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FINAL REPORT

PROMOTION OF CHEMICAL INDUSTRIES[1]

JAMAICA

by

H.A. El Sharawy
UNIDO Expert

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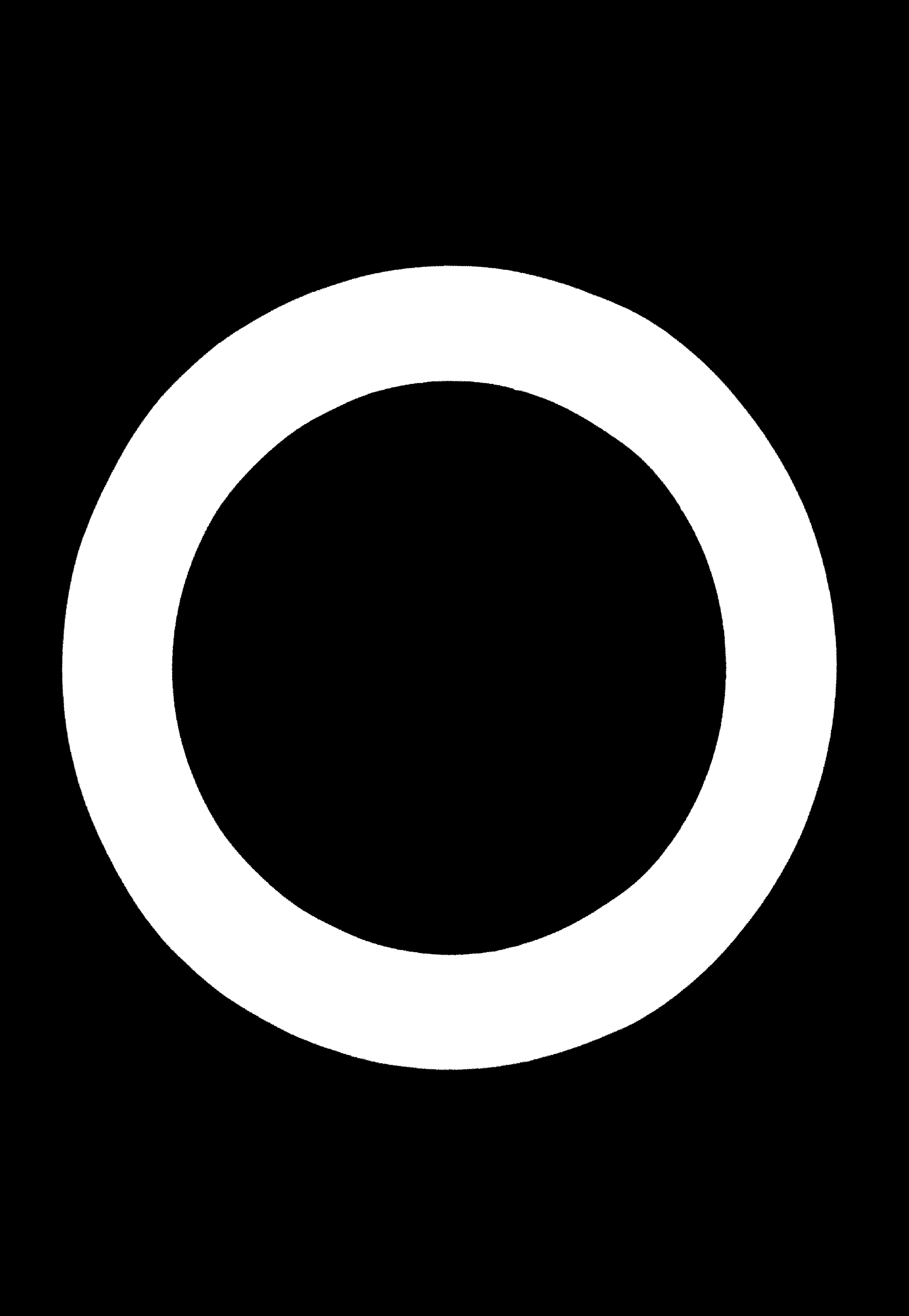

C O N T E N T S

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FINAL REPORT

PROMOTION OF CHEMICAL INDUSTRIES - JAMAICA

RESTRICTED

COUNTRY: JAMAICA

OFFICIAL: H.A.EL SHARAWY

PROJECT NO.: JAM/72/003/A/01/37

FIELD OF WORK : CHEMICAL INDUSTRIES

DATE: JANUARY, 1973

INTRODUCTION

The programme of technical co-operation in industry between Jamaica and UNIDO has recently been expanded to include assistance to specific areas. Thus, according to a previous project, a UNIDO Chemical Industries Expert was assigned to the Jamaica Industrial Development Corporation (JIDC). He first carried out an over-all survey of the situation in the country, and then, according to his first assessment, he identified some potential foreseeable projects especially those based on locally available raw materials.

Because of the importance to the national economy, the Government of Jamaica requested this new project, which is actually an extension of the previous one, to provide assistance primarily to the development and diversification of Chemical Industries in Jamaica especially by the establishment of resource-based industries.

The immediate objectives of the project are:-

a. To carry out research and conduct feasibility studies for foreseeable chemical industries projects with particular reference to the utilization of local raw materials and the establishment of resource-based industries.

b. To provide technical and consultancy services to the JIDC and other industrial establishments whenever necessary.

In the work done in this project, special attention has been given to the most promising of chemical industries possibilities foreseeable for the near future, namely:-

- Solar Salt Production
- Manufacture of Caustic Soda
- Chemical Complex based on Salt and products from the newly proposed Refinery
- The use of Cassava Starch as settling aid in Alumina Processing
- Manufacture of Starch from Cassava
- Manufacture of Glucose from Cassava or Imported Starch.

Other aspects of work done covered technical and consultancy assistance to the JIDC and other industrial establishments such as necessary investigations regarding the application of industrial incentives to new projects, assistance in formulating plans for expansion of existing industries or recommendations on approach to certain questions or comments.

Work done is discussed below.

I. WORK DONE

1. Follow-up of Previous Studies of Solar Salt Production in Jamaica

A. Previous Recommendations for Solar Salt Project

The following recommendations were proposed by the Expert for implementing solar salt projects in Jamaica at the Yallahs Site and possibly at the West Harbour Site:-

(i) **To expedite the steps to depute a UNIDO Solar Salt Production Expert (according to the terms of reference submitted already to the Government and accepted by UNIDO) since preliminary feasibility studies for Yallahs and West Harbour Sites have been completed, also, because the Ministry of Rural Land Development - now the Ministry of Agriculture - has no objections to the use of the Yallahs Ponds for solar salt production.**

(ii) **At present, because conditions at Yallahs are more positive and mature, it is preferable to use this site primarily for salt production, especially because either of the two proposed projects would satisfy the needs of the local market.
In the future, the West Harbour site could be implemented as its operation would depend on ensured export markets or the manufacture of caustic soda in Jamaica.**

(iii) To identify the topography of the large Yallahs Pond as well as leakage rates and soil conditions at the Pond and the adjacent land.

(iv) If the topography and soil conditions results are positive, a meteorological station should be set up at Yallahs Site.

(v) Project No. 1 of the Yallahs site could be implemented first, then it could possibly be expanded later as Project No. 2.

(vi) In the meantime as the above steps are being taken, formal approval of the Ministry of Agriculture (formerly known as the Ministry of Rural Land Development) should be sought to use the West Harbour Site for salt production.

(vii) To identify the topography of West Harbour and the nearby Ponds, as well as leakage rates and soil conditions.

(viii) If the results from (vii) above were positive, three meteorological stations should be set up at the West Harbour Site to confirm the weather data as suggested in the feasibility study.

B. The Yallahs Project

Because the UNIDO Solar Salt Expert who has been requested by the Government is not yet assigned, the present Expert continued the work on the Yallahs project, hoping that this will assist the Solar Salt Expert when he arrives, and also as a follow-up of the previous work. For this reason the Expert had discussion with D. E. Robinson, Head of the Geology Department of the University of the West Indies, and requested the Department to carry out the necessary steps to fulfill recommendation (iii) mentioned before with regard to the topography, leakage rates and soil conditions at the Yallahs Ponds and the adjacent land.

The Geology Department agreed to undertake the following work which is necessary before implementing the project:-

- Investigation of the sediment in the pond itself and the vicinity to assess the level of the bedrock. This will give the foundation conditions.

- Investigate the geological evolution of the present salt ponds.

- Carry out a hydrological study of the salt ponds for circulation, seepage, etc. This stage includes borings and other soil tests.

This work was not pursued because of the departure of Dr. Robinson for a research mission abroad.

On the other hand, the Expert obtained more up-to-date data on rainfall and evaporation at East Albion near the Yallahs Ponds. The previous data from this meteorological station (on which the Yallahs Project Study was based) was available for only five years from 1966, when the station first started, up to 1970. Together with the new information the available data will cover seven years until the end of 1972. This will help to throw more light on the rainfall and evaporation conditions at this site and will show whether or not there is a deviation from the previously obtained five years data which might affect the feasibility of the project.

Table 1 (page 5) and Table 2 (page 6) show the Seven Years Monthly Rainfall and Evaporation at East Albion respectively.

Examination of the data in Table 1 and Table 2 shows that the averages of annual rainfall and evaporation changed from 40.32" for rainfall and 86.66" for evaporation during the five-year period to 38.51" and 87.45" during the seven-year period. The result is that the average annual net evaporation at the Yallahs site can be assumed now as 48.94" instead of 46.34".

Since the average annual gross evaporation from Class A meteorological pans at Yallahs is 87.45", therefore this figure must be changed to the corresponding evaporation rates from fresh water large reservoirs and from brines having sp. gravity 1.10 (in concentrators) and 1.25 (in crystallizers) thus:

Type	Gross Evaporation (inches/year)
Fresh water Class A pans	87.45
Fresh water large reservoirs (x 0.7)	61.21
Brine having sp. gravity 1.10, i.e. in concentrating ponds (x 0.9)	55.09
Brine having sp. gravity 1.25, i.e. in crystallizing ponds (x 0.8)	48.97

Since the average annual rainfall is 38.51", therefore the net evaporation per year available in the crystallizers at Yallahs would be:

48.97 - 38.51 = 10.46".

TABLE 1

Seven Years Monthly Rainfall in Inches at East Albion (Yallahs Ponds Site)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total Annual
1966									3.71	8.50	8.09	2.60	-
1967	0.88	1.66	0.14	0.02	0.81	2.50	1.40	0.78	4.51	2.60	1.43	0.90	17.63
1968	1.34	2.33	0.76	0.22	1.45	5.35	3.06	2.96	6.93	8.44	0.91	0.48	34.23
1969	2.00	0.07	0.06	1.01	12.99	14.77	2.90	4.01	5.69	10.93	4.42	3.64	62.49
1970	5.82	0.39	0.63	1.35	4.93	3.04	7.37	8.73	5.15	1.91	3.29	1.14	43.75
1971	2.15	1.39	0.90	0.48	1.37	0.89	1.34	7.38	4.29	7.02	7.08	0.35	34.64
1972	2.06	2.34	1.16	0.00	6.01	3.63	0.73	1.03	7.16	7.07	0.03	1.22	32.44
Σ	14.25	8.18	3.65	3.08	27.56	30.18	16.80	24.89	37.44	46.47	25.25	10.33	
	÷	÷	÷	÷	÷	÷	÷	÷	÷	÷	÷	÷	
n (months)	6	6	6	6	6	6	6	6	7	7	7	7	
$\bar{x}$ (monthly average)	2.38	1.36	0.61	0.51	4.59	5.03	2.80	4.15	5.35	6.64	3.61	1.48	38.51

TABLE 2

Seven Years Evaporation in Inches at East Albion (Yallahs Ponds Site)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total Annual
1966									6.60	6.20	6.30	4.96	-
1967	6.20	5.04	8.37	8.40	8.68	7.20	9.61	9.30	8.10	8.06	6.00	6.20	91.16
1968	6.51	5.80	7.13	8.70	9.92	7.80	8.99	8.68	6.60	6.20	5.70	6.82	83.85
1969	6.20	7.00	7.75	8.10	8.06	7.80	7.75	7.44	5.70	7.75	5.40	5.27	84.22
1970	5.56*	6.50	7.43	8.86	8.17*	8.55*	7.75	7.82*	5.52*	6.70*	5.16*	6.15	84.17*
1971	6.20*	6.72	6.82	7.80	8.68	9.30	8.68	7.13	7.20	7.13	8.10	5.89*	89.65
1972	6.82	6.38	6.51	9.00	5.89	7.80	8.99	8.68	6.90	8.68	6.30	6.51	88.46
Σ ÷ n(months)	37.49 ÷ 6	37.44 ÷ 6	44.01 ÷ 6	50.86 ÷ 6	49.40 ÷ 6	48.45 ÷ 6	51.77 ÷ 6	49.05 ÷ 6	46.62 ÷ 7	50.72 ÷ 7	42.96 ÷ 7	41.80 ÷ 7	
$\bar{x}$ (monthly average)	6.25	6.24	7.34	8.48	8.23	8.08	8.63	8.18	6.66	7.25	6.14	5.97	87.45

* Corrected values of evaporation for complete month or year.

This result is more assuring when compared with [illegible]" previously obtained from information covering 5 years only.

Table 3 (page 8) shows the analysis of the monthly rainfall and evaporation data for the Yallahs site (based on 7 years period) and the corresponding evaporations from brines of specific gravity [illegible] and 1.25 on a cumulative basis. The analysis reveals that evaporation conditions in the crystallizers are positive during [illegible] months of the year and are slightly better than those calculated previously on the basis of 5 years period.

The analysis also shows that the salt production cycle and time schedule for operation would remain the same as suggested in the previous study.

Conclusion and Recommendations

It is obvious therefore, that the new information and calculations regarding the Yallahs site are supporting the previous preliminary study and give more assuring results that this project will be feasible subject to the results of the geological and topographical survey, the hydrological study and the soil tests to be carried out on the Ponds and the adjacent land.

To implement this Yallahs Project, it is recommended to speed up the following actions:-

(i) To assign the requested UNIDO Solar Salt Production Expert.

(ii) To carry out the geological and topographical survey, the hydrological study and the soil tests mentioned above.

(iii) To set up a meteorological station at the site to provide specific data for this project, e.g., rainfall, evaporation, sunshine, wind speed and direction, humidity, etc.

TABLE 3

Analysis of Seven Years Monthly Rainfall and Evaporation for East Albion (Yallahs Site)

Month	Rainfall (Inches)	EVAPORATION (Inches)									
		Fresh Water Class A pans (Gross)	Fresh Water Large Reservoirs			Brine - Sp.Gr. 1.10			Brine - Sp.Gr. 1.25		
			gross	net	cumul.	gross	net	cumul.	gross	net	cumul.
Dec.	1.48	5.97	4.18	2.70	2.70	3.76	+2.28	2.28	3.34	+1.95	1.86
Jan.	2.38	6.25	4.38	2.00	4.70	3.34	+1.56	3.84	3.50	+1.12	2.98
Feb.	1.36	6.24	4.37	3.01	7.71	3.93	+2.57	6.41	3.5[illegible]	+2.14	5.12
Mar.	0.61	7.34	5.14	4.53	12.24	4.62	+4.01	10.42	4.11	+3.50	8.62
Apr.	0.51	8.48	5.94	5.43	17.67	5.34	+4.83	15.25	4.75	+4.24	12.86
May	4.59	8.23	5.76	1.17	18.84	5.18	+[illegible]	15.84	4.61	+0.02	12.88
Jun.	5.03	8.08	5.66	0.63	19.47	5.09	+0.06	15.90	4.52	-0.51	12.37
Jul.	2.80	8.63	6.04	3.24	22.71	5.44	+2.64	18.54	4.83	+2.03	14.40
Aug.	4.15	8.18	5.73	1.58	24.29	5.15	+1.00	19.54	4.58	+0.43	14.83
Sep.	5.35	6.6[illegible]	4.66	-0.6[illegible]	23.60	4.2[illegible]	-1.15	18.39	3.73	-1.62	13.21
Oct.	6.64	7.25	5.08	-1.56	22.04	4.57	-2.07	16.32	4.06	-2.58	10.63
Nov.	3.61	6.14	4.30	0.6[illegible]	22.73	3.87	0.26	16.58	3.44	-0.17	10.46
Total	38.51	37.45									

C. **The West Harbour Project**

According to the previous study on the West Harbour site, it was found that the economics of the project could be enhanced and that the project would be feasible if one or both of the two following conditions are satisfactory.

(i) If evaporation rates were favourably higher than those available for this site at the time the previous study was carried out.

(ii) If the rainfall during May until the end of July occurs primarily as a few major showers per month to allow the decantation of nearly 60% of this rainfall before mixing with and diluting the concentrated brine. This would result in having a higher accumulated net evaporation in the crystallizing ponds which would enhance the economics of the project.

Also, in order to be feasible, this project, as in the case of Yallahs, depends on the topography, the hydrological and soil conditions of West Harbour, the other small ponds and the adjacent land.

To develop this foreseeable project further, the Expert in this present assignment tried to obtain more information on evaporation and rainfall as mentioned in (i) and (ii) above.

It was possible, through the Meteorological Office and the Sugar Estate authorities, to obtain a ten days average evaporation at Monymusk (near the site) over a period of five years from 1951-1955 as shown in Table 4 (page 10).

From these figures, the Expert computed five years monthly evaporation at Monymusk, West Harbour site, (from 1951-1955) as shown in Table 5 (page 11).

The average annual evaporation during these five years is 74.71". This is higher than 67.44", the annual average during eleven years (1958-1968) which was obtained in the previous study on this site.

When the total monthly evaporations during these five years were added to the corresponding totals during the other eleven years (1958-1968), new values for average monthly evaporation during 16 years were obtained as shown in Table 6 (page 12). The average annual evaporation during these 16 years is 69.71" instead of 67.44" during 11 years. This increase in evaporation rates is not sufficient as such to enhance the economics of the project and to make it feasible.

TABLE 4

Ten Days Average EVAPORATION (In Inches) at Monymusk

	1951			1952			1953			1954			1955		
	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30
Jan.	.142	.136	.155	.128	.178	.149	.094	.123	.152	.164	.175	.176	.174	.180	.179
Feb.	.190	.178	.227	.157	.178.	.193	.177	.219	.240	.187	.160	--	.241	.194	.218
Mar.	.190	.217	.206	.206	.223	.275	.210	.235	.247	. -	-	-	.184	.226	.269
Apr.	.197	.253	.207	.241	.248	.192	.252	.287	.313	.259	.227	.263	.267	.259	.247
May	.265	.172	.226	.175	.255	.262	.317	.287	.152	.225	.264	.300	.278	.249	.247
Jun.	.213	.297	.226	.210	.241	.277	.205	.212	.172	.246	.222	.260	.228	.242	.275
Jul.	.258	.257	.264	.246	.211	.212	.226	.209	.287	.245	.281	.271	.206	.254	.234
Aug.	.275	.231	.223	.234	.224	.234	.290	.256	.229	.260	.245	.224	.225	.230	.200
Sep.	.164	.231	.160	.177	.222	.168	.199	.170	.142	.174	.233	.199	.193	.202	.196
Oct.	.153	.146	.168	.187	.189	.134	.172	.188	.186	.184	.185	.209	.260	.173	.160
Nov.	.169	.166	.155	.162	.148	.152	.164	.161	.148	.188	.156	.164	.163	.165	.158
Dec.	.159	.153	.176	132	.126	.125	.155	.146	.124	.181	.173	.179	.155	.143	.153

TABLE 5

Five Years Monthly Evaporation in Inches at New Monymusk (West Harbour Site)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
1961	4.46	5.54	6.32	6.57	6.85	7.35	8.06	7.53	5.55	4.84	4.89	5.05	73.01
1962	4.71	5.10	7.29	6.81	7.16	7.29	6.91	7.16	5.67	5.27	4.62	3.97	71.96
1963	3.81	5.94	7.16	8.52	7.81	5.88	7.47	8.00	5.10	5.64	4.74	4.40	74.47
1964	5.33	4.84	5.37	7.50	8.15	7.29	8.25	7.53	6.06	5.98	5.07	5.52	76.89
1965	5.52	6.10	7.01	7.74	8.00	7.44	7.16	6.76	5.91	6.14	4.86	4.65	77.29
Σ 5 years ÷ n(months)	23.83 ÷ 5	27.52 ÷ 5	33.15 ÷ 5	37.14 ÷ 5	37.97 ÷ 5	35.25 ÷ 5	37.85 ÷ 5	36.98 ÷ 5	28.28 ÷ 5	27.87 ÷ 5	24.18 ÷ 5	23.50 ÷ 5	
X̄ 5 years	4.77	5.50	6.63	7.43	7.59	7.05	7.57	7.40	5.66	5.57	4.84	4.70	74.71 Annual average

TABLE 6

Sixteen Years Average Monthly Evaporation in Inches at New Monymusk (West Harbour Site)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
Σ 5 years	23.83	27.52	33.15	37.14	37.97	35.25	37.85	36.98	28.28	27.87	24.18	23.50	
Σ 11 years (1958-1968)	46.81	51.43	66.65	70.80	73.82	69.60	78.43	75.33	62.10	54.87	46.80	44.95	
Σ 16 years	70.64	78.95	99.80	107.94	111.79	104.85	116.28	112.31	90.38	82.74	70.98	68.45	
	÷	÷	÷	÷	÷	÷	÷	÷	÷	÷	÷	÷	
n (months)	16	16	16	16	16	15	16	16	16	16	16	16	
$\bar{\bar{x}}$ 16 years	4.42	4.93	6.24	6.75	6.99	6.55	7.27	7.02	5.65	5.17	4.44	4.28	69.71

It is therefore obvious from the newly obtained data during this assignment, that evaporation conditions at the West Harbour site cannot be different from those considered in the previous study.

The other remaining possibility to enhance the economics of this project and to make it feasible, is whether the rainfall during May until the end of July occurs at this site primarily as a few heavy showers or storms and therefore would allow the decantation of 60% of that rainfall.

As mentioned in the previous study, daily rainfall data for four years (1966-1970) at Monymusk, kindly provided by the West Indies Sugar Company (WISCO), supported this possibility. However, a four-year period would not be enough to draw a definite conclusion as far as this possibility. More daily rainfall information would be indispensable for at least another 4 - 6 years from 1971 to 1974 or to 1976.

Unfortunately the Expert was not able to obtain the 1971 and 1972 information when this was sought from the Sugar Company to throw some light on this hanging possibility.

Conclusion and Recommendations

The possibility of producing about 150,000 tons salt/year (or more) at the West Harbour site is still foreseeable. This project is particularly important because the salt produced could primarily be used as raw material to manufacture caustic soda in Jamaica in close proximity to the bauxite industry.

To complete the feasibility study on this project, it is recommended that the following actions be speeded up:-

(i) To ascertain the assumption that rainfall at the site during May - July occurs as a few heavy showers or storms. This can be reached by studying the daily rainfall data at Monymusk for some years (1971-1974), and by setting three meteorological stations in this comparatively large site to serve this purpose as well as to give information on evaporation and other weather conditions.

These meteorological stations would preferably be established at:

- The south coast of West Harbour;
- East to Mitchell Town and as near as possible from Bog and Boggy Ponds (possibly at Bog Beach);
- On Dolphin Island or on the coast of Peake Bay.

(ii) To carry out the hydrological, topographical and soil tests at West Harbour, the three crystallizing ponds and the adjacent land.

2. Further Study of the Manufacture of Caustic Soda in Jamaica

The possibility of manufacturing caustic soda in Jamaica by the Electrolytic or the Solvay Process was discussed in other reports by the Expert during the previous assignment.

The consumption of caustic soda in Jamaica and other CARIFTA Countries is substantially more than chlorine. The main use of caustic soda in Jamaica is for alumina processing. The combined capacity of the existing alumina plants in Jamaica is more than 2 million tons of alumina per year and is expected to be about 3 million tons by 1975 when the new expansions start production. If the consumption of caustic soda in alumina processing is assumed to be about 10% of the alumina produced (allowing for other uses of caustic soda in alumina plants), then the demand for caustic soda would be at present about 200,000 tons/year (now imported) and about 300,000 tons/year in 1975.

If either of these two amounts of caustic soda is manufactured locally by one of the two manufacturing processes, the price of the local product must be, for obvious reasons, competitive or equal to the imported one.

For this reason it becomes a matter of utmost importance to the economy of the country to compare the merits of the two processes taking into consideration some new foreseen possibilities in Jamaica, namely, if the Refinery Complex Project and perhaps the Solar Salt Project are implemented.

A. In Case the Electrolytic Process is used in Jamaica

This process is generally cheaper than the Solvay Process, especially if cheap electricity is available. The main material and utilities inputs required for the Electrolytic Process are Salt (Sodium Chloride), Electric Power and Fuel.

Salt can either be imported at international prices (about US$5.00 per ton), or may be completely or partially produced locally if the solar salt project is implemented. About 320,000 tons/year of salt will be required if the capacity of the caustic soda plant is 200,000 tons/year or about 480,000 tons/year of salt if the caustic soda plant has a capacity of 300,000 tons/year. These amounts of salt are mentioned to give an idea of the foreign currency part needed in case this raw material is imported.

The products of this Electrolytic Process are caustic soda, chlorine and hydrogen in a ratio of 1.1:1:0.0275 approximately.

<u>The Production Costs of Caustic Soda before Foreseeing the Possibility of Implementing the Refinery Complex</u>

In the report on Chemical Industries in Jamaica of July 197[illegible] by the Expert, estimates of costs of manufacture relevant to different plant capacities in Jamaica were determined and compared with those in the U.S.A. (as a large scale producing and exporting country in the area).

The relations between the different plant capacities and the costs of manufacture were represented graphically (Figure 1, page 16). The graph shows that the optimum capacity would be 200,000-[illegible] tons/year caustic soda. This corresponds to 550-660 tons/day caustic soda and 500-600 tons/day chlorine.

The basis for the production costs and for the comparison in the case of U.S.A. and Jamaica, <u>before foreseeing the possibility of implementing the Refinery Complex</u>, was as follows:

Item	Price in U.S.A. (US$)	Price in Jamaica (US$)
Salt	5.00/ton	5.00/ton
Electric Power	0.006/Kwh	0.012/Kwh
Fuel	0.20/MMBTu	0.37/MMBTu
Labour	4.00/manh.	3.20/manh.
Depreciation	15 years	15 years

On the above basis, the production costs of caustic soda would be determined as follows:

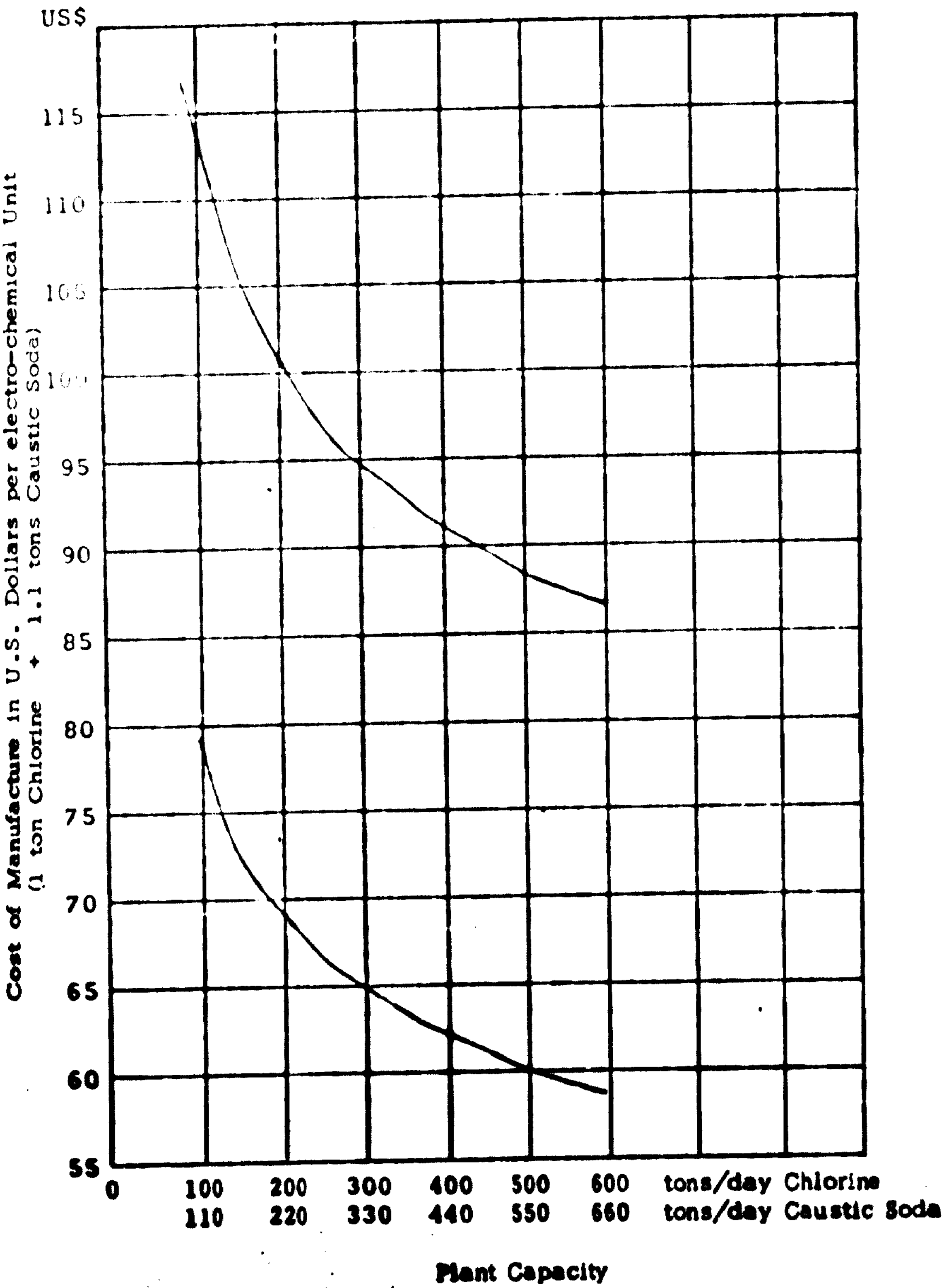
The production costs of 1 electro-chemical unit (i.e., 1.1 tons caustic soda + 1 ton chlorine) is either:

About US$88.20 for a plant capacity of 200,000 tons/year caustic soda in Jamaica as compared with about US$60.50 in U.S.A.

or

About US$86.00 for a plant capacity of 300,000 tons/year caustic soda in Jamaica as compared with about US$58.50 in U.S.A.

FIGURE 1


US$
115
110
105
100
95
90
85
80
75
70
65
60
55
Cost of Manufacture in U.S. Dollars per electro-chemical Unit
(1 ton Chlorine + 1.1 tons Caustic Soda)
0
100 200 300 400 500 600 tons/day Chlorine
110 220 330 440 550 660 tons/day Caustic Soda
Plant Capacity

If the netback for chlorine is assumed to be US$40.00-44.[illegible] per ton (as compared with the current price of US$46.00 per ton f.o.b. Gulf Coast), and,

If it is assumed that this chlorine is sold at a very small or no profit (considered as a by-product which offers difficulty in its disposal),

therefore the production cost of [illegible] by the [illegible] process in Jamaica can be assumed as equal to [illegible].

Since the production cost per electro-chemical unit in Jamaica is estimated as:

US$88.20 for a 200,000 ton/year caustic soda plant
or
US$86.00 for a 300,000 ton/year caustic soda plant,

therefore the production cost of caustic soda in Jamaica [illegible] be estimated as:

US$40.20-43.80/ton caustic soda 50% solution in a 200,000 ton/year caustic soda plant (or US$80.40-87.60/ton caustic soda on dry basis),

or

US$38.20-41.80/ton caustic soda 50% solution in a 300,000 ton/year caustic soda plant (or US$76.40-83.60/ton caustic soda on dry basis).

Profitability of the Electrolytic Process in Jamaica Before Foreseeing the Possibility of Implementing the Refinery Complex

The price of the presently imported caustic soda in Jamaica is about US$50.00/ton 50% solution delivered at alumina plants including duties, transportation, etc. (as calculated in Progress Report of 5th July,1971).

Assuming that the caustic soda produced locally would be sold to the alumina plants at US$50.00/ton as the imported,

therefore, the profitability of the Electrolytic Process in Jamaica (before implementing the Refinery Complex) would be as follows:

The netback for 1.1 ton caustic soda	US$55.00
The netback for 1 ton chlorine	40.00 - 44.00
Total netback for 1 electro-chemical unit	US$95.00 - 99.00

Since the estimated production cost of the electro-chemical unit

= US$88.20 for a 200,000 ton/year caustic soda plant
or
= US$86.00 for a 300,000 ton/year caustic soda plant

therefore Gross Profit

= US$6.80-10.80 in case of a 200,000 ton/year caustic soda plant
or
= US$9.00-13.00 in case of a 300,000 ton/year caustic soda plant.

In the above cases, the Gross Return would be:

(a) For a 200,000 ton/year caustic soda plant -
= 7.7% if the netback for chlorine is US$40.00, or
= 12.2% if the netback for chlorine is US$44.00.

(b) For a 300,000 ton/year caustic soda plant -
= 10.5% if the netback for chlorine is US$40.00, or
= 15.1% if the netback for chlorine is US$44.00.

The Production Costs of Caustic Soda and the Profitability of the Electrolytic Process in Jamaica if the Refinery Complex is Implemented

The situation will change with respect to the following:

(a) Fuel will become available at a cheaper price.

(b) Electric power will become available at a cheaper price.

(c) Chlorine, if produced by the Electrolytic Process, will have an assured local demand either to manufacture Ethylene Dichloride or PVC within the Complex.

As a result of implementing the Refinery Complex, a reduction in the local prices of fuel and electricity will result in improving the economics of the Electrolytic Process to a great extent. Because the extent of this reduction in prices is not known at present, no attempt is made now to show the effect of such reduction on the production costs of the electro-chemical unit in the chlorine-caustic plant.

However, as a result of implementing the Refinery Complex, the price of electricity produced will not be expected to be higher than US$0.009/Kwh, and could be even lower. In other words, it is more likely that there will be a reduction of about US$0.003/Kwh from

US$0.012/Kwh previously taken as basis when estimating the production costs of the Electrolytic Process in Jamaica before foreseeing the implementation of the Refinery Complex.

For every reduction of US$0.001/Kwh in the price of electricity in this process, there will be a reduction of about US$2.80 per electro-chemical unit.

Therefore the new expected price of electricity of US$0.0[illegible] (after implementing the Refinery Project) will result in reducing the cost of production of the electro-chemical unit

from US$88.20 to US$79.80 in a 200,000 ton/year caustic soda plant,

or

from US$86.00 to US$77.60 in a 300,000 ton/year caustic soda plant.

Assuming that the netback for chlorine is US$3[illegible]/ton (considered as a by-product price to overcome the difficulty in its disposal, and to enhance the economics of the other plants to be included in the suggested Chemical Complex for manufacturing Ethylene Dichloride or PVC),

therefore this price will be competitive with the current price of US$46.00/ton chlorine f.o.b. Gulf Coast.

If it is also assumed that this Chlorine is sold at no profit,

therefore the production costs of chlorine by the Electrolytic Process in Jamaica after the implementation of the Refinery Complex can be considered as US$35.00 per ton.

Since the production costs per electro-chemical unit in this case in Jamaica is:

US$79.80 in a 200,000 ton/year caustic soda plant

or

US$77.60 in a 300,000 ton/year caustic soda plant,

therefore the costs of production of caustic soda by the Electrolytic Process in this case would be:

US$40.70/ton in a 200,000 ton/year caustic soda plant

or

US$38.70/ton in a 300,000 ton/year caustic soda plant.

If this locally produced caustic soda would be sold to the alumina plants at US$50.00/ton 50% solution (as the imported price including other expenses and charges),

therefore <u>the total netback for the electro-chemical unit</u> would be

US$35.00 (for 1 ton chlorine) + US$55.00 (for 1.1 tons caustic soda)
= US$90.00.

The Gross Profit in this case would be:

= US$10.20 in the case of a 200,000 ton/year caustic soda plant

or

= US$12.40 in the case of a 300,000 ton/year caustic soda plant.

The Gross Return in the above cases would be:

(a) 12.7% for a 200,000 ton/year caustic soda plant

or

(b) 16% for a 300,000 ton/year caustic soda plant.

If, however, the prices of fuel and electricity are ultimately going to approach the corresponding ones in the U.S.A. as a result of implementing the Refinery Complex, then it can be safely assumed that the production costs of the electro-chemical unit in an Electrolytic Caustic Soda plant in Jamaica would be close to those of a large chlorine-caustic plant in U.S.A., but would still be very slightly higher on account of slight differences in the prices of fuel and electricity. In this case the production costs would be slightly higher than US$60.50 for a 200,000 ton/year caustic soda plant, or slightly higher than US$58.50 for a 300,000 ton/year caustic soda plant.

B. In Case the Solvay Process is Used in Iraq

The main material requirements for this process are salt, limestone (for the production of Carbon Dioxide and lime) and ammonia.

The manufacture of caustic soda by this process takes place in two main operations:

In the first, Soda Ash (or Carbonated Soda) is produced using salt, ammonia and carbon dioxide (obtained from burning of limestone in rotary or shaft furnaces).

In the second main operation, caustic soda is produced by further treating of the soda ash solution (or the Carbonated Soda) with slaked lime, and the subsequent separation of the precipitated calcium carbonate from the solution of caustic soda formed. The caustic soda solution is then concentrated to give marketable qualities of concentration for sale and use.

The second operation of manufacturing caustic soda from soda ash usually takes place in the soda ash plant. However, the two operations can also take place separately. Thus, soda ash available in the market can be causticized with slaked lime to produce caustic soda in a separate plant where the main inputs in this case would be soda ash and lime only.

The amount of salt required in the Solvay Process is larger than the corresponding one in the Electrolytic Process. Thus for the production of 200,000 tons caustic soda by the Solvay Process, about 440,000 tons of salt will be needed, whereas 660,000 tons salt will be required to manufacture 300,000 tons caustic soda. Either all this amount of salt or a good part of it will have to be imported.

Also, a considerable amount of limestone will be needed in the Solvay Process. Thus for every ton caustic soda produced, about 1.8 - [illegible] tons limestone will be required. The purity of limestone should be of high quality, and this locally available material will need transportation to the plant site. The costs of this transportation will probably raise the price of this raw material considerably.

The quantities of ammonia required (as make-up for the loss) are, however, very small in this case. Only about 12 lb. will be required for the production of one ton caustic soda.

Although the manufacture of caustic soda by the Chemical method (Solvay), would eliminate the problem of the chlorine disposal encountered in the Electrolytic Process, yet there seems however little possibility of arriving at a cost lower than US$[illegible]0.00 - 95.00 per ton caustic soda by the Solvay Process. Also, starting from imported soda ash which costs about US$48.00/short ton, the cost of production of caustic soda will unlikely be lower than US$95.00 - 100.00.

The Effect of Implementing the Refinery Complex on the Production Cost of Caustic Soda by the Solvay Process

The availability of cheap electric power as a result of implementing the Refinery Complex, will have little effect on the production cost of caustic soda manufactured by the Solvay Process, since the consumption of electricity is not as considerable as in the Electrolytic Process.

Also, although ammonia could be produced in the complex at a cheap cost from hydrogen gas obtained in the Refinery and from atmospheric nitrogen, yet the quantities of ammonia required in the Solvay Process as mentioned before are so small that variation in its price will be again of little effect.

As regards products and by-products other than Soda Ash and Caustic Soda which could be obtained in the Solvay Process, it is to be noted that a very small market is available for them in the CARIFTA Countries. Although a product such as sodium bicarbonate (Baking Soda) has uses in many industries as medicines, beverages, baking powder, food products and fire extinguishers, yet the limited requirements of the region may not justify its manufacture on a large industrial scale.

3. New Possibilities for the Suggested Chemical Complex

The expert was able to identify and to suggest, during the previous assignment, the opitmum capacities of units of a Chemical Complex based on either locally produced or imported salt. A preliminary economic study was carried out as outlined in a previous report.

It was suggested that the Complex should comprise the following units and capacities:

a. A Chlorine-Caustic plant to produce 200,000 tons/year caustic soda and about 183,000 tons/year chlorine. The capacity of this plant could still be larger than this.

b. An Ethylene Dichloride plant to produce 200,000 tons/year

c. An Ethylene plant to produce about 67,000 tons ethylene from Naphtha in a Stripped-Down plant (by the low-cost Diener Process). Alternatively Ethylene could be imported if Naphtha is not available at an economic price.

d. A Vinyl Chloride plant to produce 15,000 tons monomer/year.

The Complex was reviewed under the present possibility of implementing an Oil Refinery project in Jamaica.

It is planned that the Refinery will produce Naphtha as one of its products, and the Refinery Complex is proposed to include, at different stages, a power plant and an aluminium smelter.

<u>The Situation of the Chemical Complex After the Implementation of the Refinery Project</u>

The following will result from such implementation:

(i) Electricity and fuel will be available at more economic prices than those assumed in the previous studies on the chlorine-caustic plant and the other units of the Chemical Complex.

(ii) The availability of relatively cheap Naphtha from the Refinery will assure the possibility of constructing an Ethylene plant by the Stripped-Down (or the Diancor) Process.

(iii) An Ammonia producing unit could now be added to the Chemical Complex since Hydrogen will be available from the Refinery and can be separated and allowed to react with Nitrogen fixed from the atmosphere.

The proposed capacity of the Ammonia Unit is 60 tons/day to satisfy the requirements of an Ammonium Sulphate plant as well as local and export markets.

It was not possible, however, to complete an economic study for the Ammonia unit because the data and prices of Hydrogen, power and fuel from the Refinery were not available.

(iv) Since ammonia can be produced locally, the manufacture of Ammonium Sulphate fertilizer from Gypsum will be cheaper than the alternative case of depending on imported ammonia from a competitor producer of the fertilizer. A previous economic study of an Ammonium Sulphate plant was not completed because the price of the imported ammonia from the competitor manufacturer was too high to make the project economic.

It is proposed that a plant to produce 70,000 tons ammonium sulphate fertilizer be included in the Chemical Complex of which 50,000 tons will be consumed locally and the rest will be for export.

A diagram outlining the modified Chemical Complex to include the newly proposed units is shown in Figure 2, page 25.

However, for implementing such a Chemical Complex certain specific issues ought to be considered such as:

a. The electric power and fuel costs as compared with elsewhere.

b. The chlorine markets and the possible production of petro-chemicals containing chlorine.

c. The markets for liquid ammonia and ammonium sulphate.

d. The overall economics of the project.

e. The technical assistance required for the development of such complex.

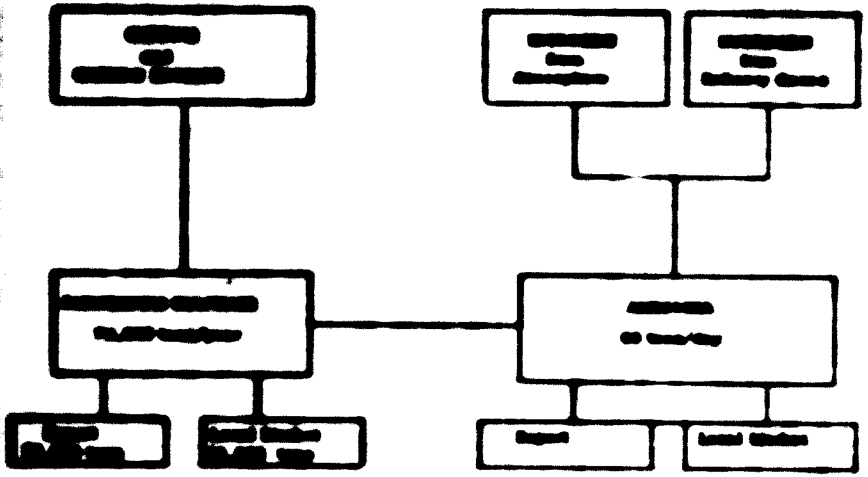
f. The likely incentives and terms and conditions required to attract foreign and local investors.

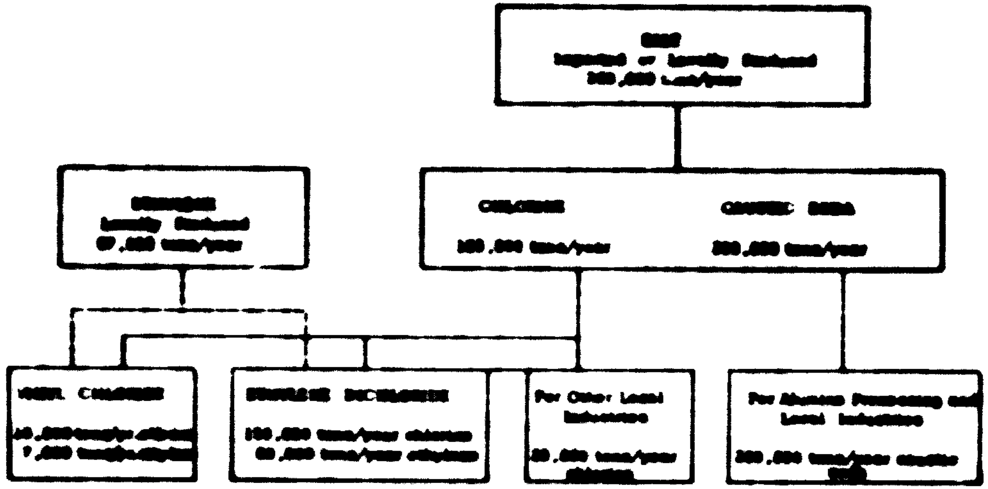
g. The stages according to which the complex could be implemented.

4. <u>The Use of Cassava as a Settling Aid in Alumina Processing</u>

Cassava is indigenous to the Americas and grows well in many tropical countries. Through the history of Jamaica, its people largely depend on Cassava as a food, particularly in the dry areas of South-central St. Elisabeth and Southern Manchester. The plant requires a warm humid climate and a light soil of medium fertility and thus it does well on the marginal terra rosa soil of these Parishes, where other and more remunerative plants cannot be grown.

Flour, meal, bread and bammies can be made from Cassava. It can also be processed into starch. However, this cassava starch has to compete on the world market with starch from maize or corn, sweet potatoes, arrow-roots and sorghum.




Locally Produced
CHLORINE
CAUSTIC SODA
For Other Local

Starch manufactured from cassava is already being experimented with in Mexico, East Africa and other countries.

Other by-products such as glucose and alcohol are being extracted for industrial uses.

Another potential use of Cassava Starch in Jamaica is in Alumina processing as a settling aid. This will be discussed in the following paragraphs together with other starches (flour) currently in use as settling aids in Jamaica.

A. Cassava Starch as a settling aid in Alumina in Jamaica

Cassava starch, like other starches, can be used as a flocculent for aiding the settling of the "red mud" residues obtained while processing alumina from Jamaican bauxite.

In fact, one bauxite company namely, Kaiser Bauxite Company, has already published in a "Report on Cassava Cultivation in St.Elizabeth, Jamaica", that the results obtained by the Company indicated that while an excellent settling aid could be obtained from Cassava, it would not be competitive from a financial standpoint with other settling aids currently available.

A second bauxite company, Alcan Jamaica Limited, carried out some tests on locally produced cassava starch and found that although it acts as a good settling aid, yet it has deleterious effects on other operations of their plant. It is understood to be responsible for the clogging of filters and for the difficulty met with in the recovery of the caustic soda from the liquor.

These deleterious drawbacks, actually have economic effects rather than operational or technological ones while processing alumina, and the fact still remains that cassava starch can act as a good settling aid.

It appears, however, from the above and from several discussions with representatives of the bauxite companies in Jamaica that they did not yet establish fully the operational conditions for its use on an industrial scale. By operational conditions, the following is meant:

- The type of material of cassava to be used, whether cassava starch, flour or meal.

- The quality and degree of purity of the material, pure cassava starch if used, would lessen or eliminate the clogging of the filters.

- The right concentration as well as other factors under which the operation is to be carried out, as these may eliminate difficulties such as those met with in subsequent operations of the plant, e.g., the difficulty in the recovery of caustic soda from the liquor.

In Guyana, however, such operational or technological conditions have been established, and cassava starch was found to be economically competitive with other starches used in processing alumina. There is, however, an important factor which characterizes the red mud of Guyana, namely, that it is much coarser than the red mud of Jamaica, with the result that the rate of sedimentation in the case of the Guyanese red mud being much higher than that of Jamaica. Accordingly, the Guyanese bauxite company uses only about 3 - 5 lbs. of starch/ton red mud. Consequently the variation in starch prices will have little effect on the total production costs of alumina.

In the meantime, it is understood that the alumina processing companies in Jamaica have recently established amongst themselves, an inter-company Committee to further investigate the use of cassava starch in alumina processing. But the terms of reference and the plans of this Committee are not quite known. Also, when suggesting to the Chairman of this Committee whether it would be possible for the expert to take part in its activities. In his capacity as consultant to the JIDC, he was told that the work of the Committee is still at an early stage.

B. Other Starches (Flour) Currently in Use as Settling Aid in Alumina Processing in Jamaica

The following is the situation at present in the main alumina processing companies in Jamaica:

(i) Alcan Jamaica Limited

This Company imports from U.S.A. about 1,500 tons/month Pillsbury wheat flour for this purpose at a landed price of J$90.00 - J$100.00/ton flour.

By cooking this flour in water and caustic soda a starch solution is obtained which will act as flocculent.

For every ton of red mud obtained during alumina processing about 35 lb. of wheat flour is used as settling aid.

Since the Company deals with about 3,000 tons of red mud/day (which is approximately equal to the daily production of alumina in their two plants), therefore the quantity of wheat flour needed

= Approximately 1,500 tons/month or

= Approximately 18,000 tons/year.

(ii) Alumina Partners of Jamaica (ALPART)

This Company imports sorghum as grain from U.S.A. in bulk shipment. This is ground in a mill at ALPART plant, and the flour obtained is used as flocculent.

The quantity of red mud obtained in processing alumina is 10% more than the alumina produced. Since about 25 lbs. of grain flour is used per ton of red mud,

therefore the requirement of grain flour

= Approximately 50 tons/day, or

= Approximately 1,500 tons/month, or

= Approximately 18,000 tons/year.

The total requirements of wheat and sorghum flour for all alumina processing companies in Jamaica

= Approximately 110 tons/day, or

= Approximately 3,300 tons/month, or

= Approximately 40,000 tons/year.

After the expansion of the ALPART plant, however, the total requirement

= 46,000 tons flour/year.

C. Quantities of Cassava needed to meet Alumina Processing Requirements

At present Jamaica consumes about 3,000 tons/year of different starches (apart from flour) for use as food and for other industrial purposes. Of this quantity less than 1,000 tons were imported in 1970.

Apart from the above quantity, if cassava is used as settling aid in alumina processing and,

...suming that the starch content in cassava is 70-75 % on dry basis, then ... requirements of pure cassava starch for alumina processing

as at present = 28,000 - 30,000 tons cassava starch/year

and after ALPART expansion = 32,000 - 34,000 tons cassava starch/year.

...sava flour is going to be used as flocculent instead of pure cassava ..., then the requirements for alumina processing

as at present = 40,000 tons cassava flour/year

and after ALPART expansion = 46,000 tons cassava flour/year .

...quantities of Cassava Roots required in either case for alumina processing

as at present = 100,000 tons cassava roots/year

and after ALPART expansion = 115,000 tons cassava roots/year.

Synthetic Flocculents Under Test At Present

The alumina processing companies in Jamaica are actively ...ting the best conditions under which synthetic flocculents would ...used economically. This is due to the following two main reasons:

(i) Quantities as small as 0.2 lb. of synthetic flocculents/ton red mud would be eventually used instead of the present practice of 25-35 lb. flour/ton red mud.

(ii) By using synthetic flocculents, it may be possible to achieve better separation and recovery of caustic soda from the red mud which will be dumped, thus avoiding the pollution effect of caustic soda. This is apart from the economic advantage resulting from more recovery of the caustic soda.

Due to these reasons, the Companies have embarked on a ...search programme and experimental work to establish the most suitable ... or types of these synthetic flocculents to be used. This programme ...y last for two to three years or even more since the use of synthetic ...cculents in alumina processing is still non-economic on one hand, and ...ause on the other hand, the operational conditions for using them are not ... fully established.

The alumina processing companies have not carried out such research on locally produced cassava starch or flour with a view to use either as a substitute for other starches. This attitude may be probably attributed to the following reasons:

(i) The supply of cassava roots and starch in Jamaica at present lacks stability and continuity due to many socio-economic factors. There are fears from difficulties arising from drought, lack of sufficient transportation facilities, and strikes or similar factors which may affect the continuity in the production of the alumina if it depands on cassava starch.

(ii) The yield of cassava roots per acre under the present conditions of growing cassava in marginal land as an agricultural product is relatively very poor. This ranges from 2 - 7 tons cassava roots per acre in Jamaica as compared with 20 tons or even up to 26 tons roots per acre in other countries as Brazil, Colombia, Thailand and Indonesia.

(iii) The current prices of cassava roots are very high in Jamaica as compared with other cassava producing countries.

This fact does not encourage any thinking for the setting up of a large scale starch industry from cassava in Jamaica unless different yields and prices of the crop can be obtained.

However if synthetic flocculents will eventually be used, it is more likely that a certain percentage of starch will still be required in the operation together with the synthetic flocculent due to certain desirable effects starch can produce. The ratio between the two types of flocculents cannot be fixed at this stage, but it may be about 15 - 25% of starch to 75 - 85% of synthetic flocculent.

Assuming that cassava starch or cassava flour would be used in this case together with the synthetic flocculent, the following quantities would be required after the expansion of ALPART plant:

Cassava Starch: 5,100 tons (15%) - 8,500 tons (25%) of cassava starch/year

or

Cassava Flour: 6,900 tons (15%) - 11,500 tons (25%) of cassava flour/year.

Cassava Roots:

The above quantities of starch or flour can be obtained from:

17,300 tons (15%) - 29,000 tons (25%) of cassava roots/year

E. Availability of Potential Land for Growing Cassava

It is to be noted that potential land for growing cassava is available in Jamaica. Apart from other areas, at least the following areas were verified through Jamaica Agricultural Society and Land Authority officers:

(i) St. Elizabeth: About 8,000 acres

(ii) St. Catherine: About 2,000 acres.

Assuming that up to 20 tons of cassava roots could be produced in certain other countries, the potential yield from the above area of 10,000 acres could be 200,000 tons of roots if certain agro conditions would exist.

F. Estimates of Current Production and Acreage of Cassava in Jamaica 1967-7

The following are estimates of production of bitter and sweet cassava and the acreage used in the years 1967 - 1970:

Type	Quantity (Million lb.)				Area Harvested (Acreage)			
	1967	1968	1969	1970	1967	1968	1969	1970
Bitter Cassava	27	13	18	32	2498	1631	not available	
Sweet Cassava	7	5	6	12	888	876	not available	
Total	34	18	24	44	3386	2507	not available	

Sources: (i) Economic Survey Jamaica, 1970. Prepared by Central Planning Unit.

(ii) A paper entitled -"A Preliminary View of Cassava Production in Jamaica". Published by the University of the West Indies, St. Augustine, Trinidad - 1971.

G. Recommendations

Because the synthetic flocculents may prove to be more economic and useful in alumina processing in the near future, it would not therefore be reasonable to start on an extensive development programme for cassava growing with a view to set up a large scale cassava starch industry on the basis that the starch would be used for few years only in alumina processing. In other words, an extensive development programme to cultivate 100,000 - 115,000 tons of cassava roots would not be safe (even if the production costs of the roots would be reduced considerably and become favourable) because the major requirement for such large amounts of cassava and cassava products may not be existing locally after few years when the synthetic flocculents become more economic and useful to alumina processing.

A more reasonable and safe plan would be to assume that only about 15 - 25% of the quantities required as flocculent in alumina industry could be of cassava starch in the near future. As a result about 17,300 - 29,000 tons of cassava roots could be consumed by the alumina industry. Apart from this amount, one must consider the requirements of cassava starch (and correspondingly of cassava roots) for other uses in Jamaica, e.g., glucose, dextrin, food, textile, packaging and wood furniture industries as well as laundry and domestic uses. These uses would consume up to 4,000 tons of cassava starch/year, i.e., about 14,000 tons cassava roots/year (taking into consideration future expansion in some of these industries).

Thus, if cassava starch is used as a settling aid and for other industries and purposes, a minimum of about 9,000 tons of cassava starch/year, i.e., about 32,000 tons cassava roots/year would be needed in the near future to meet all requirements (except that of cassava as a diet).

From a preliminary feasibility study on the manufacture of starch and glucose from cassava which was carried out by the Expert it is concluded that a cassava starch plant having a capacity of about 9,000 tons starch/year would be feasible under these conditions.

On the above basis, the following actions are recommended:

(i) Putting into proctice and making use of Agro-Experimental work done on growing of cassava whether in Jamaica or abroad to obtain the more desirable varieties at economic prices.

The aim should be a yield of about 20 tons of cassava roots/acre, and a crop with relatively high starch content, thus the prices of cassava roots can be competitive with those of other cassava producing countries as Brazil, Thailand and Indonesia.

Immediate steps towards this end should be taken by the Ministry of Agriculture and other appropriate organizations to fulfil the above aim.

(ii) The bauxite companies in Jamaica should be encouraged to start on an active programme of research and experimental work on cassava as a settling aid. Such a programme should include a wide range of testing conditions on pilot and industrial scale to determine finally whether or not cassava starch or flour could be used economically as a flocculent either alone or with other synthetic ones.

(iii) If the results obtained from actions taken in (i) and (ii) above are satisfactory and promising, it would be necessary to organize the growing and marketing of cassava probably on a national or regional basis, and to deal perhaps with one or more farmers' co-operative organizations for this purpose.

This would be necessary to be able to plan the production of cassava, and to guarantee a continuous supply of the desirable varieties to industry.

5. Preliminary Feasibility Studies for Manufacturing Cassava Products

The following preliminary feasibility studies for the manufacture of Starch and Glucose were carried out:

A. Feasibility Study for the Manufacture of 6,000 Long Tons Starch/Year from Cassava Roots

(i) Availability of Land and Market

The potential major areas of land available for growing cassava are 10,000 acres as mentioned before in this report under Part 4. The yield of cassava roots from this area could probably vary between 40,000 and 200,000 tons of cassava roots depending whether the yield of roots is 4 or 20 tons/acre. Apart from this potential land, there is about 2,500 - 3,300 acres of land in which cassava was grown in 1968 and 1967 respectively. Therefore one can assume that the Island can potentially produce large amounts of cassava roots if an economic market is also available to justify the production of such quantities.

The estimate of consumption of starch for food purposes in 1961 was about 1,000 short tons. There has been not much change in this consumption pattern since then. Of this amount about 180-190 tons were imported annually, and the rest was produced locally. The imports and values of starch for food purposes (1966 - 1970) are given in the following Table.

TABLE 7

Imports and Values of Starch for Food Purposes: 1966 - 1970*		
Year	Imports (short ton)	c.i.f. Value (J$)
1966	182.2	20,780
1967	183.5	20,404
1968	189.3	29,148
1969	205.6	34,508
1970	318.8	54,192

* Source: Statistics

There is also a demand for imported starch for industrial purposes (other than alumina processing) .

Table 8 shows the quantities of Imported Starch for industrial purposes and their values (1966 - 1970).

TABLE 8

Imports and Values of Starch for Industrial Purposes: 1966 - 1970		
Year	Imports (short ton)	c.i.f. Value (J$)
1966	533.6	82,622
1967	675.8	86,054
1968	657.0	80,212
1969	432.0	69,212
1970	587.6	80,005

From the above, one can safely assume that the total consumption of starch for domestic and industrial purposes at present is about 2,000 tons/year.

Apart from this, the following represents the estimate of consumption of starch for other potential uses in the Island:

- For Glucose manufacture 2,000 - 3,[illegible] tons/year
- For Alumina processing as a settling aid 5,000 - 8,[illegible] tons/year.

(ii) Plant Capacity and Yield

For the above reasons an economic study was [illegible] a starch plant having a capacity to process 80 tons of Cassava Roots/day.

Assuming that the yield of starch will be about [illegible] of the roots,

therefore the yield will be 20 tons of starch/day.

On the basis of 300 working days/year, the [illegible] requirements of cassava roots will be 24,000 tons/year,

and the production capacity of the plant will be [illegible] tons starch/year.

This capacity was thought to be on one hand, representing a capacity for a medium plant, and on the other hand, it will be near to the requirements of the starch market in the Island if glucose is manufactured locally from cassava starch. (If, however, cassava starch is used as a settling aid for alumina processing, the minimum requirements of starch in the Island would be about 9,000 - 10,000 tons/year.

(iii) Manufacturing Process and Main Equipment

Starch can be manufactured from cassava roots by what is called the "Wet Process" through the following steps:

(a) Production of wet starch

- cleaning or scraping the roots
- crushing or grinding the roots
- extraction of starch (by Jet Extractor)
- purification of wet starch (by raw milk separator channel separators and jet refiners)

(b) Dewatering, Drying and Sifting of Starch

- dewatering (by Filter)
- drying (by Rapid Circulation Drier)
- sifting.

(c) Residues (for animal feed)

- dewatering (but not drying).

(iv) Preliminary Economic Study

a Price of Cassava Roots in Jamaica, and Supply

Because it is essential from the point of view of the
industry to guarantee a continuous supply of one or more varieties of
cassava roots to the starch plant (to satisfy its production schedules
and the required specifications of the raw material), and because most
of the producers of cassava are small farmers, it is anticipated that it
might be necessary to organize the growing of cassava on a national
or regional basis and to deal perhaps with some sort of one or more
Farmers' Co-operative Organizations.

On the other hand, it was found out during this study that
the current price of cassava roots produced in Jamaica according to the
present agro-practice and the varieties produced is not favourable at all
for the establishment of an economic starch industry from cassava roots.
The current price of the roots is as high as J$32.00 - 48.00/ton, and
unless it is lowered to about J$9.00 - 10.00/ton, the project will not
be feasible. This could be achieved by putting into practice and
making use of Agro-Experimental work done on the growing of cassava
(whether in Jamaica or abroad) to obtain more desirable varieties at
economic prices. The aim should be a yield of about 20 tons cassava
roots/acre (or more) and a crop with relatively high starch content, thus
the local prices of cassava roots can be competitive with those of other
cassava producing countries as Brazil and Thailand, as well as with other
starch producing crops as corn, sorghum, etc.

During the course of this economic study, it was found that
the price of cassava roots should not exceed US$14.00/ton so that the
project would be economically marginal. To make it more feasible either
the capacity of the plant is increased to about 9,000 instead of 6,000 tons
starch/year, or the price of cassava is lowered to about US$11.00/ton roots.

The price of US$14.00/ton roots is assumed in the following
study.

b Capital Cost Estimates

		US$	US$
Land	2½ acres at US$1,200.00		3,000
Buildings			20,000
Machinery and Equipment			
	- Machinery (imported)	532,000	
	- Other Equipment and auxiliary plants (of which about $10,000 imported)	38,000	
	- Freight and Insurance (about 8% of imported machinery and equipment, i.e., of $550,000)	44,000	
	- Erection Costs (about 16% of $550,000)	88,000	
	Total Machinery and Equipment		702,000
	∴ Capital Cost Estimates without Contingencies =		[illegible]
Contingencies			
	10% of imported machinery and equipment		55,000
			US$[illegible]

c Production Cost Estimates

		US$
Depreciation	(15 years)	52,000
Interest	(7% of Capital Cost)	54,000
Maintenance	(3%)	23,400
Insurance	(0.5%)	3,900
Overheads	(2%)	15,600

Labour

- **Operating and Maintenance** (27 men)

1 Foreman x 3 Shifts at $2.00/hour	= US$48.00/day
8 Operators x 3 Shifts at $1.00 hour =	192.00/day
4 Transport x 1 Shift at $1.00/hour =	32.00/day
5 Maintenance x 1 Shift at $1.20/hr. =	48.00/day

∴ Sub-total of Operating and Maintenance = US$320.00/day

or = 320.00 x 312 paid days = US$99,800/year.

- **Supervision**

1 Manager at	US$8,600/year
3 (Secretary, Accounting Clerk and Storekeeper) x 1 shift at $1.60/hour =	38.40/day
1 Balance Operator x 1 shift at $1.00/hour =	8.00/day
2 Assistants x 3 shifts at $1.00/hour =	48.00/day
1 Guard x 3 shifts at $1.00/hour =	24.00/day

∴ Sub-total without Manager = US$118.40/day

or = 118.40 x 312 paid days = US$36,900/year

∴ Sub-total for supervision

= 8,600 + 36,900/year = US$45,500/year

∴ Total labour costs

= US$99,800 + 45,500 = US$145,300/year.

Raw Materials

- Cassava Roots

80 tons/day x 300 working days at US$14.00/ton = US$336,000

- Sulphur (very small quantities) -

Utilities

- **Electricity**

  330Kw x 7200 hours at 1.6¢(US)/Kwh = US$38,000

- **Fuel**

  236.5 Kg. oil/hour
  i.e., about 393,700 gals/year
  at 12.7 US¢/gal. = 50,000

- **Water**

  37 m³/hour
  i.e., about 70,375,000 gals./year
  at about 40 US¢/1000 gals. 20,000

∴ Total Annual Production Costs = US$746,800

∴ Production Cost per long ton starch = US$ 124.46.
$$= \frac{747{,}000}{6{,}000}$$

Profitability

Since the present c.i.f. price of starch for industrial uses is about US$130.00/long ton, and assuming that this will also be the selling price of the local product, therefore,

Annual sales
= 6,000 at US$130.00 = US$780,000

∴ Gross Profit
= 780,000 - 746,800 = US$ 33,200

∴ Return on Investment

= [illegible] x 100 / [illegible] Capital Cost = 4.25%.

Conclusion

This result shows that the project under the above conditions would be economically marginal, and it would not be advisable to implement unless one or both of the following two conditions are fulfilled:-

- That local cassava roots would be available at a price of US$11.00 - 12.00/ton.

- That cassava starch would be used as a settling aid in alumina processing together with synthetic flocculents. In this case, the capacity of the starch plant would increase at least to 9,000 - 10,000 tons/year as mentioned before in this study.

B. Feasibility Study for the Manufacture of 3,000 tons Glucose/Year

(i) Market of Glucose and Capacity of the Plant

There is a market for Glucose in Jamaica. All the requirements, whether in the form of Glucose Syrup or solid, are imported.

The imports of Glucose and their values (1967-1970) are shown in Table 9 below.

TABLE 9

Imports of Glucose 1967 - 1970 *

Year	Imports (short ton)	c.i.f. Value (J$)
1967	1,451.2	175,594
1968	1,359.5	167,438
1969	2,109.3	510,003
1970	1,227.8	167,124

* Source: Statistics

The average market for imported glucose during the four years 1967-1970 is over 1,500 tons. It is expected that the market by 1973 and 1974 would approach 2,000 tons owing to the expansion in certain food and pastry industries which consume glucose.

If export to other CARIFTA Countries is estimated at half the local requirements, then the capacity of the suggested glucose plant could be assumed to be 3,000 tons/year (syrup and solid).

(ii) Manufacturing Process

Glucose is manufactured from starch as raw material. Either cassava starch or other imported starch can be used. Starch is hydrolysed in a converter (made of acid-resisting material) by heating in presence of acid. The solution is neutralized with soda ash and filtered, then concentrated to about 30 Be. The resulting syrup is decolourised with activated carbon, and evaporation is continued under pressure until the concentration becomes 42 - 45 Be. The resulting Glucose Syrup contains Dextrose, Maltose, Dextrin and water and is sold either as such or may be dried between two steam heated chromium drum rollers until the moisture is reduced to less than 5%. The solid is then scraped off the rollers and ground to a fine powder and sold in moisture-proof plastic bags.

Glucose can either be manufactured by the "Continuous Process" or the "Batch Process".

(iii) Preliminary Economic Study for Manufacturing 3,000 Long Tons Glucose Syrup/Year by the Continuous Process

a Capital Cost Estimates

		US$	US$
Land			
	1.5 acres at US$1,200		1,800
Building			8,000
Machinery and Equipment			
	- Machinery (imported)	240,000	
	- Other Equipment and auxiliary plants (of which US$10,000 is imported)	20,000	
	- Freight and Insurance (about 8% of imported machinery and equipment, i.e., of $250,000)	20,000	
	- Erection Costs (about 16% of imported items)	40,000	
Total Machinery and Equipment			[illegible]

		US$
∴ Capital Cost Estimates without Contingencies		330,000
Contingencies		
	10% of imported machinery and equipment	25,000
∴ Capital Cost Estimates with Contingencies		355,000

b. Production Costs Estimates

Depreciation	(15 years)	23,700
Interest	(7% of Capital Cost)	25,000
Maintenance	(3%)	10,700
Insurance	(0.5%)	1,800
Overheads	(2%)	7,000

Labour

- **Operating and Maintenance** (12 men)

  1 Foreman x 3 shifts at $2.00/hour
  = US$48.00/day
  3 Operators x 3 shifts at $1.60/hour
  = US$115.20/day
  i.e., US$163.20/day or 163.20 x 312 days
  = US$50,900/year

- **Supervision**

  1 Manager at US$4,200/year
  2 Clerks x 1 shift at $1.60/hour
  = US$ 25.60/day
  1 Guard x 3 shifts at $1.00/hour
  = US$24.00/day

∴ Sub-total without Manager = US$49.60/day

or = 49.60 x 312 paid days
= US$15,500/year

∴ Sub-total for Supervision = US$19,700/year

∴ Total Annual Labour Costs 70,600

Raw Materials

- Starch
  2950 tons/year at US$130.ton — 383,500
- Chemicals — 8,200

Utilities

- Electricity
  26Kw x 7200 h at 1.6 US¢/Kwh — 3,000
- Fuel
  101.25 Kgs, oil/h, or
  4,350 Kg oil/day, or
  1007 gals/day, or
  1007 x 300 = 302,100 gals./year
  at 12.7 U.S.¢/gal. = — 38,400
- Water — 2,600

∴ Total Annual Production Costs = 574,500

∴ Production Cost/Long Ton Glucose Syrup

$$= \frac{574,500}{3,000} = US\$191.50$$

Profitability

Since the price of imported Glucose syrup is US$202-212/long ton, and assuming that a selling price of the local product is US$207/ton, therefore,

Annual Sales
= 3,000 long tons at US$207 = US$621,000, ∴ Gross Profit
= US$621,000 - 574,500
= US$ 46,500.

∴ Return on Investment

$$= \frac{46,500 \times 100}{355,000} = 13\%.$$

If the Selling Price is US$212/ton

∴ Return on Investment = 17.8%.

On the above basis the project would be feasible.

(iv) Preliminary Economic Study for Manufacturing 3000 Long Tons Glucose Syrup Year by the Batch Process

a - Capital Cost Estimates

			US$
Land	1.5 acres at US$1,200		1,800
Buildings			8,000
Machinery and Equipment			
	- Machinery (imported)	US$182,000	
	- Other Equipment and auxiliary plants (of which US$10,000 imported)	20,000	
	- Freight and Insurance (8% of imported items)	15,300	
	- Erection Costs (16% of imported items)	30,700	
	- Total Machinery and Equipment		248,000
	∴ Capital Cost Estimates without contingencies		257,800
Contingencies	(10% of Machinery and Equipment)		20,000
	∴ Total Capital Cost Estimates with contingencies		US$277,800

b - Production Costs Estimates

Depreciation	(15 years)	18,500
Interest	(7% of Capital Cost)	19,400
Maintenance	(3%)	8,300
Insurance	(0.5%)	1,400
Overheads	(2%).	5,600

		US$
<u>Labour</u>	- <u>Operating and Maintenance</u> (15 men)	
	1 Foreman x 3 shifts at US$2.00/hour = US$48.00/day 4 Operators x 3 shifts at US$1.60/hour = US$153.60/day i.e., US$201.60/day or, 201.60 x 312 days = US$62,900/year	
	- <u>Supervision</u>	
	1 Manager at US$4,200/year 2 Clerks x 1 shift at US$1.60/hour = US$25.60/day 1 Guard x 3 shifts at US$1.00/hour = US$24.00/day	
	∴ Sub-Total without Manager = US$49.60/day for supervision or 49.60 x 312 paid days = US$15,500/year	
	∴ Sub-Total for Supervision = US$19,700/year	
	∴ Total Annual Labour Costs =	82,600
<u>Raw Materials</u>	- Starch 2,950 tons/year at US$130.00/ton=	383,500
	- Chemicals	8,500
<u>Utilities</u>	- Electricity 26Kw x 7200 h at US¢1.6/Kwh =	3,000
	- Fuel 296 Kgs oil/h or, 7,000 Kg/day or, 1,639 gals/day or, 1,639 x 300 = 491,700 gals/year at US¢12.7/gal. =	62,400
	- Water	2,600
∴ Total Annual Production Costs =		<u>[illegible]</u>

∴ Production Cost per Ton Glucose Syrup

$$= \frac{595,800}{3,000} = \text{US\$198.60}$$

Profitability

If selling price is US$207/ton

∴ Annual Sales = US$621,000

∴ Gross Profit = US$ 25,200

∴ Return on Investment

$$= \frac{25,200 \times 100}{277,800} = 9\%.$$

If the selling price of Glucose Syrup is US$212.00/long ton,

∴ Return on Investment = 14.4%.

In this case also the project would be feasible.

6. Other Activities

A. Evaluation of a Lime Manufacturing Plant in Jamaica

The Jamaica Industrial Development Corporation asked the Expert to pay visits to and evaluate a plant for the Manufacturing of Quick Lime and Hydrated Lime.

The Expert has given his recommendations to the JIDC, but, because the publication of these recommendations may disclose certain details relevant to the plant, it was thought not to do so. Only some facts and some data pertaining to the analysis of the cost of production of lime and the selling prices are given below.

Site and Property: The factory is located in an area of about 55 acres. The property also includes a second area of hilly land of about 900 acres in which quarrying is taking place. This is connected to the first area by means of a road that passed through other property.

Raw Materials: The formation shows the presence of "Limestone" (i.e., Calcium Carbonate) in unlimited quantities. It is in many places covered with a superficial layer of alumina that can be 10 - 20 feet in thickness.

Mining: After quarrying (by means of drilling using a small mobile power generating unit, and exploding the rock by ammonium nitrate), the limestone is cut by hand tools to pieces of about 4 - 8" in diameter. These are carried by truck to the factory.

It is to be noted that there are no mechanical crushers or the so-called Vibrating Grizzly Feeders in use in this operation.

Pilot Operation for the Production of Aggregate: A small pilot operation was installed near the quarrying are for the production of aggregate for construction purposes (making concrete blocks).

Although this could be a good potential product, yet it seems that it was not sufficiently exploited.

The Main Product: The main product is Quick Lime (i.e., non-hydrated Calcium Oxide). However, most of this product is hydrated at the factory to give Hydrated Lime which is packed in 3-ply bags when sold locally, or in 5-ply paper bags when exported. The relatively small quantity of Quick lime which is sold as such to Monymusk Sugar Estate is delivered in returnable steel drums.

The Manufacturing Process: Limestone (4"-8" from the quarry) is dumped at the factory, and then fed from the top into 2 Vertical Kilns (each working separately). Bunker-C fuel oil, after pre-heating, is injected into each kiln from below. The process of limestone roasting goes on for about three days in the kiln which operates continuously. During this step Carbon Dioxide gas evolves and the conversion of the limestone into lime becomes complete near the bottom of the kiln. The loss in weight due to the conversion into lime is between 40 - 44%.

The company claims that the quick lime produced has a composition of 98% Calcium Oxide. The other 2% would be unconverted limestone and other impurities. (Chemical Analysis carried out by the Bureau of Standards at the request of the Expert, confirms this). Quick lime is collected at the bottom of the kiln every four hours as fairly brittle stone.

The major part of this quick lime is crushed to less than 1" diameter and hydrated by adding water to it in a hydrator, a process which lasts for about 15 minutes and is accompanied with the evolution of great amounts of heat. The fine particles of hydrated lime produced are then pulverized by means of a hammer mill and packed in paper bags by a mechanical packing machine. Hydrated lime is composed of 75% Calcium Oxide and 25% water.

There are three kilns in the factory one of which is out of use at present, being too old.

Material Balance:

1.25 Limestone heating 0.75 tons quick lime.
0.75 ton quick lime + 0.25 ton water = 1 ton hydrated lime.
1 ton hydrated lime produced required 60 gals fuel oil.
1 ton hydrated lime is packed in 40 paper bags
(each bag has a capacity of 56 lbs.)

Production Costs: The company has [illegible] given a global production cost for hydrated lime as J$17.45/ton. This was based on a fuel oil price of J9.75¢ /gal.

The company estimates also that limestone cut to 4" - 8" in diameter and delivered at the factory near the kiln would cost J$1.20/ton, and therefore 1.25 ton would cost about J$1.50.

The following is the analysis of the production costs per ton hydrated lime as calculated:-

	J$
Limestone (1.25 tons)	1.50
Fuel Oil (60 gals)	5.80
Electricity	0.20
Lubricating oils, gas, etc.	0.25
Supervision and labour	4.00
Containers (40/ton at 8¢)	3.20
Maintenance and Repairs	1.50
Overheads	1.00
J$	17.45

Selling Prices: **J$28.00/ton quick lime**
J$32.00/ton hydrated lime.

B. <u>Aid to Improve the Production in a Plant for Manufacturing Mixed Fertilizers</u>

The Animal Feeding Company Limited, Kingston requested assistance from the JIDC regarding improvement of production at its small plant for manufacturing mixed fertilizers.

The Expert visited the Company, and on discussing the programme of production and the requirements with the Manager, the Expert suggested to add a compact granulator to improve the production. On his advice, and after contacting manufacturers abroad, the Company started the necessary steps to acquire the granulator.

C. <u>Other Studies and Technical Assistance to JIDC and Industrial Enterprises</u>

Assistance was extended to:

- Different departments of the JIDC and particularly the Incentives Committee in connection with studies of certain projects for the application of the Industrial Incentives.

- Some industrial enterprises regarding formulating plans for industrial research and future development.

- Recommendations and comments on certain matters submitted to the JIDC Authorities, the previous and the present Hon. Ministers of Industry, on their request.

The following are some of the areas and names of projects studied for the JIDC and some enterprises:-

- Application for PVC resin manufacture.
- Application for the manufacture of compounded resins.
- Application for the manufacture of Aqueous Latex Dispersions.
- Application for the manufacture of Synthetic Resin Vehicles (Alkyd Resins) and Synthetic Resins of the Thermoplastic and Thermosetting types.
- Manufacture of a PVC-coated foam laminate.

- Manufacture of chemical additives to improve the efficiency of steam boilers.
- A research investigation with the Bureau of Standards on the corrosive effect of chlorine on the metal alloy of propellers of boats. (This study was made on the request of the Manager of the Dry Dock project).
- Manufacture of Glucose.

Details of the work done to assist in formulating plans for research and development is not discussed here at the request of the industrial enterprises concerned, for obvious competition reasons.

Work done covered also visits to factories, meetings at different levels, attending seminars and giving talks.

An interesting discussion took place with Dr.Trevor Byer of the International Atomic Agency concerning the possibility of setting up a nuclear power station of about 500 MW capacity to serve the proposed Chemical Complex, Refinery and Aluminium smelting plants as well as other industries within reach of the power station.

7. Acknowledgement

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