HARDWICKE BAY

B.P.N.L. Stansbury West N°1

B.P.N.L. Stansbury Town N°1
STANSBURY

S.A.D.M. Stansbury Strat. Bore

WEAVERS LAGOON

560 ac.

94 ac.

72 ac.

98 ac.

64 ac.

53 ac.

67 ac.

185 ac.

P.O.S. N°1

WAROOKA

PEESEY SWAMP

YORKETOWN

WOOL BAY

PORT GILES

COOBOWIE

S A L T C R E E K

B A Y

LAKE FOWLER
2400 ac.

EDITHBURGH

B.P.N.L. Edithburgh N°1

SULTANA POINT
B.P.N.L. Troubridge N° 1

TROUBRIDGE ISLAND

S T U R T B A Y

W A T E R L O O

B A Y

35° 00'

35° 10'

137° 20'

137° 30'

137° 40'

137° 50'

138° 00'

ENV 1063

Scale 1:100,000

0 1 2 3 4 5 6 7 Miles

0 1 2 3 4 5 6 7 8 9 Kilometres

SUMMARY OF THE SALT POTENTIAL OF YORKE PENINSULA

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REGISTRY

ELEVATION MAP

CONTOUR INTERVAL 100 FEET.
50 FOOT AUXILIARY CONTOURS ARE SHOWN SOUTH OF Lat. 34° 45' AND EAST OF Long. 137° 20'

Lake. Swamp. ⌀ Well.

B.P.N.L. ..... Beach Petroleum N.L.
S.A.D.M. .. South Australian Department of Mines.
P.O.S. ..... Peninsula Oil Syndicate.

GEOSURVEYS of AUSTRALIA Pty. Ltd.

Report N° 1969/8 Enclosure 2 GEO. 566

ENV 1063(D)-7