Table II-18 SALES PLAN OF UREA FROM BINTULU PLANT, MALAYSIA

(Urea '000 ton)

		1984	1985	1986	1987	1988	1989	1990
Marketable Urea (A)		259.9	391.9	441.4	445.5	445.5	445.5	445.5
Shipment for:								
Domestic Market								
W. Malaysia	(BL)	130.0	136.7	141.5	147.4	153.3	158.9	164.8
Sabah	(BL)	9.4	9.8	10.2	10.7	11.3	11.7	12.2
Sarawak	(BG)	6.1	6.3	6.5	6.7	6.7	7.0	7.2
Total		145.5	152.8	158.2	164.8	171.3	177.6	184.2
ASEAN Countries								
Philippines	(BG)	49.0	51.5	53.8	55.9	58.2	60.4	62.9
	(BL)	114.5	120.2	125.7	130.6	135.8	141.1	146.7
	Sub-total	163.5	171.7	179.5	186.5	194.0	201.5	209.6
Thailand	(BG)	31.0	36.3	42.0	47.5	53.5	60.0	67.0
Singapore	(BL)	8.7	8.7	8.7	8.7	8.7	8.7	8.7
Total		203.2	216.7	230.2	242.7	256.2	270.2	285.3
Grand Total (B)		348.7	369.5	388.4	407.5	427.5	447.8	469.5
Export Requirement for the Markets outside ASEAN (A – B)		–	22.4	53.0	38.0	18.0	–	–

Notes: BG –– Bagged urea
BL –– Bulk urea

Table II-19 PROJECTION OF WORLD UREA TRADE

(Urea '000 ton)

	1979	1981	1983	1985	1987	1990
Import:						
S.E. Asia	874	1,024	1,090	893	872	1,038
S.W. Asia	851	1,091	1,479	576	1,048	1,085
East Asia	965	763	1,176	1,209	1,581	1,540
Mideast	1,452	639	428	148	154	28
Oceania	78	108	54	–	11	48
W. Europe	261	278	296	313	330	357
E. Europe	846	370	470	465	526	585
N. America	643	691	739	787	833	904
C. America	–	–	–	–	–	–
S. America	502	437	193	–	–	–
Africa	841	535	74	39	172	185
Total	7,312	5,936	5,999	4,430	5,527	5,770
Export Potentiality:						
S.E. Asia	544	938	1,225	1,425	1,350	1,212
S.W. Asia	24	50	531	763	480	196
East Asia	2,355	3,028	2,826	2,663	2,197	2,111
Mideast	757	1,147	1,718	1,972	1,992	2,461
W. Europe	1,991	2,087	2,265	2,370	2,417	2,424
E. Europe	4,093	5,539	7,280	8,567	7,946	7,363
N. America	687	774	789	796	780	722
C. America	1,330	1,376	1,817	2,491	2,385	3,352
S. America	–	–	–	261	430	691
Total	11,781	14,939	18,451	21,308	19,977	20,532

Table II-20 SUPPLY/DEMAND PROJECTION OF UREA, MAJOR ASIAN COUNTRIES EXCLUDING ASEAN COUNTRIES

(Product '000 ton)

		1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
China	Supply	2,846	5,009	5,887	6,491	6,928	7,054	7,311	7,565	7,822	7,983	8,128
	Demand	5,232	6,334	6,818	7,295	7,691	8,136	8,487	8,894	9,031	9,564	9,668
	Balance	-2,386	-1,325	-931	-804	-763	-1,082	-1,176	-1,329	-1,209	-1,581	-1,540
Burma	Supply	107	107	107	107	107	170	176	185	265	265	265
	Demand	115	133	154	180	209	230	252	274	296	326	350
	Balance	-8	-26	-47	-73	-102	-60	-76	-89	-31	-61	-85
Vietnam	Supply	76	82	82	82	82	82	82	82	181	313	330
	Demand	460	485	511	530	552	567	583	597	610	620	632
	Balance	-384	-403	-429	-448	-470	-485	-501	-515	-429	-307	-302
India	Supply	3,187	4,135	5,044	5,540	5,670	5,798	6,126	6,672	7,203	7,494	7,567
	Demand	4,351	5,044	5,694	6,167	6,524	6,986	7,533	7,746	7,701	7,979	8,534
	Balance	-1,164	-909	-650	-627	-854	-1,188	-1,407	-1,074	-498	-485	-967
Pakistan	Supply	593	593	1,024	1,052	1,110	1,605	1,638	1,964	1,981	2,015	2,015
	Demand	942	884	1,024	1,052	1,110	1,157	1,273	1,394	1,520	1,633	1,767
	Balance	-349	-291	0	0	0	448	365	570	461	382	248
Australia	Supply	130	130	130	130	130	204	211	220	307	307	307
	Demand	156	166	178	190	217	280	308	331	364	394	415
	Balance	-26	-36	-48	-60	-87	-76	-97	-111	-57	-87	-108

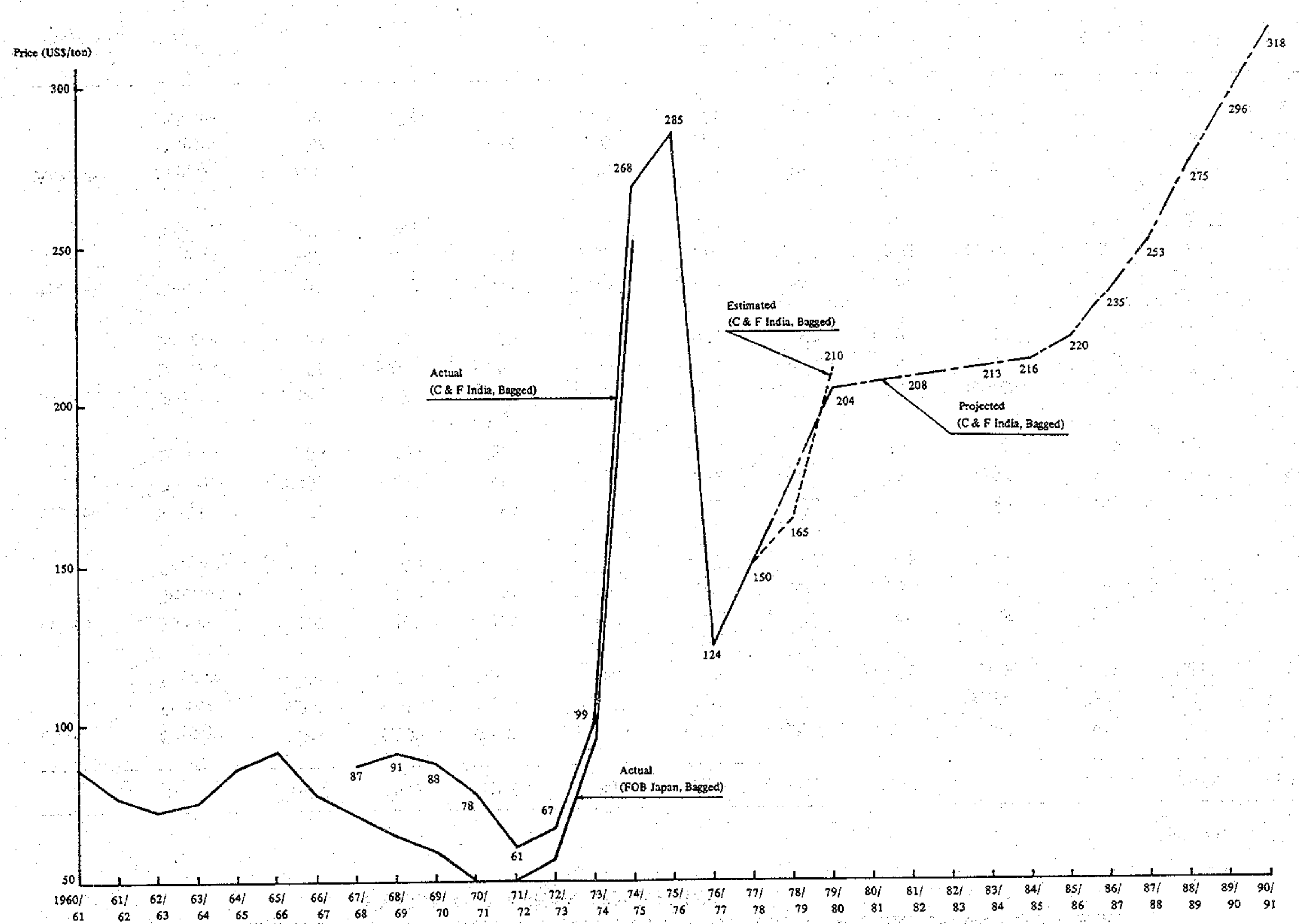


Fig. II-1 PAST TREND AND PROJECTION OF INTERNATIONAL PRICE OF UREA

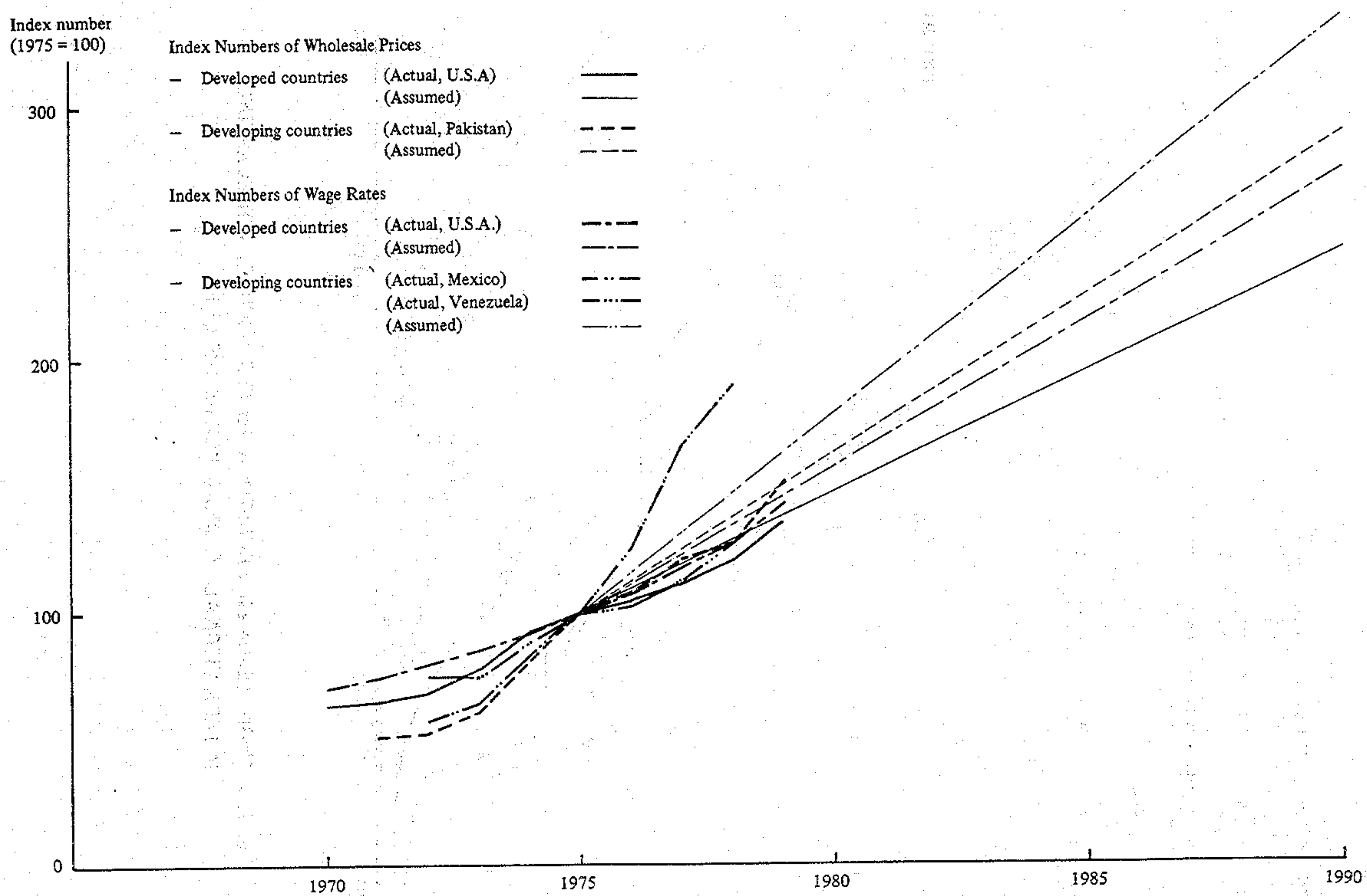


Fig. II-2 MAIN ASSUMED FACTOR PRICES USED IN FORECASTING INTERNATIONAL MARKET PRICES OF UREA

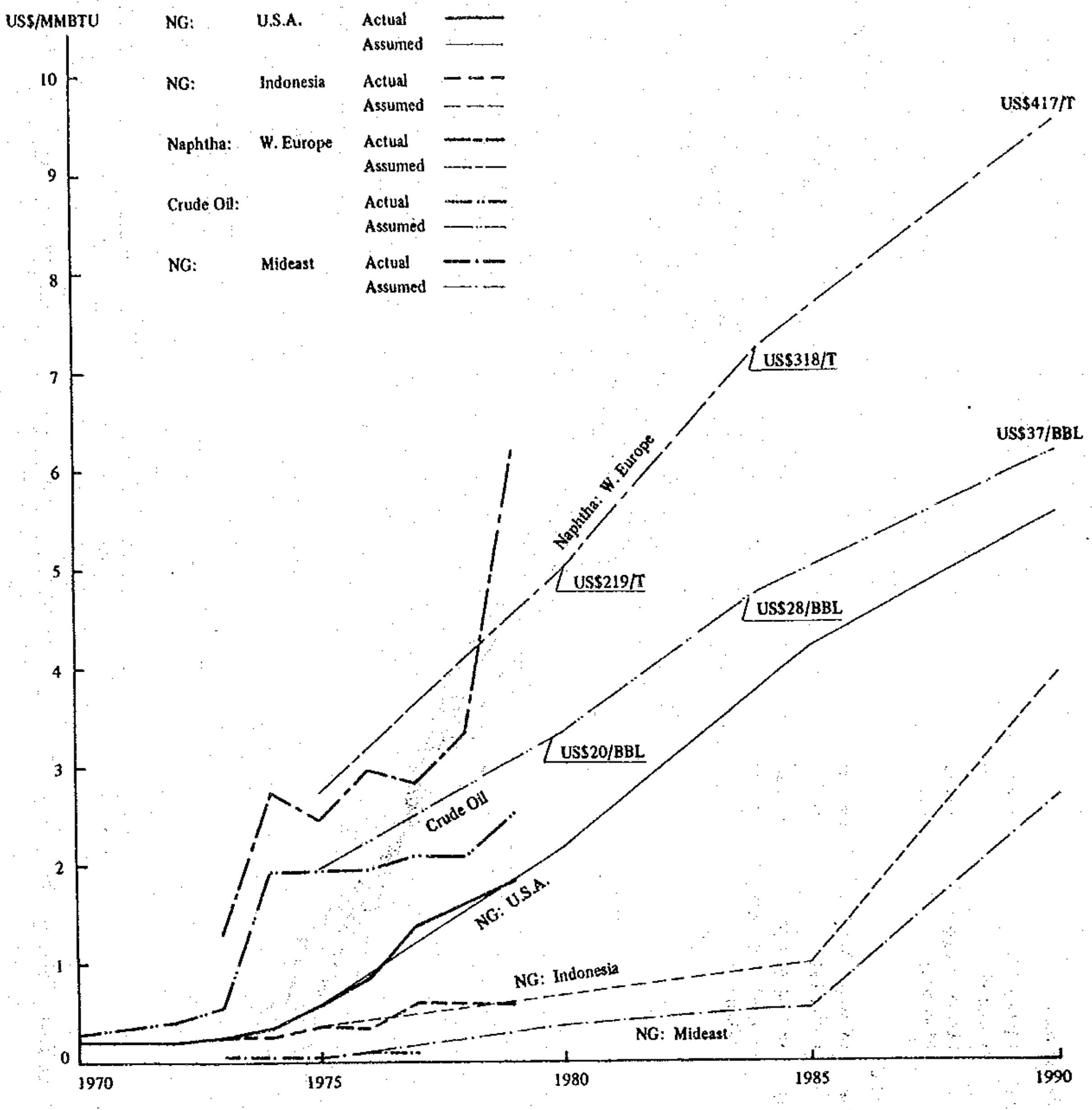


Fig. II-3 MAIN ASSUMED FEEDSTOCK PRICES USED IN FORECASTING INTERNATIONAL MARKET PRICES OF UREA

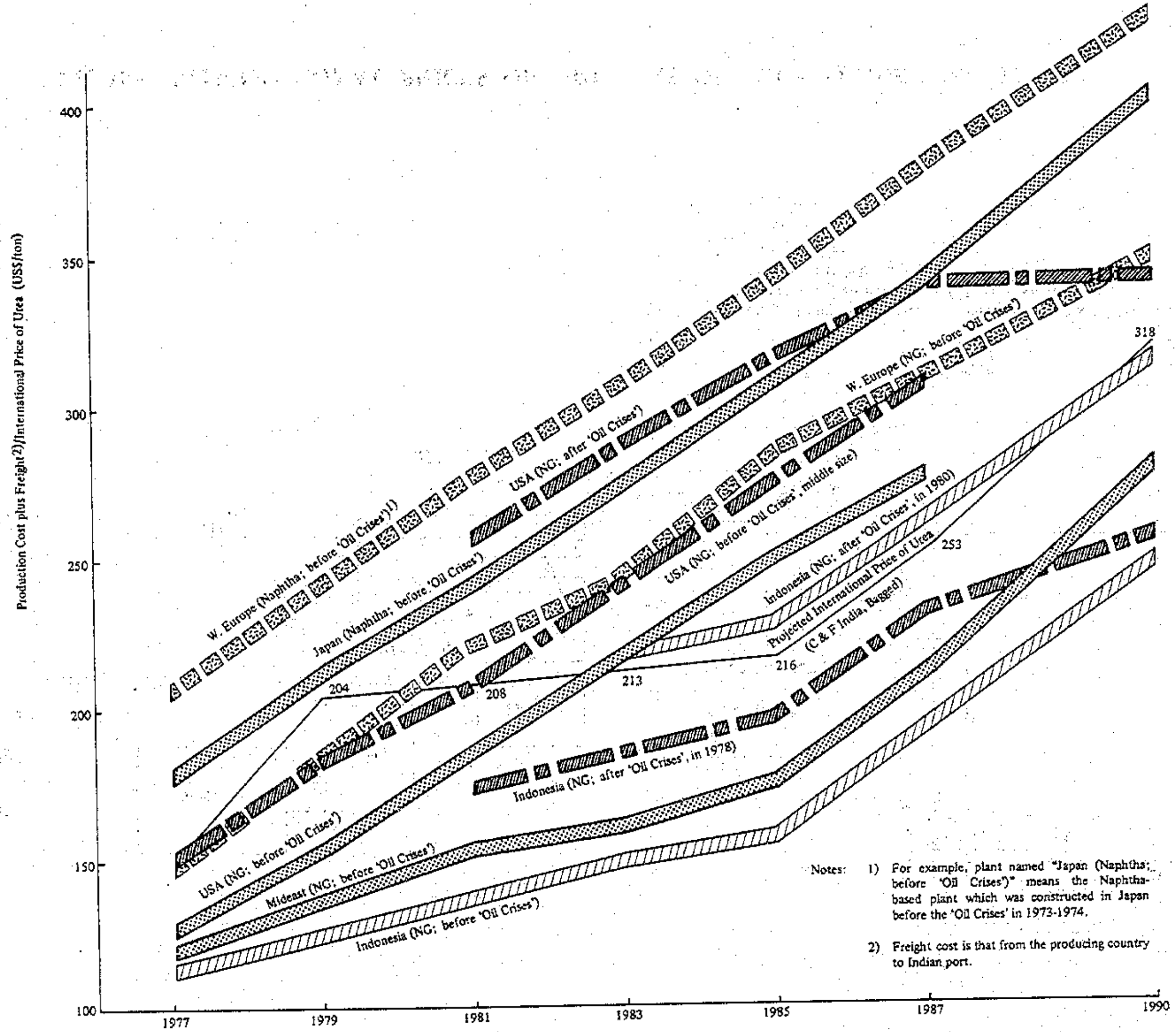
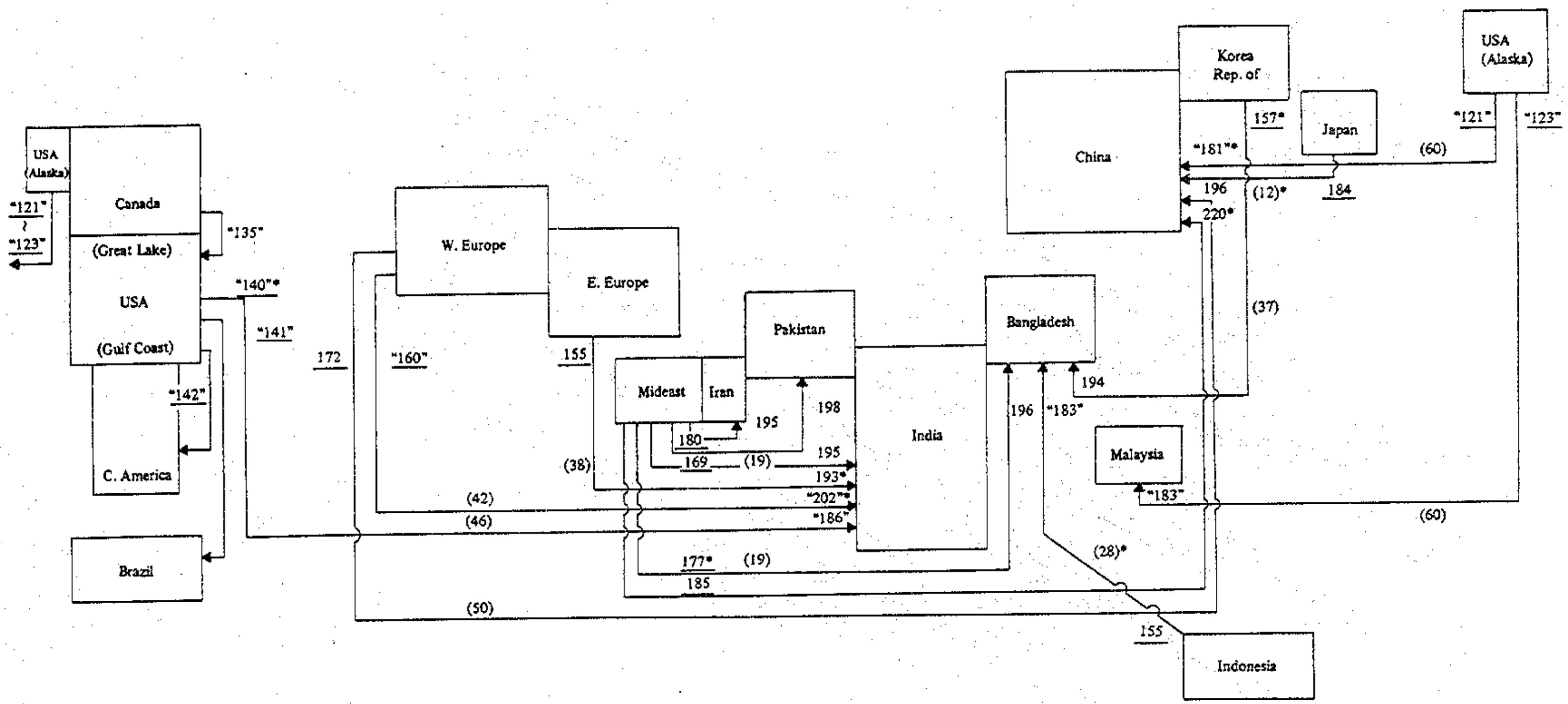


Fig. II-4 ESTIMATED "PRODUCTION COST PLUS FREIGHT" OF UREA BY PLANT IN MAIN UREA EXPORTING COUNTRIES



Notes: 1. Urea prices are expressed in terms of U.S. dollars per ton, C & F in bags, if not specified.
2. Freight rates are expressed in terms of U.S. dollars per ton of urea.
3. * ; Estimated prices/freight rates
4. " " ; Bulk urea price
5. ___ ; FOB price
6. ( ) ; Freight rate

Fig. II-5 INTERNATIONAL PRICES OF UREA, AS OF JULY/AUGUST IN 1979

PART III

STUDY ON THE SUPPLY OF NATURAL GAS

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PART III STUDY ON THE SUPPLY OF NATURAL GAS

CHAPTER 1 INTRODUCTION

This Part summarizes the results of the study regarding the extent of reserves, composition and plan for supply of natural gas which is to be used as feedstock and fuel in the Ammonia and Urea Complex. Data and information provided by PETRONAS for the present study are as shown in Table III-1. The primary objective of the study task of the Evaluation Study Team was to confirm the adequacy of the natural gas for use in the Complex, by means of clarifying the bases for the reserve estimates which were officially adopted by PETRONAS, and thereby evaluating the appropriateness of the estimates in broad terms. Therefore, the Evaluation Study Team did not conduct its independent estimates regarding the reserves.

The source of natural gas to be supplied to the Complex is planned to be non-associated gas which will be produced in offshore gas fields scattered 130 - 180 km from Bintulu (see Fig. III-1). In these gas fields, named the Central Luconia fields, accumulations of gas have been confirmed in 10 structures thus far, of which it is planned to supply gas for this Project from five fields: E11, F23, F6, E8 and F13 (see Fig. III-1).

With regard to the natural gas reserves of these fields, there are two estimates which have been officially announced. One estimate has been made by Sarawak Shell Berhad (SSB) which is performing exploration and exploitation of natural gas in these fields as the production-sharing contractor to PETRONAS, and another by INTERCOMP Resource Development and Engineering, Inc. (U.S.A.) engaged as the consultant to PETRONAS. The Evaluation Study Team used these estimates to confirm the adequacy of the gas reserves in the subject fields.

Examination on the suitability of gas to be supplied to the Complex was made on the basis of data provided by PETRONAS as those showing composition of feed gas. It is noted that this composition was estimated by PETRONAS on the basis of analytic values obtained using gas samples collected from test wells in the above-mentioned fields and in accordance with the gas production schedule projected.

Adequacy of the gas supply system was evaluated by means of reviewing the system planned for the supply of gas to the MLNG project which is based on the gas from the aforesaid five gas fields, and which Malaysia LNG Sdn. Berhad (MLNG) is proceeding to implement prior to this Ammonia and Urea Complex Project, because the gas transmission and processing facilities would be installed primarily for the supply to the MLNG project that will utilize the greater part (1,250 MMSCFD) of gas produced in the fields.

The following provides the results of study and evaluation of the natural gas supply plan for the Complex, based on data and information supplied by PETRONAS.

CHAPTER 2 NATURAL GAS RESERVES

In the Central Luconia area, which is an extensive sedimentary basin located in the South China Sea off Bintulu, the gas reservoir are Reefal Carbonate Buildup, formed in the Miocene era.

Extensive exploration activities performed by SSB have discovered gas accumulation in the main five fields (E11, F23, F6, E8 and F13) and also in an additional five fields (B12, E6, F14, M1 and M3). Reservoir data of each of the main five fields is shown in Tables III-3 to III-7, and their production test results are summarized in Table III-8. Further, drawings showing the structure and cross section of these reservoirs are given as Figs. III-2 to III-11. For the estimation of the gas reserves, SSB employed a probabilistic calculation model which was used to statistically calculate the reserves by adopting probabilistic distribution for all input parameters used in reserve calculations. The results of estimations were classified into two categories, "Mean Reserve" and "Proved Reserve". (The reserve estimating procedure applied to the SSB's estimation is described in Appendix III-1.)

The estimation of gas reserves, performed by SSB, indicates the recoverable reserves of the main five fields as 10.6 TSCF (Mean) and 7.1 TSCF (Proved), and, with the addition of the recoverable reserves estimated for other gas fields, the total recoverable reserves of the Central Luconia fields as 14.3 TSCF (Mean) and 9.6 TSCF (Proved). (The estimates of gas reserves for each field are given in Table III-2.)

The above estimates are based on reservoir data of the main five fields (shown in Tables III-3 to III-7) and also on a recovery factor which was determined on the assumption that the production limit is reached at 800 psia of reservoir pressure.

It is reported that INTERCOMP estimated the recoverable reserve of the five fields as 9.7 TSCF (Mean), and of that of all Central Luconia as 13.8 TSCF (Mean). However, details on the method and basic data used for this estimation were not available for review by the Evaluation Study Team.

There are discrepancies in figures between the reserve estimates made by SSB and those made by INTERCOMP, and there may be some argument as to which estimate shall be taken as the basis for evaluation. Nevertheless, because there are no basic data available for evaluating the appropriateness of the reserve estimates made by INTERCOMP, as the basis for evaluation, the Evaluation Study Team used the SSB's estimate which is summarized below:

		Recoverable Gas Reserves (Hydrocarbon Only) (TSCF)	
		(Mean)	(Proved)
1)	Main Five Fields (E11, F23, F6, E8, F13)	10.598	7.074
2)	Other Fields	3.689	2.563
	Total (Central Luconia Fields)	14.287	9.637

CHAPTER 3 COMPOSITION OF FEED GAS

Natural gas for this Project is to be supplied from the main five gas fields (E11, F23, F6, E8 and F13) in the Central Luconia fields. The gas produced in each of these fields, as is shown in Table III-10, has a composition different from that of the rest. Nevertheless, the composition of gas produced in any field will gradually change over time due to change in formation of condensate which takes place within the reservoir as the reservoir pressure decreases. Further, any change in the proportion of gas supplied from each field will cause fluctuation of the composition of gas to be supplied to the Complex. Therefore, it is necessary that the composition of feed gas be estimated with some range. The rich and lean limits of the thus-estimated composition are as shown in Table III-9. This table also shows the maximum and minimum contents of impurities such as hydrogen sulfide, nitrogen and carbon dioxide.

In view of this composition, the gas is fully usable as feedstock and fuel in the Ammonia and Urea Complex, although it contains acid gas such as carbon dioxide and hydrogen sulfide which must be removed before being fed to the steam reformer. The heating values of the feed gas are estimated as follows:

High heating value:	987 to 1,114 BTU/SCF
Low heating value:	888 to 1,002 BTU/SCF

CHAPTER 4 NATURAL GAS SUPPLY PLAN AND SUPPLY/DEMAND BALANCE

According to PETRONAS's plans, development of the Central Luconia fields is to begin in 1979, with gas field E11, after which, in 1980, F23, and then, in sequence, F6, E8 and F13 are to be developed. Of these, details of the development schedule of E11 and F23 are provided in Fig. III-12. Each gas field will have individual offshore production facilities consisting of drilling platforms and production platforms which are linked by sub-sea flow lines. Gas gathered through the flow lines will be sent to the Bintulu Terminal to be built in the Kidurong area, through a trunk gas pipeline, to which another line is to be added in the later stage (see Fig. III-13). Drilling of production wells will be achieved at an inclination from the drilling platforms and at each field one platform will be used to drill several wells. The gas produced at each well will be sent to the adjacent production platform, where condensate and gas will be separated, and then gas will be dehydrated, metered, mixed again with condensate and transmitted to the onshore terminal in two phase flow. It is planned that compressors will be installed in order to boost up supply gas pressure if it drops due to decrease in reservoir pressure in the future. The schematic process flow of the field facilities planned for production platforms is shown in Fig. III-14 and a completion design for wells is shown in Fig. III-15. It is noted, however, that detailed specifications have not yet been prepared.

The drilling plan for production wells is as follows:

Gas Field	No. of Initial Wells	No. of Additional Wells	Total
E11	10	4	14
F23	10	0	10
F6-A	12	0	12
F6-B	8	0	8
E8	8	2	10
F13-W	6	0	6
F13-E	10	0	10

The F6 and F13 fields which cover a large area will have two drilling platforms respectively, and other fields have one drilling platform each.

The well-stream gas which has reached Bintulu Terminal will be separated into gas and condensate at 830 psia and 86°F by a slug catcher, and after metering, dry gas will be supplied to the Ammonia and Urea Complex.

Fig. III-16 illustrates the gas production plan prepared by SSB for supply to the LNG plant, which is based on the main five fields. The gas volume to be supplied to the MLNG project from the Central Luconia fields for the 20 years from 1982 to 2001, is projected to be 1,250 MMSCFD in terms of dry gas delivered to the gate of the LNG plant. In consideration of the gas requirements of the Complex, however, the supply volume should be increased to 1,296 MMSCFD. Assuming an on-stream factor of 320 days per year, the total volume of gas to be supplied for the MLNG project is estimated to be 7.41 TSCF for the period of project life. On the other hand, the gas requirement for the Ammonia and Urea Complex is 46.4 MMSCFD which amounts to 0.23 TSCF for the project life of 15 years on the basis of 330 stream days a year. Therefore, the gas required for both projects is 7.6 TSCF.

The recoverable reserves in the main five fields, as is stated above, is 10.6 TSCF (Mean Reserve). In comparing the above requirements for both projects, it is revealed that the estimated reserves have a surplus which is equivalent to an allowance of about 30% against the requirements. Therefore, it is judged that the gas reserve is adequate to assure the supply over the project life of this Project.

The gas supply capacity, estimated on the basis of the present development schedule, is shown in Fig. III-17. The given chart clearly indicates that the five main gas fields have ample capacity to supply the gas needed by both projects, throughout their project life. Details concerning the estimation of capacity shown in this figure have not been provided, but it is judged that the given projection of production capacity is reasonable, judging from the production test results (see Table III-8).

It is planned that gas will be delivered to the Complex at its boundary. Gas discharged from the slug catcher, where gas and condensate are separated, will be supplied to the Complex through a pipeline. In view of the length of the pipeline, it is expected that pressure and temperature of the gas at the delivered point may be little different from those at the slug catcher (830 psia, 86°F).

PETRONAS-Upstream Division will be responsible for construction of a branch line to be laid to connect the slug catcher with the Complex and other facilities needed for supplying gas to the Complex. Regarding the facilities for gas to be supplied to the LNG plant, the specifications were not provided, because tenders for these facilities are to be invited in the near future, so that examination of adequacy of the facilities was not made. Nevertheless, according to PETRONAS-Upstream Division's explanation, all facilities are to be designed on the basis of 1,340 MMSCFD of gas to be transmitted for use by both projects. In view of this figure, it is assumed that there may be no problem regarding the adequacy of facilities. It is planned that the gas supply facilities will be completed in 1982, so that completion of the facilities will meet the schedule for the Complex, unless any delay occurs in progress.

CHAPTER 5 OBSERVATIONS AND RECOMMENDATIONS CONCERNING FEED GAS SUPPLY PLANS

5-1 Natural Gas Reserves

In view of gas reserves in the main five fields of the Central Luconia fields which is estimated to be 7.1 TSCF of proved reserve and 10.6 TSCF of mean reserve, it is believed possible to supply the 7.6 TSCF which the Complex and the MLNG project require. However, inasmuch as these are estimates made at a time when there are few wells and no production history, it is to be expected that at some time in the future these values will have to be revised. Therefore, in order to increase the certainty on which basis the gas development and production plans are made, it is necessary to compile more data, and re-assess the estimates of the reserves.

It is recommended that the following studies be carried out in accordance with the collection of additional data.

1. Carry out (a) re-assessment of initial gas in place by applying a volumetric method, and (b) projections of production behavior by applying a material balance method, at the time of completion of drilling production wells.

2. Carry out re-assessment of the gas reserves by applying a reservoir simulation model, at the time when a production history and data concerning gas reservoir pressure are obtained.

3. Periodically update the gas reserve estimates, based on information compiled with regard to change or fluctuation of reservoir pressure and gas composition.

5-2 The Relation of Gas Composition to Production Planning

It is noted that the gas composition given as that of feed gas for the Ammonia and Urea Complex has been estimated on the basis of a gas production program developed for each of the subject gas fields to supply gas to the MLNG project and also in consideration of analyzed production behavior. If there is any modification of the developed gas production program, it may result in change in the composition of feed gas. In this context, it is recommended that a revised gas production program be urgently developed in consideration of gas supply not only to the MLNG project but also the Ammonia and Urea Complex, whereby the composition of feed gas be finally confirmed. Further, it is also recommended that influence on any changes in the composition of feed gas be analyzed at such a time when the gas production program is modified.

5-3 Supply of Natural Gas to Other Projects

The present study has been limited to the supply of natural gas for the MLNG project and the Ammonia and Urea Complex. Therefore, in the event that in the future it is intended to supply gas from the Central Luconia fields to other projects, it will be necessary to prepare a revised gas supply plan based on future demands and the remaining gas reserves.

Table III-1 LIST OF DATA PROVIDED TO JICA EVALUATION STUDY TEAM BY PETRONAS

1. Migrated Depth Contour Maps of E11/F23/F6/E8/F13 Gas Fields
2. Cross Section and Reservoir Quality of E11/F23/F6/E8/F13 Gas Fields
3. Well Logs and Lithological Interpretations of Carbonate Section, E11/F23/F6/E8/F13 Gas Fields
4. Central Luconia Reserve Parameters – Mean Values
5. Central Luconia Reserves
6. Reserve Estimating Procedure
7. Field Location Map with the Names of Gas Fields Provisionally Proposed for Development
8. Central Luconia Platform Configuration
9. MLNG Upstream Project Development Schedule
10. Central Luconia, Number of Wells per Field
11. Process Flow Sheet, Typical Field Facilities (Offshore), Commingled Production
12. Proposed Central Luconia Completion Design
13. Tentative Plan – Bintulu Industrial Area, Sarawak
14. Gas Composition of B12/E6/E8/E11/F6/F13W/F13E/F14/F23/M1/M3/Sh. Clastics (H sands)/Sh. Clastics (L sands)
15. MLNG into Plant Feed Gas Composition / Natural Gas Supply Schedule / Production Profile

Table III-2 CENTRAL LUCONIA GAS RESERVES

Field	Gas in Place (TSCF)		Recovery Factor (%)			Reserves (TSCF)		
	INTERCOMP	SSB	INTERCOMP	SSB		INTERCOMP	SSB	
	(Mean)	(Mean)	(Mean)	(Mean)	(Proved)	(Mean)	(Mean)	(Proved)
E11	1.998	2.199	61.56	70.76	70.09	1.230	1.556	1.085
F23	2.612	2.962	45.60	62.76	59.54	1.191	1.859	1.261
F6	5.218	5.133	60.57	66.34	65.98	3.155	3.405	2.378
E8	3.325	2.705	68.78	66.06	65.95	2.287	1.787	1.166
F13	3.112	2.882	57.90	69.08	68.72	1.802	1.991	1.184
Sub-total	16.265	15.881	(59.42)	(66.73)	–	9.665	10.598	7.074
Others	8.244	5.983	50.74	61.66	–	4.183	3.689	2.563
Total	24.509	21.864	(56.50)	(65.34)	(62.86)	13.848	14.287	9.637

Table III-3 SUMMARY OF RESERVOIR DATA, E11 GAS FIELD

Number of Existing Wells (Exploratory and Appraisal)	3
Datum Depth (feet subsea)	6,000
Gas Zone Area (acre)	6,000
Max. Gross Pay Thickness (feet)	1,710
Avg. Porosity* (%)	20
Avg. Water Saturation* (%)	15
Initial Reservoir Pressure (psia)	2,885
Reservoir Temperature (°F)	222
Gas Gravity (air = 1)	0.690
Original Gas in Place* (TSCF)	2.20
Estimated Recovery Factor* (%)	71
Ultimate Gas Reserves* (TSCF)	1.56

Note:
* mean values used/calculated by SSB in the probabilistic model.

Table III-4 SUMMARY OF RESERVOIR DATA, F23 GAS FIELD

Number of Existing Wells (Exploratory and Appraisal)	2
Datum Depth (feet subsea)	4,500
Gas Zone Area (acre)	5,000
Max. Gross Pay Thickness (feet)	1,060
Avg. Porosity* (%)	23
Avg. Water Saturation* (%)	16
Initial Reservoir Pressure (psia)	2,430
Reservoir Temperature (°F)	222
Gas Gravity (air = 1)	0.697
Original Gas in Place* (TSCF)	2.96
Estimated Recovery Factor* (%)	63
Ultimate Gas Reserves* (TSCF)	1.86

Note:

* mean values used/calculated by SSB in the probabilistic model.

Table III-5 SUMMARY OF RESERVOIR DATA, F6 GAS FIELD

Number of Existing Wells (Exploratory and Appraisal)	5
Datum Depth (feet subsea)	4,100
Gas Zone Area (acre)	23,000
Max. Gross Pay Thickness (feet)	840
Avg. Porosity* (%)	25
Avg. Water Saturation* (%)	22
Initial Reservoir Pressure (psia)	2,190
Reservoir Temperature (°F)	201
Gas Gravity (air = 1)	0.687
Original Gas in Place* (TSCF)	5.13
Estimated Recovery Factor* (%)	66
Ultimate Gas Reserves* (TSCF)	3.40

Note:

* mean values used/calculated by SSB in the probabilistic model.

Table III-6 SUMMARY OF RESERVOIR DATA, E8 GAS FIELD

Number of Existing Wells (Exploratory and Appraisal)	3
Datum Depth (feet subsea)	5,300
Gas Zone Area (acre)	6,000
Max. Gross Pay Thickness (feet)	1,330
Avg. Porosity* (%)	21
Avg. Water Saturation* (%)	13
Initial Reservoir Pressure (psia)	2,550
Reservoir Temperature (°F)	215
Gas Gravity (air = 1)	0.721
Original Gas in Place* (TSCF)	2.70
Estimated Recovery Factor* (%)	66
Ultimate Gas Reserves* (TSCF)	1.79

Note:
* mean values used/calculated by SSB in the probabilistic model.

Table III-7 SUMMARY OF RESERVOIR DATA, F13 GAS FIELD

	WEST	EAST
Number of Existing Wells (Exploratory and Appraisal)	3	
Datum Depth (feet subsea)	6,300	6,300
Gas Zone Area (acre)	7,000	7,000
Max. Gross Pay Thickness (feet)	370	340
Avg. Porosity* (%)	20	21
Avg. Water Saturation* (%)	15	21
Initial Reservoir Pressure (psia)	2,890	2,940
Reservoir Temperature (°F)	220	220
Gas Gravity (air = 1)	0.741	0.784
Original Gas in Place* (TSCF)	1.34	1.54
Estimated Recovery Factor* (%)	69	69
Ultimate Gas Reserves* (TSCF)	0.93	1.06

Note:

* mean values used/calculated by SSB in the probabilistic model.

Table III-8 SUMMARY OF PRODUCTION TEST RESULTS

Well.	Interval (ft. ss)	Pe (psig)	K (mD)	S*1	AOF*2 (MMSCFD)	Qg*3 (MMSCFD)	Remarks
E11.3	5,403 - 5,978	2,818	82	-0.6	970	100	post-acidization
	6,116 - 6,334	2,878	23	0.4	135	20	post-acidization
F23.2	4,184 - 4,766	2,400	84	-1.3	407	87	post-acidization
F6.5	3,742 - 3,882*4	2,180	920	3	4,600	390	
	4,278 - 4,360*4	2,199	1,100	3	121	33	
	3,956 - 4,218*4	2,203	80	10	103	19	
E8.4	4,956 - 5,650*4	2,550	36	-3	490	69	
	5,428 - 5,582*4	2,567	10	-1	78	6	
	5,428 - 5,640*4	2,567	12	-1	120	10	
F13.3	6,264 - 6,364	2,904	4.5	–	88	8	pre-acidization

Note:

*1 S : total skin factor
*2 AOF : absolute open flow potential
*3 Qg : well deliverability at 100 psi drawdown
*4 : depth along hole

Table III-9 NATURAL GAS SUPPLY CONDITIONS TO THE ASEAN UREA PROJECT (MALAYSIA)

	Richest	Leanest
– Composition (in mol percent) :		
C_1	89.07	87.11
C_2	4.39	2.34
C_3	2.79	1.24
iC_4	0.60	0.27
nC_4	0.64	0.26
iC_5	0.23	0.11
nC_5	0.13	0.07
C_6	0.12	0.11
C_7+	0.02	0.03
Sub-total	97.99	91.54
H_2S (ppm)	7	14
N_2	max. 1.8	
CO_2	max. 8.0	
– Heating Value (BTU/SCF) :		
Gross Heating Value	1,114	987
Low Heating Value	1,002	888
– Temperature:	86°F	
– Pressure:	830 psia	

Table III-10 COMPOSITION OF RESERVOIR FLUID

(in mol percent)

FIELD	E11	F23	F6	E8	F13W	F13E	Avg.
C_1	86.17	88.00	87.75	85.41	81.34	77.08	84.29
C_2	2.40	3.35	4.00	5.16	2.25	1.95	3.19
C_3	1.30	2.52	2.90	3.47	1.18	1.03	2.07
iC_4	0.29	0.72	0.81	0.74	0.27	0.23	0.51
nC_4	0.30	0.66	0.86	0.97	0.27	0.24	0.55
iC_5	0.14	0.33	0.38	0.45	0.11	0.10	0.25
nC_5	0.10	0.19	0.27	0.29	0.06	0.09	0.17
C_6	0.21	0.42	0.37	0.48	0.14	0.15	0.30
C_7+	0.41	0.98	0.57	0.94	0.85	0.68	0.74
BNZ+	0.31	0.16	0.09	0.25	0.0	0.29	0.15
N_2	1.25	0.54	0.50	0.0	1.96	2.03	1.05
CO_2	7.30	2.13	1.50	1.84	11.57	16.13	6.75
H_2S*	(7)	(8)	(20)	(4)	(0)	(0)	(6.5)
He	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Note: * ( ) in ppm

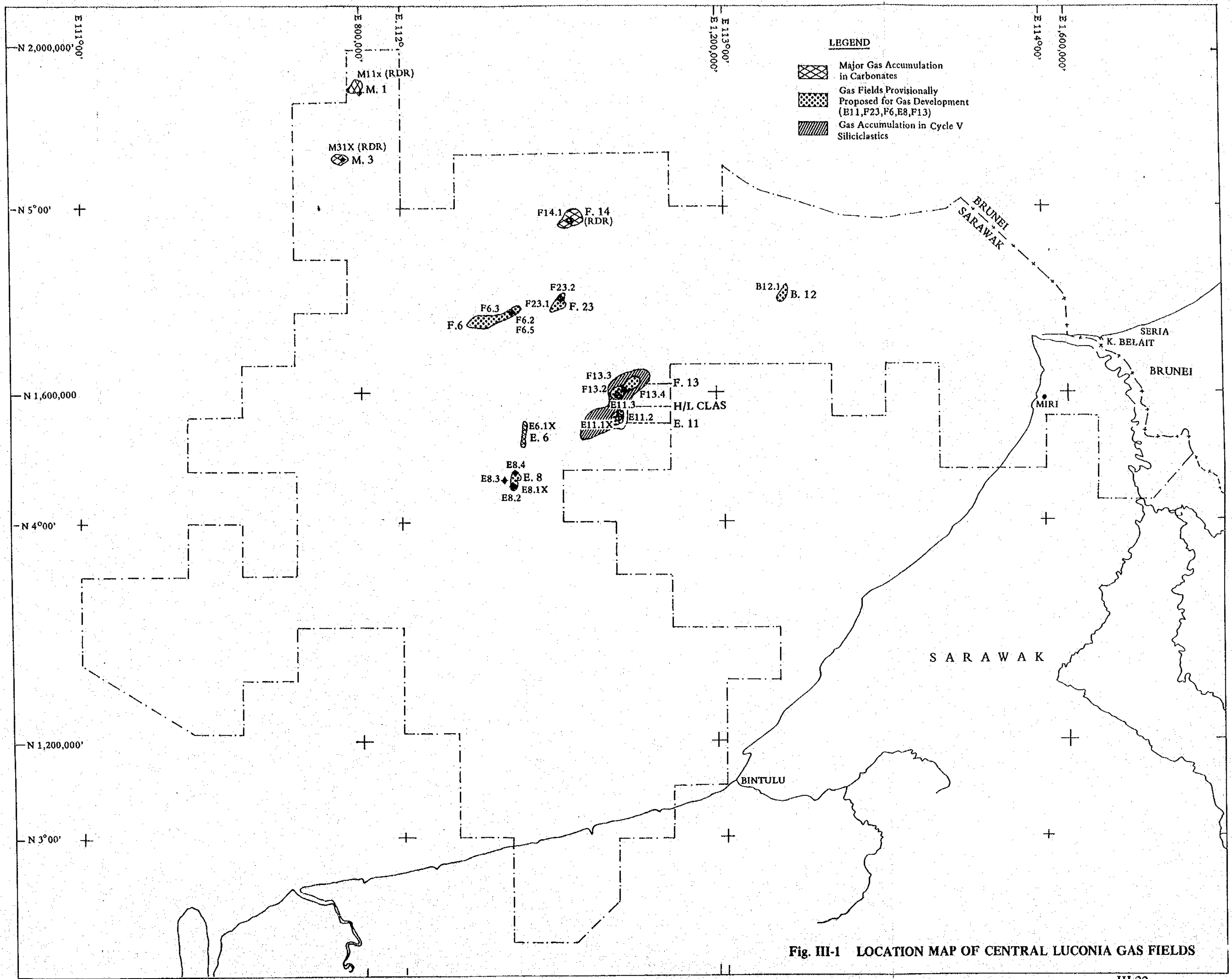
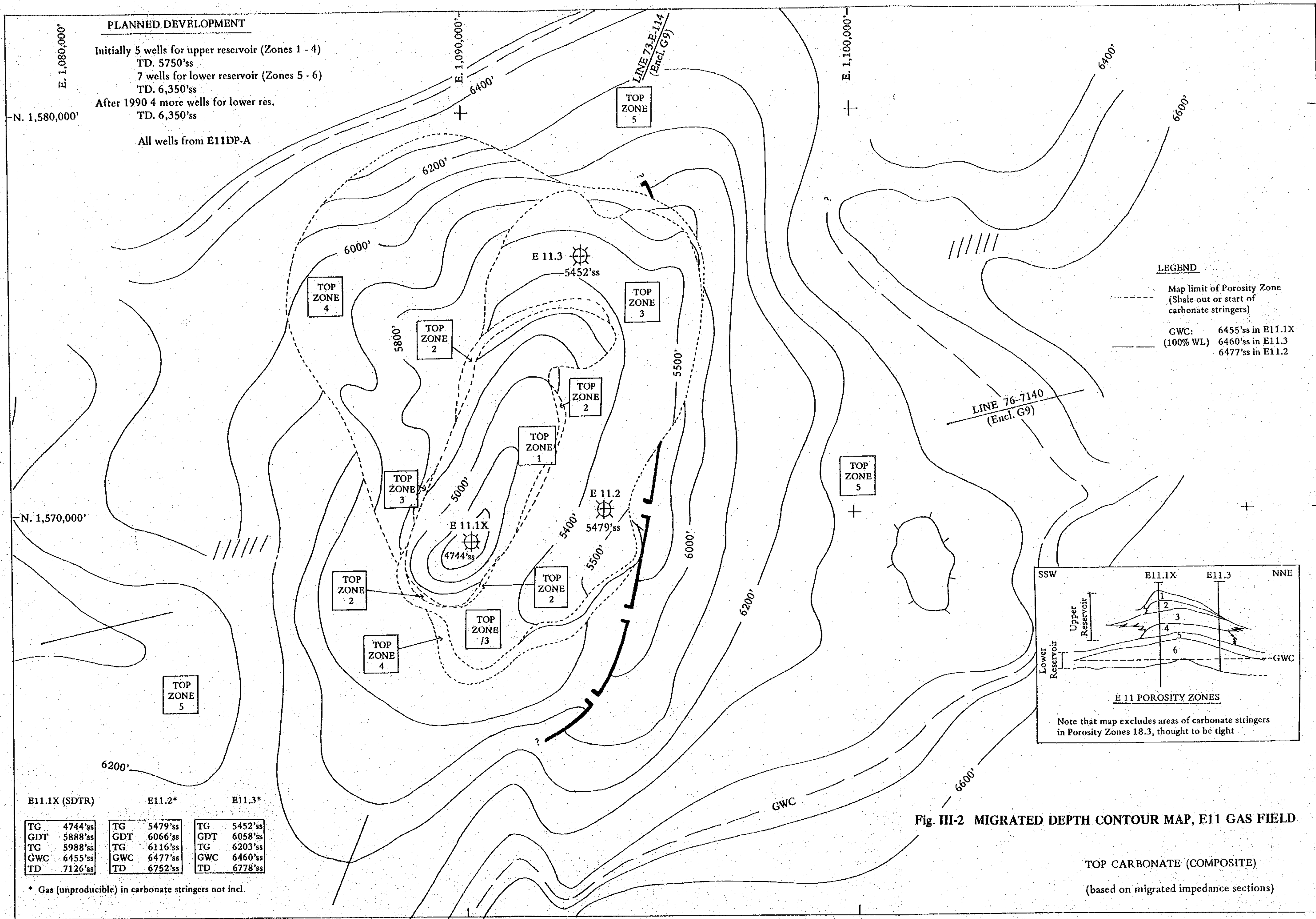


Fig. III-1 LOCATION MAP OF CENTRAL LUCONIA GAS FIELDS



E11.1X (SDTR)

TG	4744'ss
GDT	5888'ss
TG	5988'ss
GWC	6455'ss
TD	7126'ss

E11.2*

TG	5479'ss
GDT	6066'ss
TG	6116'ss
GWC	6477'ss
TD	6752'ss

E11.3*

TG	5452'ss
GDT	6058'ss
TG	6203'ss
GWC	6460'ss
TD	6778'ss

* Gas (unproducible) in carbonate stringers not incl.

Fig. III-2 MIGRATED DEPTH CONTOUR MAP, E11 GAS FIELD

TOP CARBONATE (COMPOSITE)

(based on migrated impedance sections)

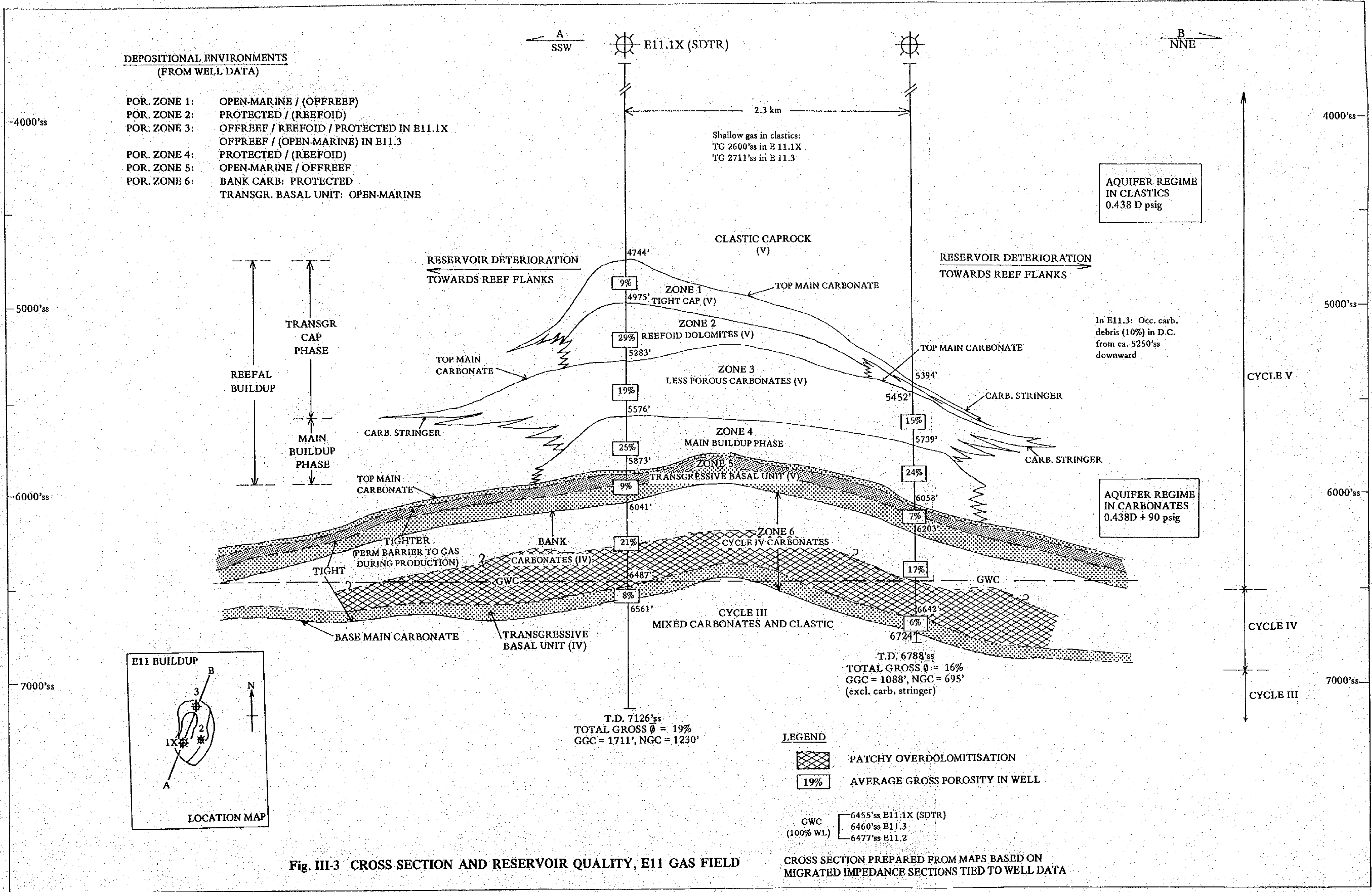


Fig. III-3 CROSS SECTION AND RESERVOIR QUALITY, E11 GAS FIELD

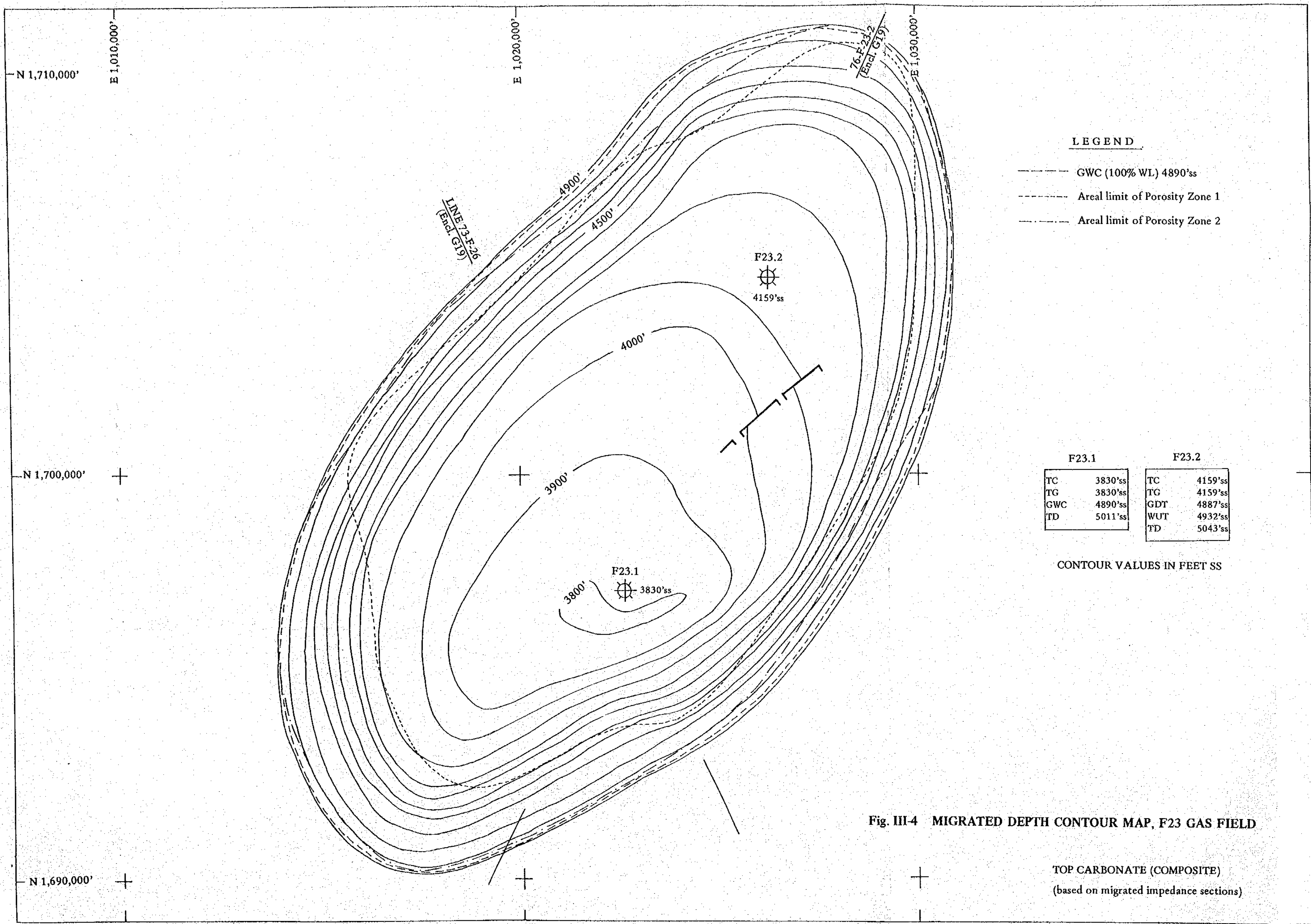


Fig. III-4 **MIGRATED DEPTH CONTOUR MAP, F23 GAS FIELD**

TOP CARBONATE (COMPOSITE)
(based on migrated impedance sections)

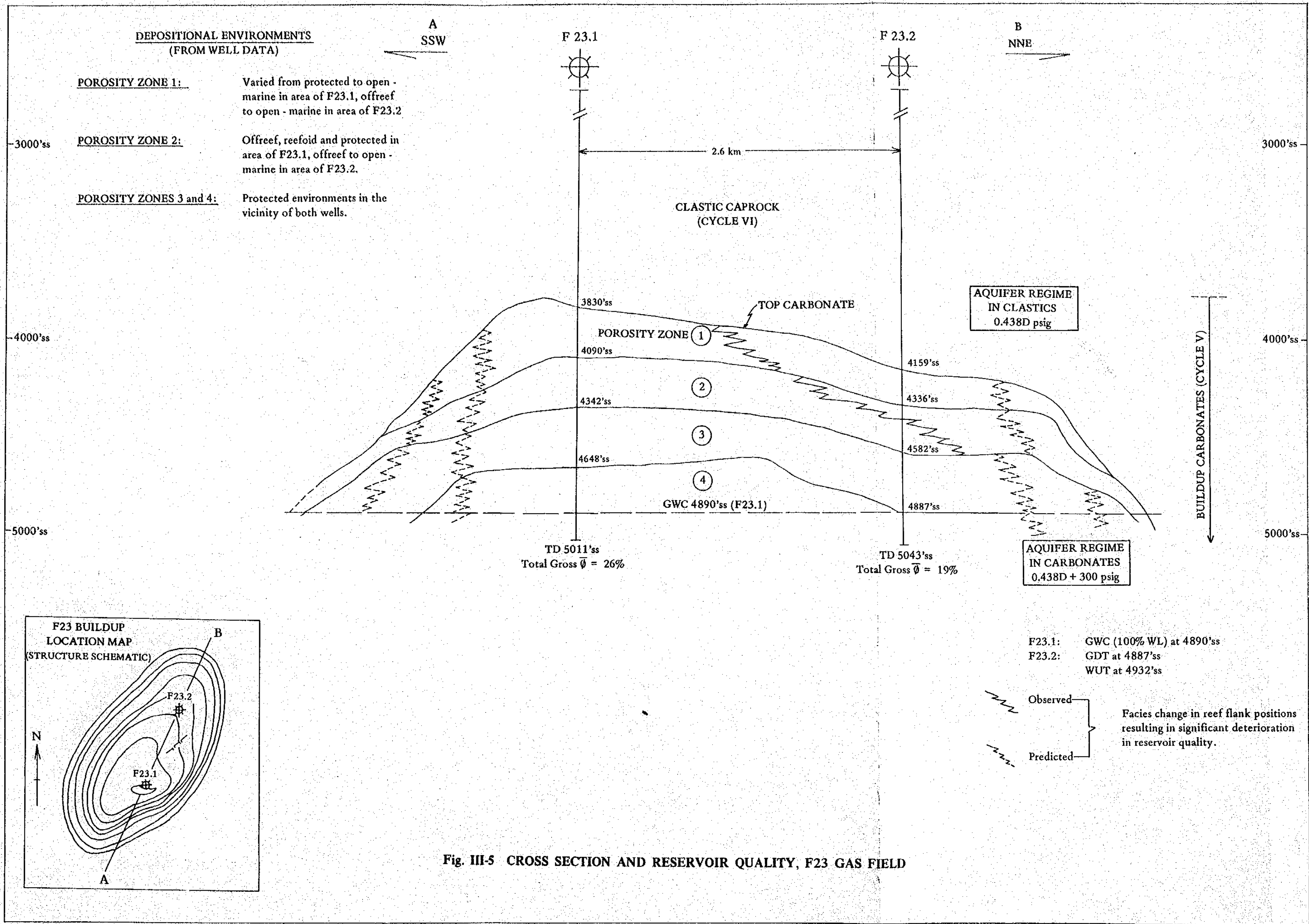
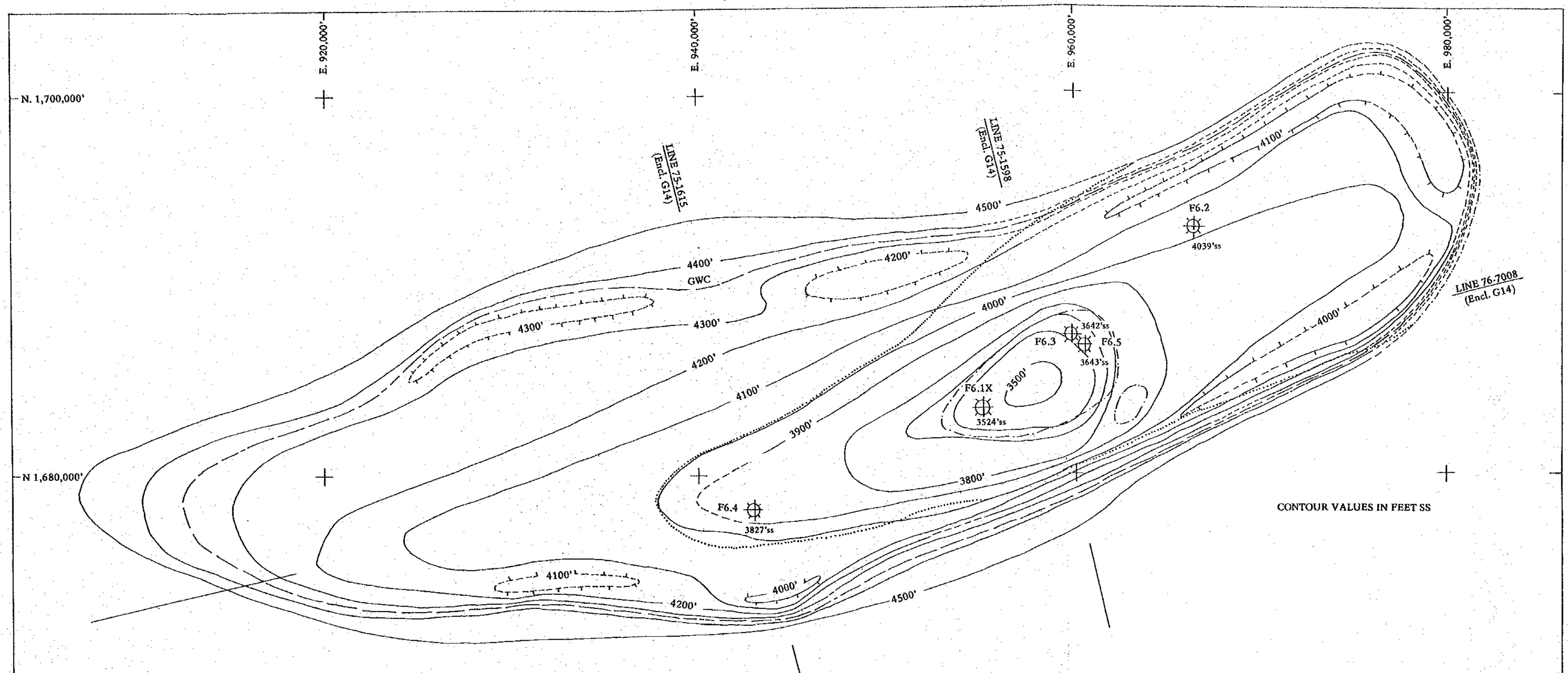


Fig. III-5 CROSS SECTION AND RESERVOIR QUALITY, F23 GAS FIELD



LEGEND

-·-·-·- Areal limit of Porosity Zone 1

·········· Areal limit of Porosity Zone 2

— — — GWC (100% WL) 4368'ss (F6.1X) 4355'ss (F6.5)

	F6.1X	F6.2	F6.3	F6.4	F6.5
TC	3524	4039'	3642'	3827'	3643'
TG	3524'	4039'	3642'	3827'	3643'
GWC	4368'				4355'
GOC		4339'			
OWC		4346'			
TD	4503'	5550'	4200'	4260'	4520'

N. 1,660,000'

Fig. III-6 MIGRATED DEPTH CONTOUR MAP, F6 GAS FIELD

TOP CARBONATE (COMPOSITE)
(based on migrated impedance sections)

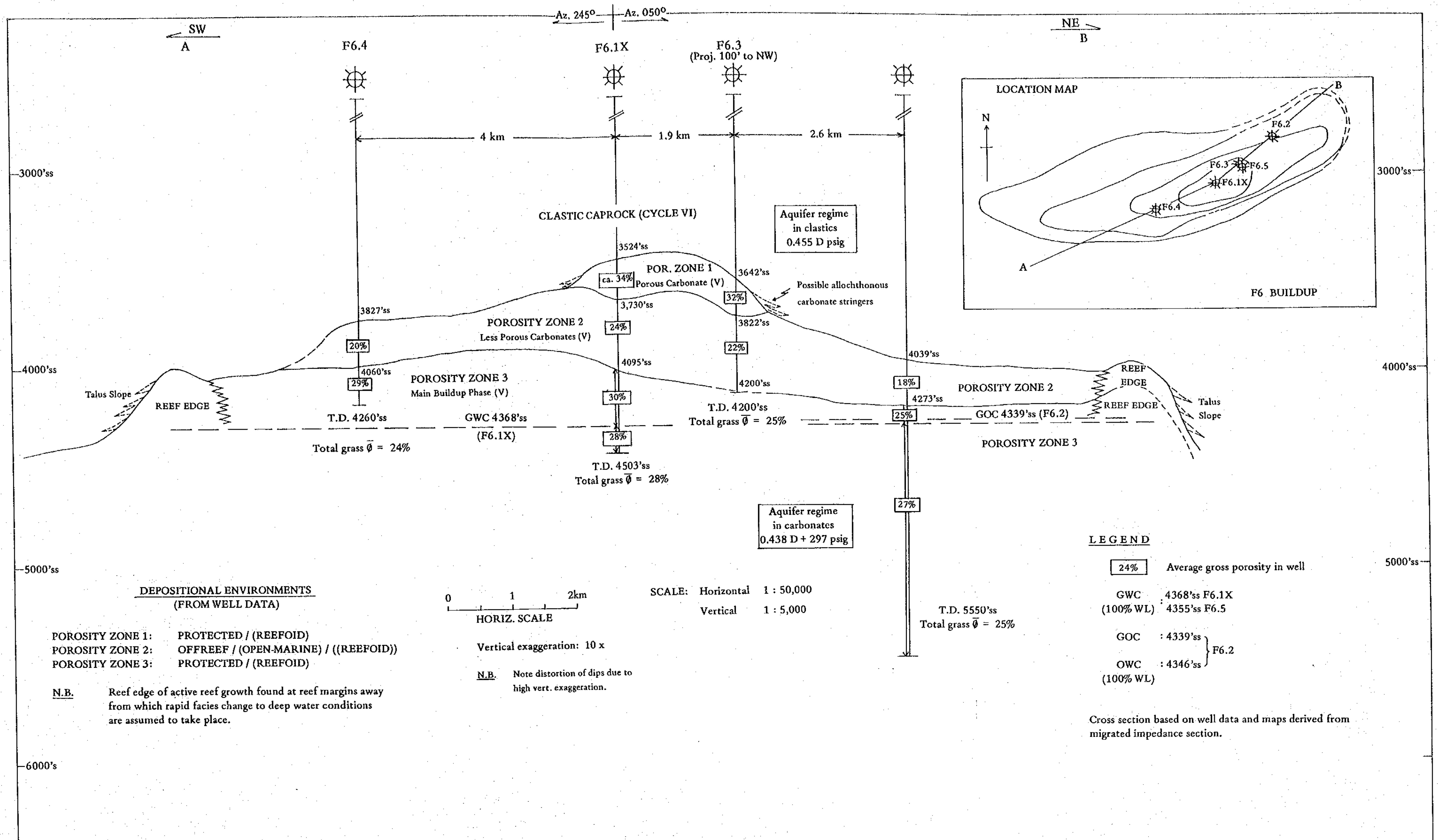


Fig. III-7 CROSS SECTION AND RESERVOIR QUALITY, F6 GAS FIELD

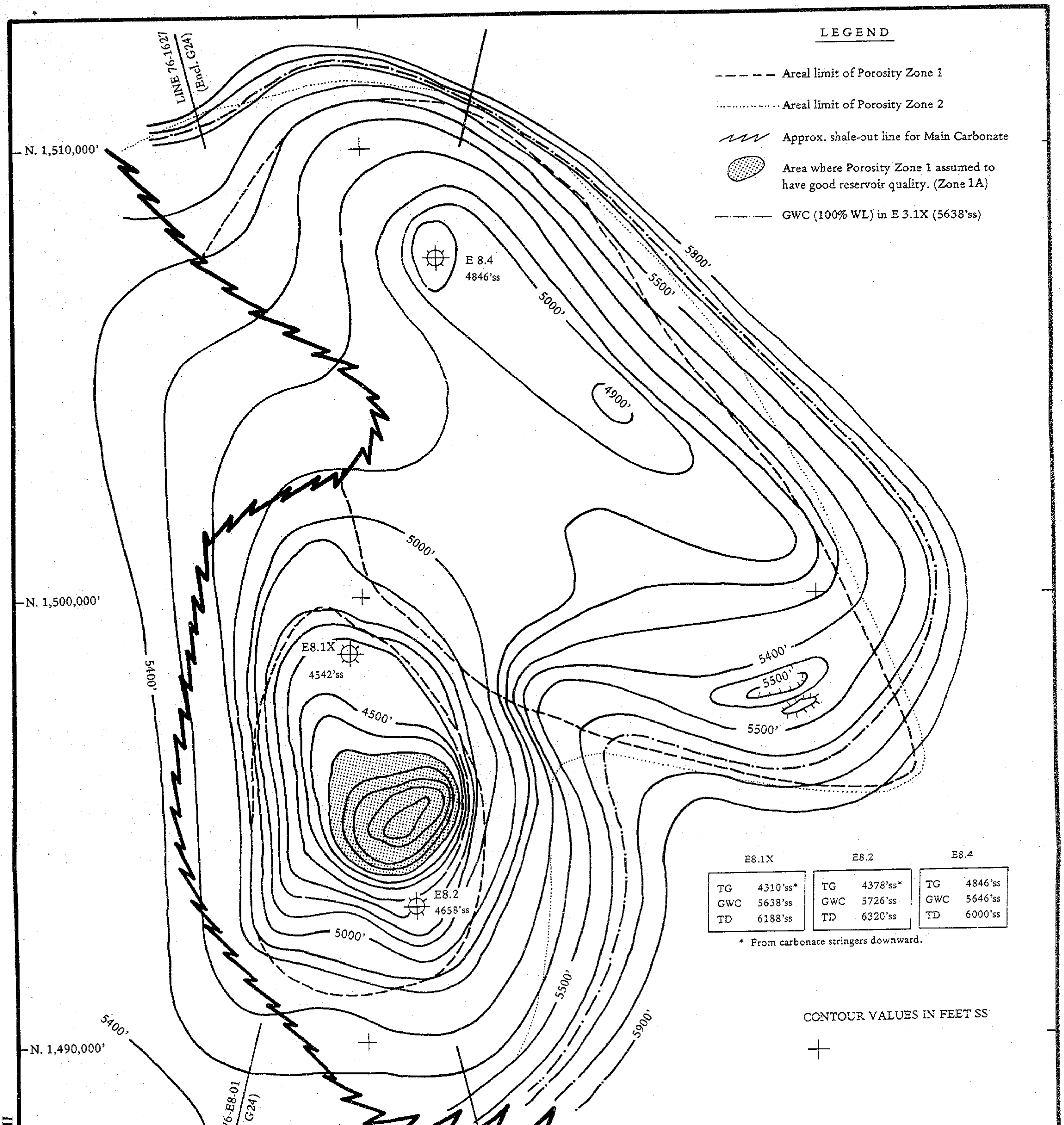
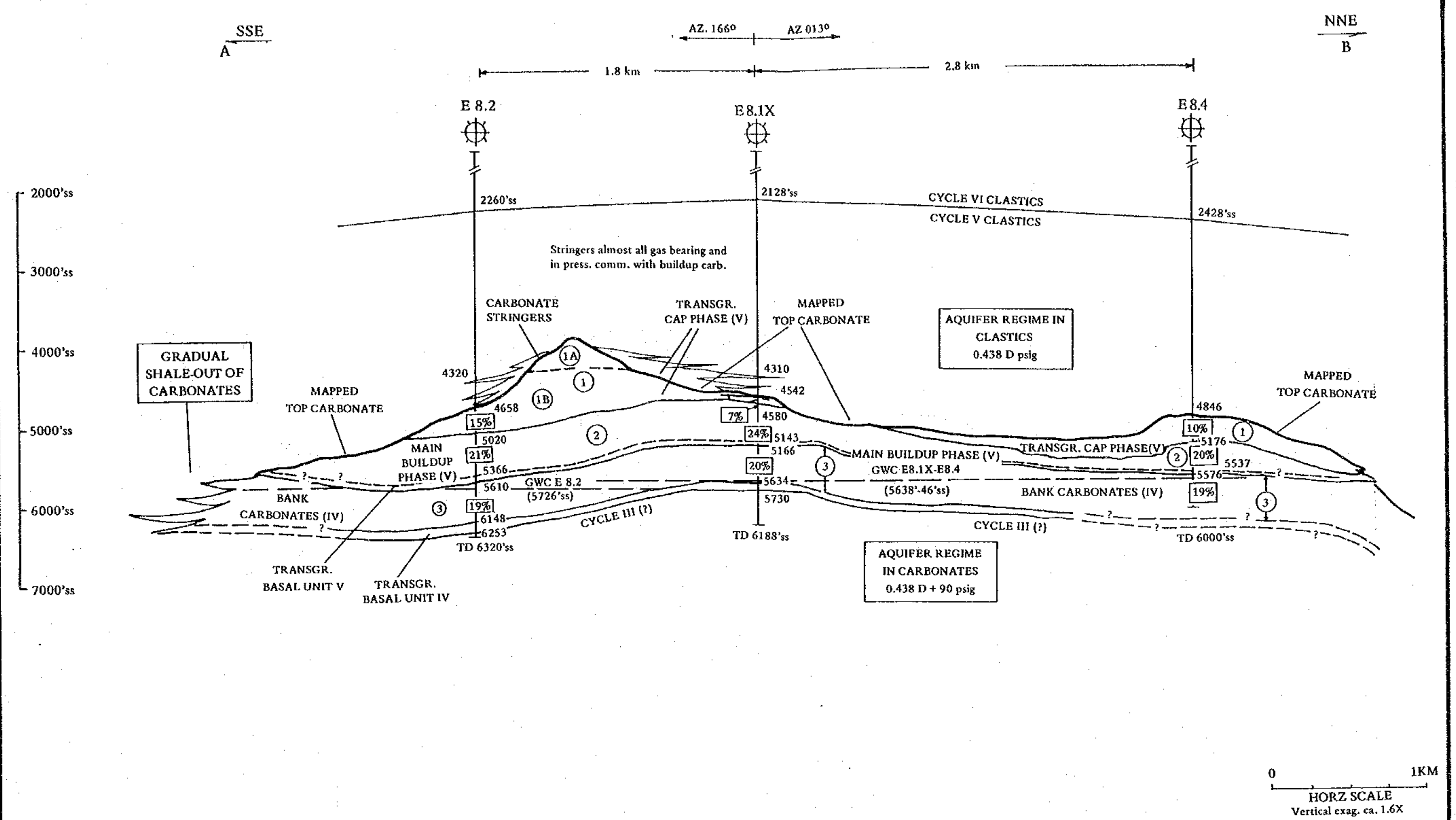
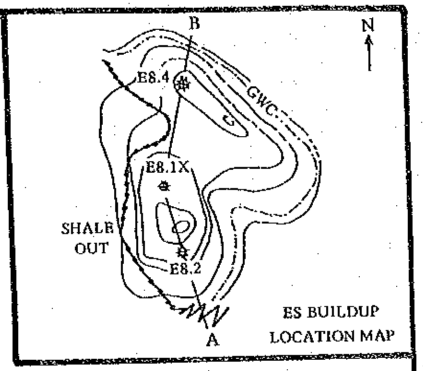


Fig. III-8 MIGRATED DEPTH CONTOUR MAP, E8 GAS FIELD

TOP CARBONATES (COMPOSITE)
(based on migrated impedance sections)





DEPOSITIONAL ENVIRONMENTS
(FROM WELL DATA)

TRANSG. CAP PHASE (V)	STRINGER ZONE:	OPEN-MARINE (CARBONATES) AND HOLOMARINE (CLASTICS)
	POROSITY ZONE 1:	OFFREEF / OPEN-MARINE / (REEFOID)
	POROSITY ZONE 2:	MAINLY PROTECTED / (REEFOID) →MAIN BUILDUP PHASE (V) BASE: OFFREEF / OPEN-MARINE →TRANSGR. BASAL UNIT V
	POROSITY ZONE 3:	PROTECTED BANK
	TR. BASAL UNIT IV:	OFFREEF
	CYCLE III (?):	OFFREEF / (OPEN-MARINE) (CARBONATES) AND HIN — LCP(CLASTICS)

N.B.
1. STRATIGRAPHIC CONTROL IN E8.1X POOR DUE TO INTENSE DOLOMITISATION AND LACK OF CORE DATA.
2. INTERNAL ARCHITECTURE OF BUILDUP SOMEWHAT UNCERTAIN DUE TO DISCONTINUITY OF SEISMIC REFLECTORS WITHIN CARBONATES.

LEGEND

(2) POROSITY ZONE 2

[19%] AVERAGE GROSS POROSITY FOR POROSITY ZONE (WELL DATA, CARBONATES ONLY)

GWC 5750'ah (5638'ss) E8.1X
5838'ah (5726'ss) E8.2
5728'ah (5646'ss) E8.4

MARKER DEPTHS ARE FEET SUBSEA.

CROSS SECTION BASED ON MIGRATED DEPTH CONTOUR MAPS AND WELL DATA

Fig. III-9 CROSS SECTION AND RESERVOIR QUALITY, E8 GAS FIELD

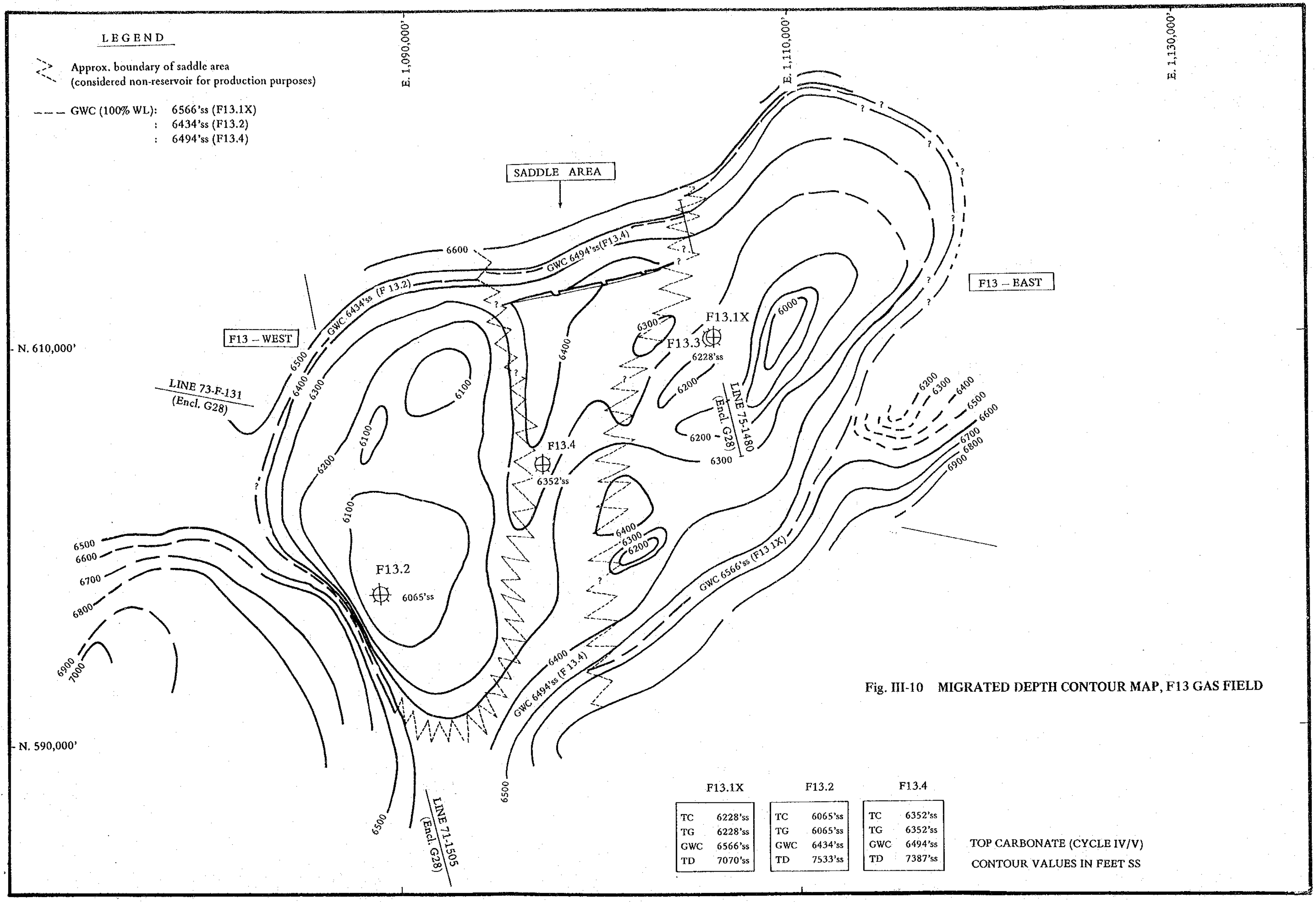


Fig. III-10 MIGRATED DEPTH CONTOUR MAP, F13 GAS FIELD

F13.1X

TC	6228'ss
TG	6228'ss
GWC	6566'ss
TD	7070'ss

F13.2

TC	6065'ss
TG	6065'ss
GWC	6434'ss
TD	7533'ss

F13.4

TC	6352'ss
TG	6352'ss
GWC	6494'ss
TD	7387'ss

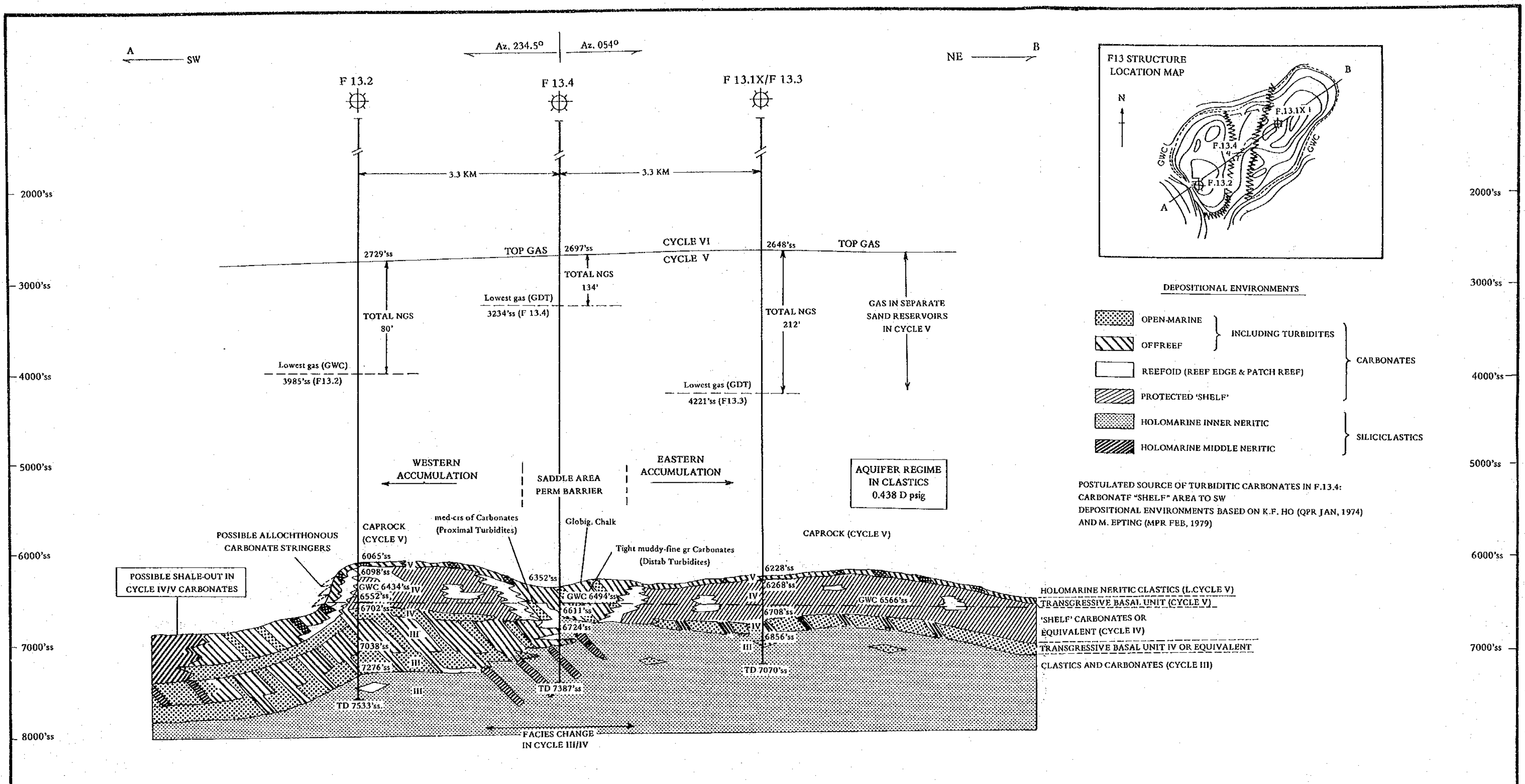


Fig. III-11 CROSS SECTION AND RESERVOIR QUALITY, F13 GAS FIELD

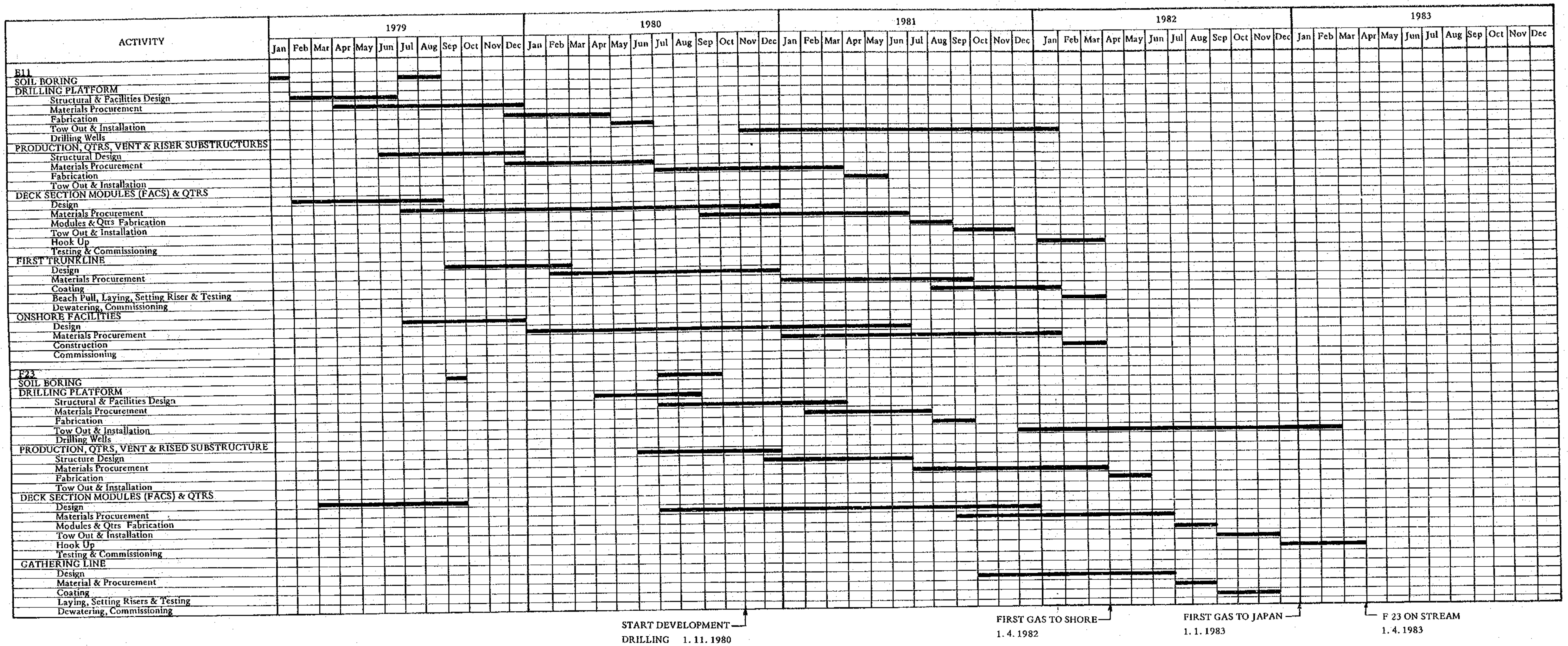


Fig. III-12 MLNG UPSTREAM PROJECT DEVELOPMENT SCHEDULE

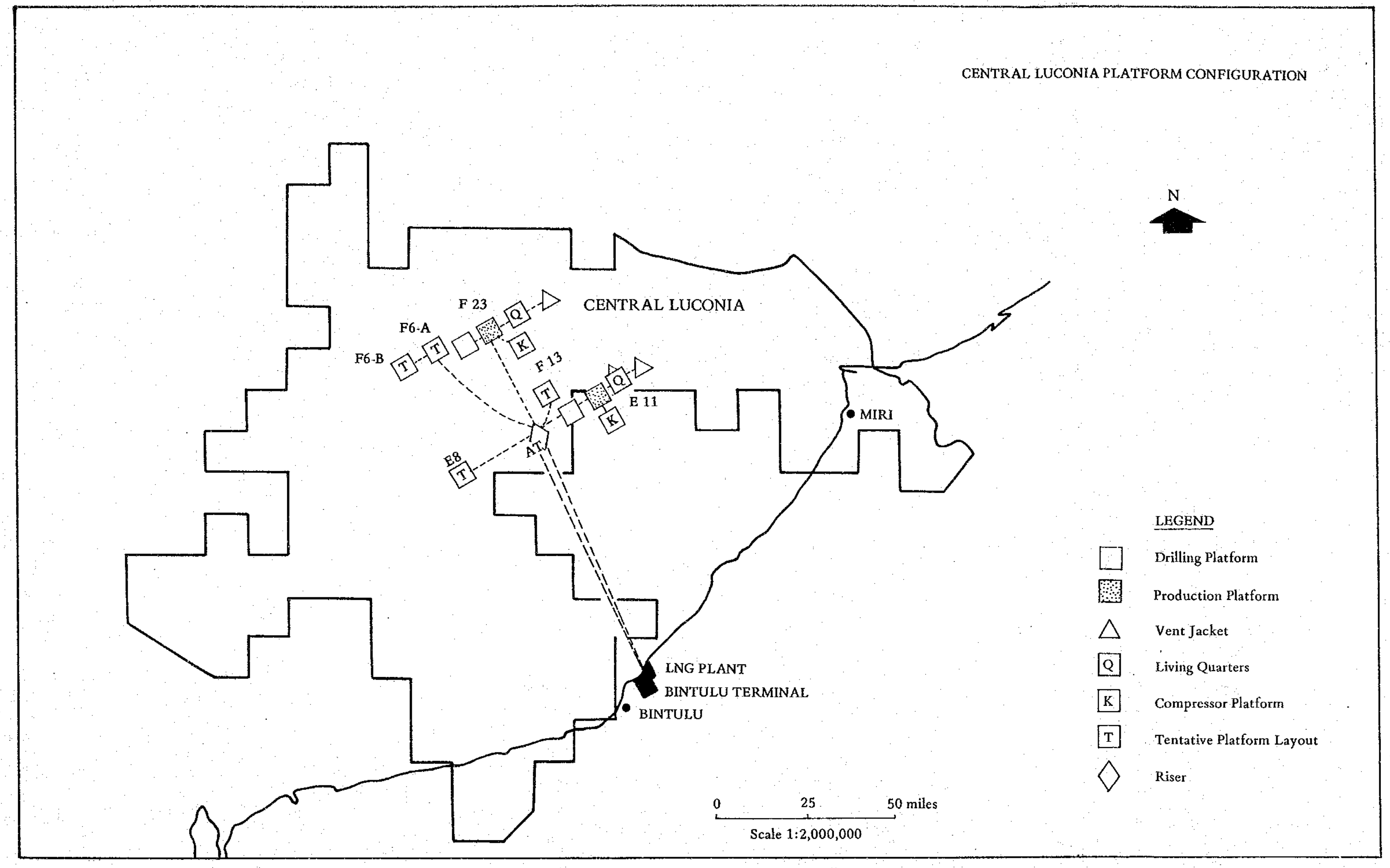


Fig. III-13 PLATFORM CONFIGURATION, CENTRAL LUCONIA

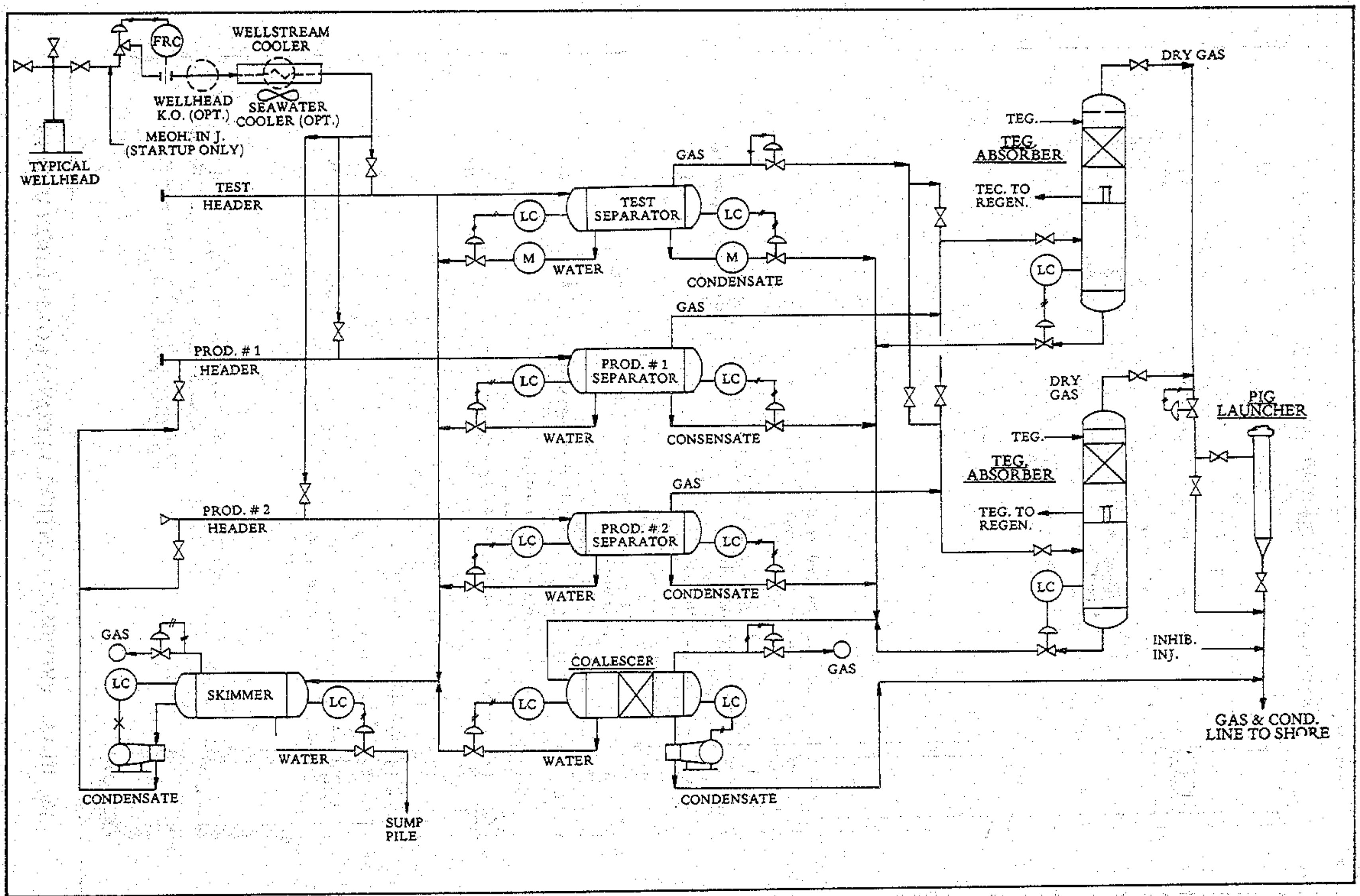
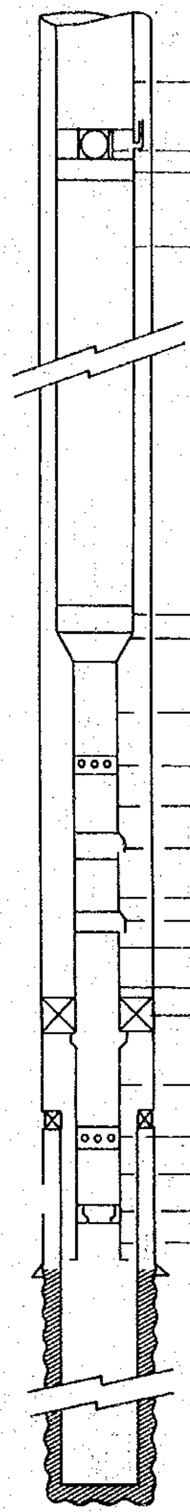


Fig. III-14 PROCESS FLOW SHEET, TYPICAL FIELD FACILITIES (OFFSHORE), COMMINGLED PRODUCTION

PROPOSED CENTRAL LUCONIA COMPLETION DESIGN

ENCLOSURE



ITEM	OD	ID
13% Cr Stainless Steel 7" tubing, 23 lb/ft		6.366
Surface Controlled Sub-Surface Safety Valve		3.625 / 3.50
Flow Coupling		
7" tubing, L 80, 23 lb/ft, Hydril Super EU	7.657 (Coupling)	6.366/6.335 (Pipe)(Coupling)
Flow Coupling, 30 ft.		
7" x 4" Crossover		
1 Jt., 4" tubing, L 80,13.4 lb/ft. Hydril PH-6	4.625 (Coupling)	3.275 (Coupling)
XD – SSD	4.810	3.125
2 Jts. 4" tubing		
Side pocket mandrel with shear disc (KBMG)	5.813	3.359
1 Jt., 4" tubing		
Side pocket mandrel with injection valve (KBMG)	5.813	3.359
10 ft. pup joint, 4" tubing		
Baker K-22 Anchor latch		4.875
Baker 194 SAB - 60 $9\frac{5}{8}$" permanent packer with 5" millout extension		4.750
1 Jt., 4" tubing		
XD-SSD		
1 Jt., 4" tubing		
Oris R Nipple	Bare	3.125
1 Jt., 4" tubing		

NOTES:
1) $9\frac{5}{6}$" Production Casing, L 80, 43.5/47 lb/ft with Premium thread connections to be set in top carbonate
2) 7" Liner, L 80, 23 lb/ft, with hanger packer, to be set through completion interval.

Fig. III-15 PROPOSED CENTRAL LUCONIA COMPLETION DESIGN

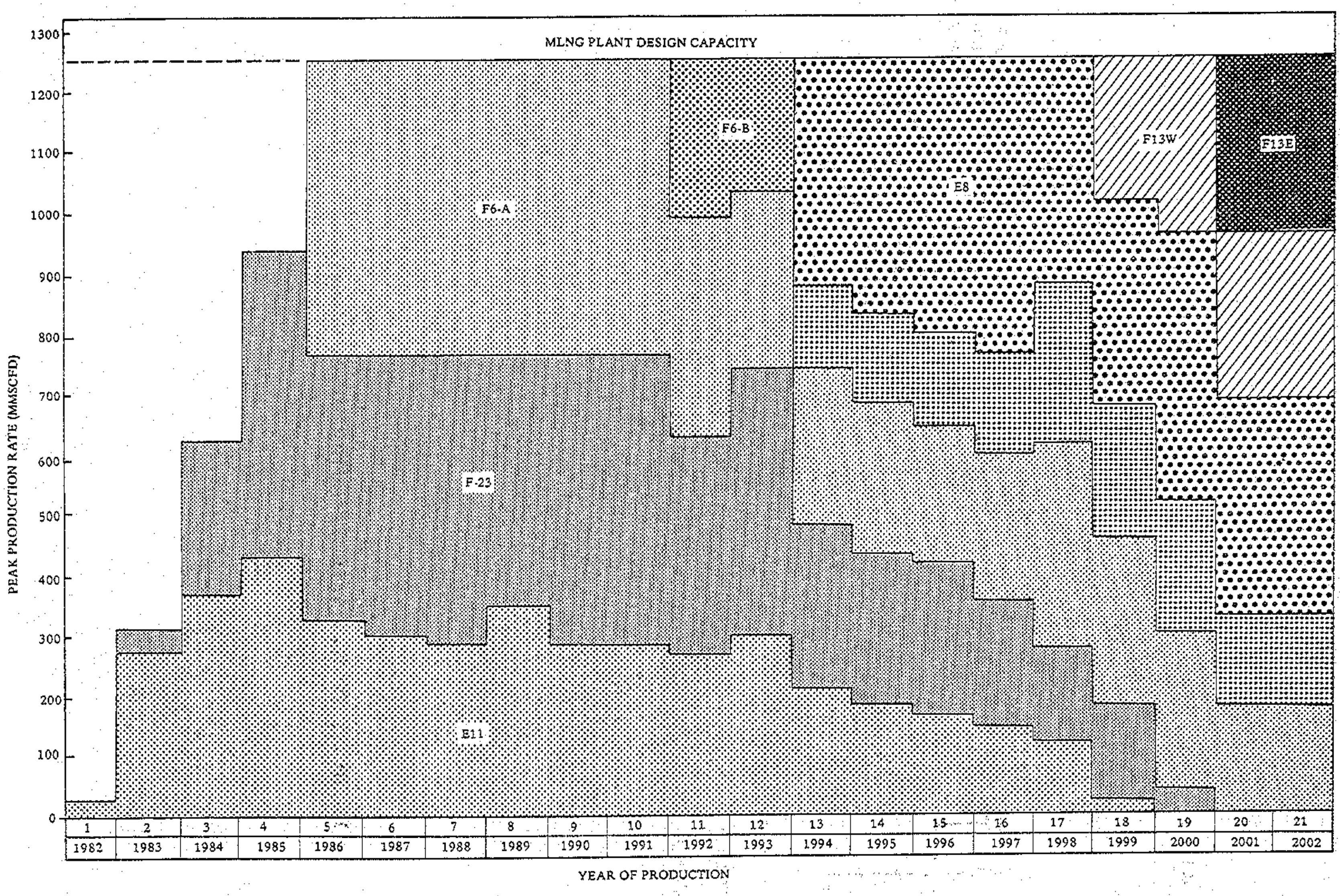


Fig. III-16 PRODUCTION SCHEME, CENTRAL LUCONIA GAS SUPPLY TO MLNG

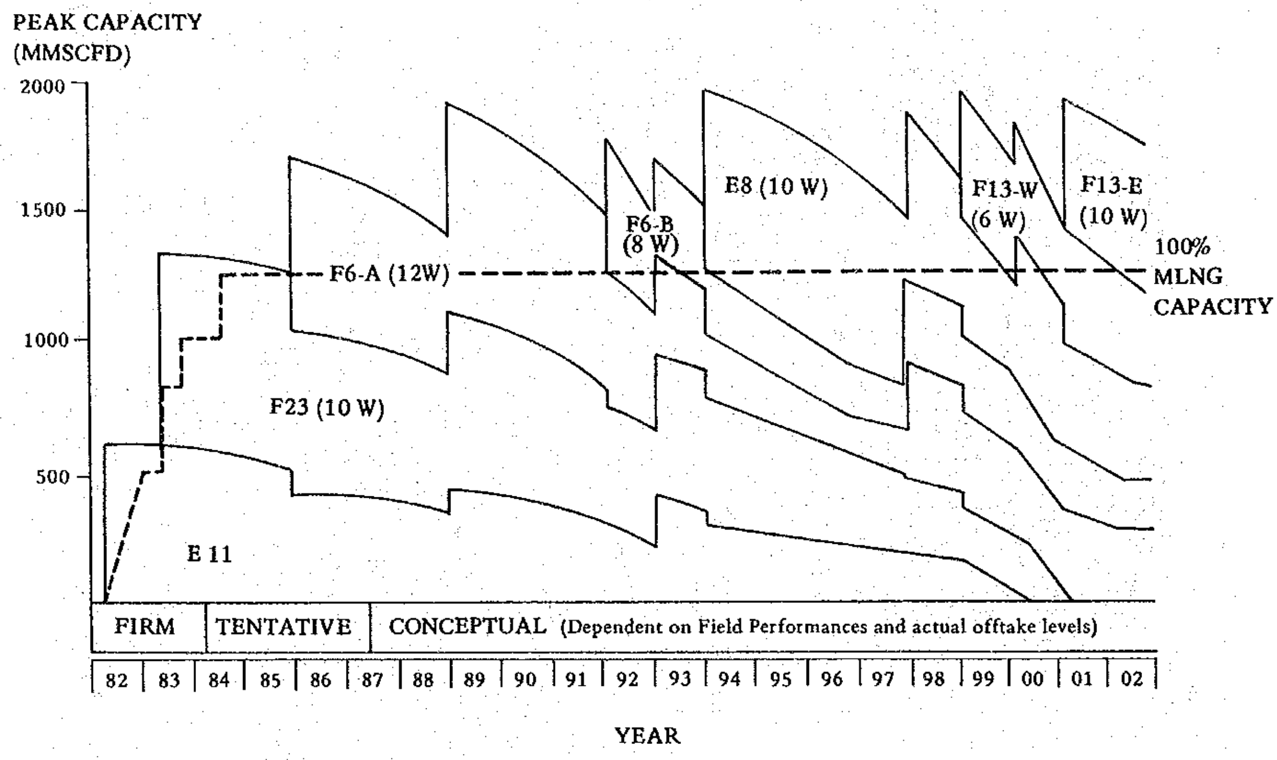


Fig. III-17 COMBINED PEAK PRODUCTION CAPACITY

P A R T   I V

EXAMINATION OF TECHNICAL ASPECTS

REGARDING THE AMMONIA AND UREA COMPLEX

(THE PROJECT)

PART IV EXAMINATION OF TECHNICAL ASPECTS REGARDING THE AMMONIA AND UREA COMPLEX (THE PROJECT)

CHAPTER 1 INTRODUCTION

This Part IV discusses technical aspects of the Project, including observations and recommendations made by the Evaluation Study Team. PETRONAS Project Team, as the executing agency for the Project, has proposed a basic plan for the Project which has been approved by the ASEAN Economic Ministers Meeting. The Team's examinations are based on the proposed plan, and the outcome of those examinations therefore adopts the plan and concept developed by the PETRONAS Project Team, except where revision or alteration is required.

The Evaluation Study Team's examinations focus on the following points in particular:

1) Selection of the site for the Complex

   The PETRONAS Project Team has located a site for the Complex in Bintulu, Sarawak State. The Evaluation Study Team therefore examines the selected site with a view of evaluating its suitability for building and operating the Complex.

2) Availability of utilities and relevant infrastructure

   At the ASEAN Economic Ministers Meeting in December, 1978, it was decided that the scope of the Project would not include water and electric power supply facilities, port facilities and a housing colony for employees. For these, the Malaysian authorities are to assume full responsibility. The Team evaluates plans and progress of the development or expansion of these facilities to ensure their availability and time schedule for meeting the requirements of the Project.

3) Definition of a project scheme and facilities of the Project

   Based on the above findings as well as the proposed plan, the Evaluation Study Team examines the planned project scheme (product items and their quality, and plant capacities), plant layout, design bases, material and utilities balance, conceptional design of facilities and other technical requirements to define the project plan as well as the scale and concept of manufacturing facilities, utility facilities and auxiliary facilities to be set up within the scope of the Project.

4) Implementation plan; organizational and managerial structure of the Project

Based on the plan and schedule conceived by the PETRONAS Project Team, the Evaluation Study Team examines the implementation schedule; form of contract for the design, engineering, procurement and construction of plants and facilities; organization, manning and training requirements; as well as requirements for employment of consultants and advisors in the respective phases of project implementation and operation.

Another important aspect examined by the Evaluation Study Team is adequacy of natural gas, in terms of quality and quantity to be supplied to be used as feedstock and fuel for the Complex. Discussions on this aspect, however, are contained in Part III of this report.

CHAPTER 2 PROPOSED SITE FOR THE COMPLEX

2-1 Criteria for Site Selection

The following points are major criteria to be considered in evaluating and selecting a site for the Ammonia and Urea Complex:

(1) Possibility for a long-term, stable supply of natural gas in adequate quality and quantity, and at economical cost, to be used as feedstock and fuel for the production of ammonia and urea.

(2) Possibility for a stable supply of electric power and water, in adequate quality and quantity, and at economical cost, as required for the operation of the Complex.

(3) Availability of a plant site which has adequate soil bearing capacity and is relatively level for easy, economical site preparation.

(4) Access to a deepwater port where large-size ocean-going vessels can be moored for loading the produced ammonia and urea to be shipped to markets in Malaysia and abroad.

(5) Convenience in bringing into the site equipment and materials required for the construction of the Complex.

(6) Existence of a suitable environment for the residences and daily life of construction workers during the construction of the Complex as well as the personnel operating the Complex after completion of construction.

Natural gas for the Complex is to be supplied from the Central Luconia fields, and gas from those fields, as noted in Part III of this report, is primarily for use at the LNG plant which will be owned by Malaysia LNG Sdn. Berhad (MLNG) and will be located at Kidurong, Bintulu, in Sarawak. It is planned that the gas for the Complex will be branched at an outlet of the slug catcher from a trunk gas pipeline which transmits gas from the aforesaid fields to the LNG plant, and will be supplied to the Complex through a branch pipeline.

The site selected by the PETRONAS Project Team for the Complex is located adjacent to the site for the LNG plant. In view of proximity to the gas supply source, the location of this site is geographically favorable to be selected for the site of the Complex if other criteria for site selection enumerated above, are satisfied. Thus the Evaluation Study Team evaluates suitability of the selected site taking those criteria into consideration.

2-2 Conditions at the Proposed Site

The proposed site is in the Kidurong area, which is in the suburbs of Bintulu town and is about 25 km northeast of the town.*)

National plans call for the development of a large industrial estate in this area, for which preparatory coordination work is now underway by the Bintulu Development Authority (BDA) which is under the direct control of Chief Minister Department in the State of Sarawak. Planned major components of the estate, which has the total area of 1,180 acres, are as follows:

(1) LNG plant: Malaysia LNG Sdn. Berhad is to undertake implementation of a project to build a 6,000,000 t/y LNG plant which is scheduled to start production in 1983. At present, site preparation work is being performed.

(2) Crude oil terminal: This terminal is operated by PETRONAS-Upstream Division for the shipment of crude oil lifted from the Kemena oil fields which are located offshore Bintulu. The terminal consists of 3 units of 65,000 m^3 tanks. Construction of the tanks is almost complete.

(3) Palm oil export terminal: Site preparation work is now being carried out.

(Note) *) Bintulu town is a small community located on the western border of the Fourth Division in the State of Sarawak, which faces the point where Kemena River (Batang Kemena) flows into the South China Sea. Bintulu at present is not industrialized. Industries in this area are agriculture, fishing, forestry and the production of glass sand. The population is only about 14,000 for the Greater Bintulu Area (1979 statistics) consisting of Malay-15%, Melanau-32%, Iban-13%, Chinese-37% and Others-3%.

(4)	Aluminum smelting mill:	Studies are now being made for an aluminum smelting project based on imported bauxite.
(5)	Direct reduction steelmill:	Studies are now being made for a direct reduction steelmill project which would use imported iron ore.
(6)	Bintulu Deepwater Port:	Target completion date, 1982. Phase I work has been begun.
(7)	Housing area, recreation area, university, new airport:	Under planning.
(8)	Expansion of water supply facilities:	Planning and studies are now being made by the Public Works Department.
(9)	Power station:	Implementation of the project is now being carried out by the Sarawak Electricity Supply Corporation (SESCO).
(10)	Ammonia and Urea Complex (the present project):	Soil investigations at the site are now being made by the PETRONAS Project Team.

Locational features of the site and its surrounding area are shown in Figs. IV-3 and IV-4. The proposed site faces the Tanjung Kidurong road which is a trunk road connecting the Kidurong Cape and is adjacent to Bintulu Deepwater Port, SESCO's new power station and the Public Works Department's water storage. Moreover, it is relatively close to the LNG plant site.

The site is presently the property of the Federal Government; site use planning is under the jurisdiction of the BDA. As the BDA has agreed to the use of the site for the Complex, there is no administrative difficulty in obtaining approval for the use of the site. The BDA's basic policy is to lease land for the site, on an "as is" basis, to the new company to be established for the operation of the Complex, although the terms and conditions for leasing the land are yet to be worked out through discussions between the BDA and PETRONAS. The site for the LNG plant of which site preparation is now in progress is under the jurisdiction of the BDA as well. The terms and conditions for land use by the MLNG for the LNG plant site are not definite yet. The terms will be finalized by further negotiations between the BDA and MLNG.

The Kidurong area is characterized by Neogene sedimentary deposits and a rainy tropical climate. The characteristics of the site can be delineated as follows:

1) Geographic location:

Kidurong area, Bintulu; 3°17'N latitude and 113°05'E longitude

2) Area: About 40 ha

3) Ownership of land: Federal Government of Malaysia

4) Topography:

The northern boundary of the site follows an east-west ridge which is at elevations of 60 - 70 m, and the southern boundary follows the Tg. Kidurong road which is at the elevation of 12 m. Therefore the site's northern and east-west boundaries are at higher elevations, and there are very strong undulations spreading in a generally southern direction.

5) Surface reconnaissance:

With the exceptions of the swamps and marshes, most of the site is covered by a dense growth of young broadleafed trees and undergrowth which is about 2 m in height. Most trees within the site are slender and tall. Timber roads have been made for removal of logs, and serious erosion has resulted. The site is divided into three parts by two marshes which flow into Bintulu Bay. The marshes form small swamps in low areas near the Tg. Kidurong road.

6) Soil:

Because no boring logs are available for land within the site, it is not possible to make a reliable judgement on soil conditions there, but the following observations may be made on the basis of the geological maps published by Malaysia's Geological Survey, soil data for Bintulu Deepwater Port, and field reconnaissance of site preparation work underway for the LNG plant. The ground is covered by a thin stratum (0.2 to 0.3 m) of topsoil which contains considerable organic matter, below which is a stratum of sandy silt (so-called tropical laterite). Below that is Neogene sedimentary sandstone and shale.

7) Climate:

According to observations at the Bintulu town airport, the monthly average of mean temperature varies by only about 1°C, from 25.8°C (December) to 26.9°C (April), and the monthly average of mean relative humidity varies by only 5%, from 84.9% (May) to 89.3% (February). The difference between the highest temperature and the lowest temperature (in terms of a monthly average) is also in a narrow range between 31.6°C (August) and 29.7°C (February). Annual rainfall is about 4,100 mm; maximum rainfall is 570 mm (December) and minimum rainfall is 165 mm (May). (For details, see Chapter 4 of this Part IV.)

The topography in the area of the site is strongly undulating, and, moreover, the site is at a considerably high elevation relative to the shoreline. Such topography in the site necessarily means that somewhat high site preparation costs must be borne. Nevertheless this region is generally composed of undulating, high-elevation land, so that no matter which place in this region be selected for the site, there would be little difference in site preparation costs.

On the other hand, such disadvantage is offset by other site conditions which are rather favorable especially in terms of proximity to natural gas and utilities supply sources and also of convenience in bringing equipment and materials to the site as well as in product shipment. It is judged that in overall terms this site is satisfactory for use for the Complex, providing that the soil conditions are acceptable.

With the approval of the BDA, PETRONAS Project Team has commissioned a preliminary site survey. This survey is being performed by a local surveyor, under the supervision of a local consultant, Jurutera Konsultant (SEA) Sdn. Berhad. The PETRONAS Project Team plans to make the final decision on the use of this site pending the outcome of the site survey which is now being made. It will be several months before the results of the survey are available, so the selection of this site at present must be considered to be still tentative. However, the PETRONAS Project Team intends to utilize the site, unless serious problems are discovered as a result of the survey.

Given this situation, it has been necessary for the Evaluation Study Team, when in the field, to make its judgements about the site by making reference to existing information about adjacent areas, in lieu of detailed soil data on the site which are not yet available. Until the results of the soil survey are available, no reliable, firm statement may be made, but in the present estimation of the Evaluation Study Team, it is surmised that the soil bearing capacity and other relevant qualities of the soil are adequate for establishment of the Complex.

In the above context, it is also presumed that the results of the soil survey might not raise any inherent drawback which makes it mandatory to use some other site. Therefore, it may be assumed for present purposes that the proposed site is to be used for the Complex. Accordingly, the following study is based on the assumption that the proposed site is the one used for the Complex.

CHAPTER 3 UTILITIES SUPPLY AND AVAILABILITY OF PORT FACILITIES AND HOUSING COLONY

Other than the supply of natural gas as feedstock and fuel, a secured supply of water (for uses including those of process water, boiler feed water, and cooling water), and electric power are essential requisites for the establishment of the Complex. Other essential requirements are availability of adequate port facilities and adequate housing and community services.

Bintulu, as is mentioned above, is a small town which has a population of about 14,000, and it lacks the infrastructure required for a large-scale industrial project such as this Complex. Therefore the harmonized development of utility supply systems, port facilities, housing and community services and other relevant infrastructure is a vital prerequisite for successful implementation of this Project.

Nevertheless, at the ASEAN Economic Ministers Meeting, it was decided that these would be excluded from the scope of the Project. The Malaysian Government would be solely responsible for the development of these facilities and services. However, it is necessary to insure that dependence upon such facilities and services to be supplied or provided by various authorities or agencies of the Government will not present any hindrance to the construction and operation of the Complex.

This chapter outlines plans and progress to date relating to the development of those facilities and services, and also discusses the Evaluation Study Team's observations and recommendations regarding necessary measures or actions to be taken by the PETRONAS Project Team.

3-1 Water Supply

The Complex requires a large quantity of water for various uses. These are cooling water, process water and boiler feed water, but also water for fire-fighting, drinking and sanitary purposes. The Complex needs, every day, approximately 5.2 million gallons (23,640 m^3) of water for these uses.

Water supply in the Bintulu area is the responsibility of the Public Works Department of the State of Sarawak. The water resources for the present supply is the Sungai

Sibiu which is a tributary of the Batang Kemena.

The Department, at present, takes water from the Sungai Sibiu in a catchment area of about 40,000 acres (16,000 ha). After purification, the water is supplied as potable water to consumers in the Bintulu area. The existing water supply system is capable of supplying one million gallons (4,500 m^3) per day of potable water, while the present water demand in this area is approximately 700,000 gallons (3,200 m^3) per day. The existing supply facilities will be unable to supply the soft water requirement of the Complex.

Given below is the future water requirement in the Bintulu area, projected by the Public Works Department:

Projected Water Requirement

(million gallons/day)

	1983	1985	1995
Bintulu residential area	1.0	1.1	1.7
University	0.1	0.2	0.4
Kidurong residential area	0.2	0.3	0.9
Kidurong industrial area	1.6	7.9	9.1
- Bintulu Deepwater Port	(0.2)	(0.2)	(0.4)
- LNG plant	(0.6)	(0.5)	(0.5)
- Direct reduction steelmill	(0.7)	(0.7)	(0.7)
- ASEAN Ammonia-Urea Complex	(0.1)	(6.5)	(6.5)
- Aluminum smelter	(-)	(-)	(1.0)
Others	0.1	0.2	0.2
Total	3.0	9.7	12.3
(Equivalent in m^3/day)	(13,600)	(44,100)	(55,900)

To meet this future growth of demand for city water in Bintulu area as well as the future need for industrial water in the Kidurong industrial estate, the Public Works Department has already proceeded with implementation of a project to expand the water supply capacity. Construction for the first phase expansion is now being carried out with the objective of increasing supply capacity by the end of 1979. This construction work will increase the capacity for intake of water from the Sungai Sibiu as well as for purification of the water taken from the river. When the construction work is completed, the supply capacity will increase to 2.5 million gallons (11,360 m^3) per day which is expected to meet the demand in the early part of the 1980's. However, because there is a limit to the volume of water which may be taken from this river, further expansion of supply capacity must be based on another source of water.

The Public Works Department (PWD), in order to meet the future demand, has decided to build a pumped storage dam having a storage capacity of 350 million gallons (1.6 million m^3) with a reservoir area of 100 acres. The dam will be located in the basin of the Sika river which is a tributary of the Sungai Sibiu. A geological survey on the dam area, necessary for the detailed design to be prepared, is now being carried out by a British consultant, Halcrow Balfour Ltd. It is planned to complete construction of this dam by the end of 1982.

Further, the PWD has a plan to lay a 750 mm pipeline from the Sika Dam to the Kidurong area, and to construct a 3.6 million gallons (16,370 m^3) emergency storage tank in the Kidurong area, to assure a stable supply of water to users there. The PWD plans to complete construction of these facilities by 1985. This will enable the PWD to increase its water supply capacity to 10 million gallons (45,460 m^3) per day by 1985, and to 14 million gallons (63,640 m^3) by 1995.

From the storage capacity and catchment area of the Sika Dam, it is concluded that, along with completion of the dam, sufficient volume of water will be made available to supply 14 million gallons per day even during the dry season. (For details on the design of this dam, see the Evaluation Study Team's observations, in Appendix IV-1.) Therefore, if the dam construction is completed as scheduled (i.e., by the end of 1982), and if the 750 mm pipeline is installed by the time of mechanical completion of the Complex, it is believed that there will be no problem in relying on the Public Works Department for supply of water for the Complex.

It is too early to make a reliable judgement on the certainty that the dam is completed as scheduled, because the dam construction project is still in the initial stage of implementaiton. Provisionally, however, it is considered that, even if completion of the dam is delayed by one full year, the dam will be ready to start water supply, with suitably ample leeway, at the time of mechanical completion of the Complex which is scheduled to be the end of September, 1983. (See Chapter 6 of this Part IV.)

In this case, a potential problem exists with regard to the timing of completion of the pipeline between the Sika Dam and the Kidurong area. As stated above, in the Public Works Department plan, the pipeline construction is to be completed by 1985, so that it is necessary for pipeline work to be rescheduled in order that the expanded water supply system may be placed in service in time to be used to supply soft water to the Complex by the time of mechanical completion of the Complex. The Public Works Department has indicated that, if necessary, it is ready to reschedule and carry out the pipeline work so as to conform to the schedule for the Complex.

Therefore, it is assumed for purposes of this study that the pipeline system will be placed in service in time, on the presumption that the Public Works Department will be promptly informed of the schedule of the Complex, so as to be able to reschedule the pipeline construction work. It is recommended that the PETRONAS Project Team take immediate action to keep in close contact with the Public Works Department and to establish full and suitable coordination of schedules between the pipeline work and the construction of the Complex.

The water of the Sungai Sibiu, which is the source for the Public Works Department's supply, is relatively good in quality, containing a low degree of dissolved salts, although it is somewhat colored and acidified by the effects of humus and humic acid and also has some turbid appearance due to the presence of fine clay. An analysis of the water is given below:

Quality of Water of the Sungai Sibiu

(Sample Analysis)

pH	5.7 ~ 7.0
Turbidity	25 ~ 100
Hazen Color Unit	60 ~ 250
Total hardness	8 ~ 20
Chlorine ion	3 ~ 5 ppm
Suspended solids	3 ~ 20 ppm

The water supplied by the Public Works Department is controlled to meet the standards of: Hazen Color Unit, 5.0; turbidity, 1.0; chlorine ion, 0.5 ppm, after treatment of water taken in the Sungai Sibiu. This standard is for potable water, and exceeds that for cooling water which accounts for the majority share of water consumption in the Complex. As a consequence, the supplied water must be purchased at a cost which is quite high for industrial uses. The present tariff sets a rate of M$2.0 per 1,000 gallons (or US$0.20 per m^3) of water supplied to industrial premises consuming a large volume of water.

The Public Works Department at the present time is committed to the present supply system and pricing formula. However, water to be used for cooling in the Complex does not require such a high level of purity as the Public Works Department now plans to supply; the necessary view is that lower-purity water would be economical to use if it is supplied at a lower cost. For this reason it is recommended that the PETRONAS Project Team negotiate with the Public Works Department to lower the cost of supplied water even if it would result in receiving lower-purity water which needs to be treated in the Complex to meet requirements for intended uses.

Nevertheless if such an arrangement is not permitted under the present legislation of Malaysia, it is recommended that the optimum cooling system be selected for adoption in consideration of economic merits of adopting any system other than soft water cooling and thereby reducing the quantity of soft water to be consumed in the Complex.

The LNG plant is designed to use seawater for its cooling. For this purpose it is planned to take approximately 887 million gallons (or approximately 4 million m^3) per day of seawater by installing seawater intake facilities in the Bintulu Deepwater Port. The temperature range of water there is 28.5 to 31.2°C. The LNG plant is designed on the basis of a seawater temperature set as 30°C.

The feasibility study made by the PETRONAS Project Team for this Project is based on the assumption that all water requirements (including those for cooling water) for the Complex will be met by soft water supplied by the Public Works Department. Further, at the ASEAN Economic Ministers Meeting, the project concept, including this assumption, has been approved, so that the Evaluation Study Team takes the same assumption in respect of the cooling system for the purpose of financial analysis of the Project. Nevertheless, as a case study, the Evaluation Study Team has made an economic comparison of using seawater for cooling to a maximum extent in order to minimize soft water consumption in the Complex. The outcome of this case study is attached as Appendix IV-5 for reference. This study indicates that there is no economic merit in adopting seawater cooling compared to soft water cooling, because of location of the selected site resulting in high seawater costs. It is recommended that examinations be made on air cooling systems.

3-2 Electric Power Supply

Responsibility for the supply of electric power in Sarawak lies with the Sarawak Electricity Supply Corporation (SESCO). In the Bintulu area, electric power at present is supplied from a small power station - 4.0 MW - located within Bintulu town. This station comprises diesel generators using diesel oil which is supplied by a pipeline from a tank installed at the existing Bintulu port.

The Complex will require approximately 7 MW of power. To meet the needs of the Kidurong area, SESCO is now proceeding with a program for increasing its power supply capacity by establishing a new power station in Kidurong. In the initial phase, this station consists of two units of generators having a capacity of 4.0 MW each. These are turbine-generators which are dual-functioned both for diesel oil and natural gas. The present construction is expected to be completed by the end of 1979. SESCO plans to add one more unit of the same scale and same type generator during 1980. Along with the construction of the Kidurong power station, SESCO is now proceeding with construction of a 33 KV transmission line which connects the Bintulu power station with the Kidurong power station and thereby forms a back-up grid. This work will be completed during 1979.

SESCO plans to further satisfy the increasing demand for electric power by completing the construction of four units of natural-gas-burning gas-turbine generators having a capacity of 10 MW each, in the Bintulu area, by 1982. After completion of this project, the power supply capacity in the Bintulu area including Kidurong will be increased to 56 MW. SESCO expects that this capacity will be ample to cope with the projected demand of 46 MW for Bintulu and Kidurong. A study is now being made to establish a natural gas supply plan for the power station.

As long-range supply plans for electric power, SESCO is now studying the possibilities of construction of a natural-gas-based gas-turbine power station with 300 MW capacity in Miri as well as of a 1,700 MW hydropower station in Belaga, Sarawak. These studies are still at the preliminary feasibility study stage. SESCO is to determine the timing and scale of these projects as a result of detailed feasibility studies to be carried out in connection with further progress of an aluminum smelting project to be built in the Bintulu industrial estate.

Malaysian industrial establishments are compulsorily obliged to use public power except the cases given special consideration, so that this Complex as well is obliged to use electric power supplied by SESCO, although the MLNG project has, as an exception, been permitted to use self-generated power. SESCO firmly plans to supply electric power to the Complex from the Kidurong power station having 12 MW capacity which, as is stated above, is to be completed at latest by the end of 1980. In view of the present progress of construction work, it is likely that the station will be completed as scheduled. Therefore, it may be assumed that there can be electric power available for the operation of the Complex.

In this case, however, precautions must be taken regarding reliability of the power to be supplied, since operation of ammonia and urea plants is adversely affected by fluctuation in voltage or cycles as well as power failures. As a consequence of the practice of ammonia and urea plants to be operated in tandem and also of the capital intensive nature of these plants, it is extremely important to maintain high operating rates, in order to attain maximum economies in production. If power outages, or voltage drops and surges, occur from time to time, they would lower operational efficiency of the plants. More seriously, a prolonged outage would cause entire shut-down of the plants, which then would need at least a few days for start-up, thereby resulting in a considerable production loss. In addition, the rapid change in temperature inside some equipment which would occur in event of sudden stoppage of plant operation due to power outage, would be destructive to this equipment as well as to catalysts.

In general, the electric power supplied to ammonia and urea plants is required to satisfy the following conditions:

1)	Voltage fluctuation:	Within ± 5% of rated voltage
2)	Cycle fluctuation:	Not more than 0.5 Hz
3)	Frequency of power failure:	Not more than 2 or 3 times a year

There are a number of ammonia and urea complexes which have originally been designed to use electric power supplied from external sources and then have eventually been provided with their own power plants, in order to improve poor operation efficiency which had been caused by unstable power supply.

In the case of this Project, there seems to be a relatively reliable power supply as long as the Kidurong station is the supply source, because in its case the supply is to be made over a short transmission distance. Nevertheless, in order to insure further reliability, it is recommended that the PETRONAS Project Team make the following arrangements. That is to connect the main transformer in the Complex directly with the power station by an exclusive transmission line so that the Complex can be supplied with electric power without any risk of interference by other users. If this arrangement is unacceptable to SESCO, an alternative measure is to make necessary arrangements so that consumers whose peak demands fluctuate greatly will be excluded from the line to the Complex.

Further, emphasis is placed on the importance of installing emergency power generators and also of consideration in designing each plant so that the plants may maintain safety operation during a power interruption.

It is emphasized that the above should be given full consideration as the prerequisite for the Complex to be based upon the power supplied by SESCO. Even after these measures have been taken, if power supply conditions still remain unstable, then it may be necessary to consider arrangements for the Complex to have its own power plant.

3-3 Availability of Port Facilities

The annual output of products for sale will be approximately 11,000 to 38,000 tons of liquid ammonia and approximately 450,000 tons of urea. The shipments of urea will be destined primarily for elsewhere in Malaysia (particularly West Malaysia) and other ASEAN countries. For the liquid ammonia, the PETRONAS Project Team plans to distribute it only to the domestic markets which are located in West Malaysia (see Part II).

In the Bintulu area, the Ministry of Transport is proceeding with a project for construction of Bintulu Deepwater Port, in connection with development of the Bintulu industrial estate. It is intended that the port be utilized not only by the LNG plant and the present Ammonia and Urea Complex but also by a direct reduction steelmill and an aluminum smelter which are planned to be built in the estate in the future.

The Bintulu Deepwater Port is to be constructed in a bay inside the Kidurong Cape which is northeast of the Bintulu town. The basic design for the harbor has already been completed by Stanley Consultants of Muscatine, Iowa in the U.S.A. (A schematic drawing of the port is given in Fig. IV-5). The port will comprise an inner harbor and an outer harbor, of which the outer harbor is to be used for LNG shipments and the inner harbor is to be used for other cargo shipments.

The inner harbor is to have a Bulk Cargo Pier (280 m in length, 30 m in width) and a General Cargo Wharf (514 m in length, 30 m in width), both having a draught of 15 m. It is planned that port construction will be completed by the end of 1982. A part of the first phase construction has been started. The overall construction work will be segmented into five contracts as follows:

Contract - 1: Site preparation and development (including construction of a Construction Jetty, 100 m in length, 15 m in width and 4.5 m in draught alongside): completion scheduled for July, 1981.

Contract - 2:	Opening of a quarry: completion scheduled for December, 1982.
Contract - 3:	Dredging of channel, 16.5 m in draught; LNG Harbor; General Cargo Harbor, 15 m in draught; and area for the Construction Jetty, 4.5 m in draught alongside: completion scheduled for July, 1982.
Contract - 4:	Breakwater and wharves construction (outer breakwater; LNG Jetty; inner breakwater; Bulk Cargo Pier, 280 m in length, 30 m in width, 15 m in draught alongside; roll-on/roll-off ramp; General Cargo Wharf, 514 m in length, 30 m in width, 15 m in draught alongside): completion scheduled for August, 1982.
Contract - 5:	Port administration office and utilities facilities construction: completion scheduled for December, 1982.

This port can be of use in connection with the Ammonia and Urea Complex in the following two ways. First, it can be used for unloading equipment and materials in the construction stage of the Complex. Second, after the Complex goes on stream, it can be used for shipment of products of the Complex (ammonia and urea). Stated below is the Evaluation Study Team's observation on the use of the port in connection with the Project, and recommendations on steps which should be taken in preparation for such use.

A. Use of the Construction Jetty at the Complex Construction Stage

It is planned to complete construction by July, 1981 of a Construction Jetty in the port, for offloading of equipment and materials for the port. As is stated in Chapter 4 of this Part, if design work for the Complex is started in January, 1981, carrying-in of equipment and materials for the Complex would not take place earlier than the later part of 1981.

Thus the jetty would be available for use in connection with construction of the Complex, if a peak time for unloading of cargoes for the Complex does not overlap with that for construction of the port. In view of the unloading schedule for both projects, it is judged that the jetty can still be of use for construction of the Complex, because such an overlap occurs only for a short period, so that coordination for occupancy of the jetty can be possible by means of delaying entrance into the port of arriving vessel for a while. It has been confirmed that the jetty will not be used in connection with construction of the LNG plant.

As a conclusion, on the presumption that the Construction Jetty for the port can be used, it is judged that it is not necessary to construct a temporary jetty for use in unloading of equipment and materials for the Complex. Nevertheless it must be emphasized that arrangements be made for use of the Construction Jetty, through discussions and close coordination between the PETRONAS Project Team and both the BDA and Ministry of Transportation.

B. Use of the Bulk Cargo Pier for Production Shipment

Shipment of bulk urea and liquid ammonia from the Complex will be carried out by using the Bulk Cargo Pier. Facilities to be installed in connection with the bulk urea shipment will be a belt conveyor system to transport the urea from the Complex to the pier as well as bulk urea loading facilities at the pier (see Fig. IV-6). For shipment of liquid ammonia, an ammonia pipeline from the Complex to the pier and ammonia loading facilities will be installed (see Fig. IV-7).

The Evaluation Study Team attempted a preliminary estimation on possible pier occupancy by ships for loading of the bulk urea and liquid ammonia (see Appendix IV-2).

The Team realizes that this estimation is still low in accuracy, because of several hypotheses which had to be used for the study. Nevertheless it is believed that this study would serve to indicate the future picture. The study indicates a possibility that the pier would be occupied to a considerably large extent for the loading of bulk urea and liquid ammonia.

It is judged that, during the initial few years of the Complex's operation, no serious problem would presumably arise with regard to utilization of the pier, since the

Complex may be the only user of this pier for a while. However, once a steelmill and aluminum smelter which are to be constructed in the Kidurong area start operation, use of the pier will have to be shared among these plants and the Complex. In this event, it is foreseen that the pier would be highly congested due to loading and unloading from or to these plants to the extent that there may be interference with product shipment from the Complex. It is recommended that the PETRONAS Project Team request the BDA and Ministry of Transport to give the Complex priority in use of the pier and to consider suitable arrangements for use of the pier taking such possible congestion into due consideration.

On the presumption that the above-mentioned steps be taken to insure that the Complex can use the port without any intereference, it is evaluated, as a conclusion, that the Project may proceed with implementation on this basis.

3-4 Employee Housing Colony and Welfare Facilities

It will be necessary to maintain a total of about 600 employees in Bintulu for the management and operation of the Complex. While it is not a conventional practice in Malaysia for employers to provide housing for their workers, because of the level of development of social infrastructure in the Bintulu area, it is considered difficult for this number of persons to obtain housing by their own resources. Moreover, it is expected that a large number of the persons to be employed at the Complex will be recruited elsewhere than in the Bintulu area and then will be transferred to the Complex. As one measure to gain assurance that highly qualified personnel can be recruited and retained, the provision of housing, or facilitation of their acquisition of housing, can be of considerable value.

The BDA is proceeding with implementation of a project to develop a large-scale residential center including housing and other community services in the Bintulu area. The master plan for this project calls for construction of housing for an ultimate population of 28,700 on a site of 870 acres between Bintulu town and Kidurong. Under this master plan, the BDA has started the construction of housing for its own employees and those of the MLNG's LNG plant. For the LNG plant, 530 units of houses having 1,300 to 2,652 ft^2 of floor area each, will be constructed. The BDA will either lease or sell these units, but it is not decided yet which method the BDA will use; this is a matter to be decided through discussions with the MLNG and deliberations of the BDA.

The BDA's master plan also calls for construction of recreational facilities, schools, hospitals, utility supply facilities, roads, a broadcasting station, hotels, shops, vocational training school and telecommunication facilities, in addition to its above-mentioned housing construction. For these, detailed plans are now being prepared by the BDA. In view of the fact that this housing development project is making successful progress, it would be the most rational approach that the Complex's employees be settled in the housing to be constructed by the BDA. The Malaysian Government's policy is to utilize the Bintulu residential center to accommodate the Complex's employees. At the December, 1978 meeting of the ASEAN Economic Ministers, this policy was accepted by the Economic Ministers of other ASEAN member states, and thus it was agreed that employee housing would be excluded from the scope of the Project. The Evaluation Study Team therefore has assumed that the Bintulu residential center would be available for the employees, and has assumed that the PETRONAS Project Team will negotiate and coordinate affairs with the BDA from an early stage, to insure that the colony and its welfare facilities are planned, built, and function at the time needed.

CHAPTER 4 MAJOR BASE FACTORS TAKEN FOR EXAMINATION AND CONCEPTUAL DESIGN OF FACILITIES FOR THE AMMONIA AND UREA COMPLEX

4-1 Products and Production Capacity

The final products to be produced in the Complex for sale are prilled urea and liquid ammonia, although the output of the latter is in a relatively small quantity. At the Seventh ASEAN Economic Ministers Meeting in December, 1978, it was decided that the capacity of ammonia and urea plants, which are the manufacturing facilities of the Complex, would be:

Ammonia plant:	1,000 t/d
Urea plant:	1,500 t/d

The urea produced in the Complex will be primarily marketed to the Malaysian domestic market and the ASEAN markets outside Malaysia. Under the agreement made by the ASEAN Economic Ministers concerning this Project, for the products from the Complex, the sales price will be set at prevailing international market prices. In view of this arrangement, it is presumed that the products of the Complex must be of international competitiveness in product cost, and, in this context, the capacity of plants for the Complex must be in an internationally economic scale.

The scale of ammonia and urea plants projected for the Complex is comparable to that recently built in various parts of the world, and therefore it is judged that the selected capacity would be adequate to yield economic production. Hence this study is based on the above-mentioned capacity as proposed by the Malaysian Government.

Given that the plants are operated at full capacity utilization, of the output of 1,000 t/d ammonia, 870 t/d is to be used as the intermediate material for producing urea. Thus the ammonia plant is to have an excess capacity of 130 t/d ammonia. The ammonia plant will produce carbon dioxide as by-product. The output of this carbon dioxide will exceed its requirement for producing urea which amounts to 1,140 t/d of carbon dioxide. The excess carbon dioxide over the requirement will be purged out to the atmosphere. The production capacity of end products for sale may be rated at:

Urea (prilled):	1,500 t/d
Ammonia (liquid):	130 t/d

The standard annual on-stream days of this type of plant is set at 330 days by taking 35 days for scheduled annual shut-down. Hence the annual production capacity of the above-mentioned end products is set at:

Urea (prilled):	495,000 t/y (1,500 t/d x 330 days)
Ammonia (liquid):	42,900 t/y (130 t/d x 330 days)

Over half of the produced prilled urea will be for export and its quality therefore must meet an internationally acceptable standard. In the specification of product urea to be met, the most important elements are nitrogen content and biuret content. Nitrogen content must be 46% N in minimum. As for biuret content, most countries set the level as being lower than 1.0%, but some countries set the biuret content lower than 0.5% particularly for urea to be used for some special crops. (Such urea containing biuret lower than 0.5% is called "low-biuret urea".) In order to produce the low-biuret urea, all the currently available urea processes adopt the crystallization system for the finishing section of urea plants, under which the produced urea solution is crystallized, and the thus-obtained crystal urea is separated from mother liquor in centrifuges, dried and re-melted. The urea-melt is sprayed from the top of a prilling tower, and is turned into prilled urea. If it is not required to produce low-biuret urea, an alternative arrangement is adoptable. It is a direct prilling system in which water of the urea solution is evaporated by a specially designed evaporator, and the highly concentrated urea-melt obtained directly from the solution is turned into prill urea by a prilling tower, in the same manner as mentioned above.

The direct prilling system requires less investment cost compared to the crystallization system, and thus the cost of urea yielded from the former system is lower than that of the latter.

In order to estimate the demand for low-biuret urea with satisfactory reliability, it is required to conduct in-depth market surveys in the field, because the present market study is too broad to provide a firm projection of low-biuret urea demand due to the time-limit given for the study. Provisionally, however, it is assumed that the urea plant will produce only low-biuret urea, since it is presumable that there is no market constraint for the sale of low-biuret urea.

If further examination made by the Project sponsor concludes that there is no need for the low-biuret urea at all, then the plant would be designed on the basis of use of the direct prilling system which could probably result in reducing the urea cost compared to that projected in the present study. It is therefore recommended that the Project sponsor make a further detailed market study so that, prior to contracting for the procurement of urea plant, the proper decision can be made on which system should be adopted for the finishing section of the urea plant.

The excess ammonia from the Complex is to be marketed to the existing fertilizer plants and other ammonia users in Malaysia. As is stated in Part II of this report, there are two types of ammonia users, those buying liquid ammonia and those buying aqua ammonia. It is likely that the present aqua ammonia users will switch to use of liquid ammonia, because it would benefit them by reducing their operating cost as well as transportation cost compared to aqua ammonia. Hence examination of necessary handling facilities is made on the assumption that the Complex will supply liquid ammonia to these users.

There are two types of ammonia tankers, both of which are operated for transportation of liquid ammonia; one is a pressure type, and the other is a cryogenic type. West Malaysia is the destination for liquid ammonia to be supplied from the Complex. In view of there being such a short transportation distance from Bintulu to West Malaysia and small quantity to be transported in each shipment, it is the general practice to use a small tanker of a pressure type (temperature; 3 - 4°C, pressure; 7 kg/cm^2 G). The ammonia handling facilities will be designed on the assumption that such pressure type tankers will be used for transportation of liquid ammonia from the Complex.

Given in Table IV-1 is an example of the specification of prilled urea and liquid ammonia to be produced at the Complex.

4-2 Supply Conditions of Feedstock and Utilities

As is stated in the preceding chapter, the Complex will use natural gas for feedstock and fuel, as well as water and electricity, which are all supplied from external sources. Supply conditions of these inputs which have been assumed as a basis for examination of necessary facilities, are as follows:

(1) Natural gas

With regard to natural gas required for the operation of the Complex, the PETRONAS - Upstream Division is responsible for its supply. PETRONAS - Upstream Division is to install a gas pipeline up to the fence of the Complex and to deliver the gas to the Complex at this point. Hence included within the scope of the Project are those facilities needed for receiving the gas at the battery limit of the Complex. Composition and other conditions of the supplied gas at the supply point, which have been assumed for technical examination, are given in Table IV-2.

(2) Water

Given that the several conditions stated in 3-1, Chapter 3 of Part IV would be satisfied, it is assumed that the Complex will adopt a soft water cooling system, and water requirements will be met by use of potable water which is supplied by the Public Works Department (PWD) in the State of Sarawak. The PWD will be responsible for installation of a water pipeline up to the fence of the Complex and to deliver the water to the Complex at the fence. Therefore it is assumed that the Complex will receive the water at its battery limit, so that only facilities needed within the battery limit will be included in the scope of this Project. It is assumed that quality of the water to be supplied to the Complex will be identical to that of potable water being presently supplied by the PWD which is given as the sample (B) in Table IV-3.

(3) Electric power

On the presumption that the conditions stated in 3-2, Chapter 3 of this Part IV, would be satisfied, it is assumed that all power requirements for the Complex will be met by electric power to be supplied by SESCO. SESCO will be responsible for the laying of a transmission line to the primary transformer of the Complex and for supplying the electric power to the Complex at this point. Therefore on this assumption installation of the electric power system for the Project will include the primary transformer and other receiving and distribution equipment to be installed within the battery limit. It is assumed that, according to SESCO's standard, the condition of supplied power will be; voltage, 33 KV; cycles, 50 Hz; and 3-phase AC.

4-3 Conditions Assumed for Infrastructure

As is discussed in the preceding chapter, the following conditions are assumed for available infrastructure.

(1) Port facilities

It is assumed that the facilities in the Bintulu Deepwater Port will be available for use in unloading equipment and materials required for the construction of the Complex and also for loading the products from the Complex.

(2) Housing colony and other welfare services

It is assumed that the Complex will fully utilize housing and other community services which are to be constructed by the BDA as a component of the Bintulu residential area development project.

4-4 Soil, Climatic and Oceanographic Conditions

The Complex is to be located at the site stated in Chapter 2 of this Part IV. Soil, climatic and oceanographic conditions in the site area which have been referred to in examining the conceptual design of facilities for the Complex, are enumerated in the following paragraphs. It must be noted that the boring tests at the site are underway, and assumptions on soil and subsoil conditions therefore will need to be revised as necessary after those conditions have been confirmed.

(1) Soil and subsoil conditions

– Soil:	Upper layer downward: Silty clay (3 - 4 m) Neogene sedimentary rock, silt stone, shale
– Soil bearing capacity (Estimated):	Excavated area 30 tons/m^2 Filled & compacted area 10 tons/m^2
– Seismic factor:	0.05 (hypothetical value due to no record of earthquake)

(2) Climatic and oceanographic conditions

– Temperature

Dry bulb	High	34.2°C	(Aug.)
	Low	20.5°C	(Jan.)
	Mean	26.3°C	

– Relative humidity

	High	100%	(Monthly)
	Low	34%	(May)
	Mean	87%	

– Rainfall

Annual		4,100 mm	
Monthly	High	570 mm	(Dec.)
	Low	165 mm	(May)
24-hours	High	160 mm	(Mar.)

– Wind velocity & direction

Monthly mean high	15 m/sec. (1%)
High	30 m/sec.
Prevailing directions	SW–NW

– Barometric pressure

High	1,014 millibars
Low	1,003 millibars

-- Seawater temperature

High	31.2°C
Low	28.5°C
Standard	30.0°C

CHAPTER 5 CONCEPTUAL DESIGN AND PLAN OF FACILITIES AND RELATED WORK FOR THE AMMONIA AND UREA COMPLEX

5-1 Introduction

(1) Ammonia and urea processes

Manufacturing facilities of the Complex, according to the plans prepared by the Malaysian Government, consist of a 1,000 t/d ammonia plant and a 1,500 t/d urea plant. With regard to ammonia and urea manufacturing processes, there are several commercially proven processes which have been utilized in plants operating in various parts of the world. The ammonia and urea plants projected for this Project are similar to those built in various countries by adopting several processes available for the manufacture of ammonia and urea, process performance of which have been verified through the operation of these plants.

Operation trouble in ammonia and urea plants, if it occurs, is less likely to be due to a defect in the adopted process itself as compared to its being due to either a defect in design and engineering performed by engineering contractors or mechanical defect of machinery and equipment involved in the plants.

With regard to the construction of this Complex, the general practice in Malaysia is to employ an engineering contractor selected through competitive bidding, which shall perform on a turn-key basis the design, engineering, procurement and construction of plants and facilities. Although the tender specifications for the engineering contractor must define the concept of ammonia and urea plants to be built, the detailed design of these plants in virtue will embody engineering know-how of the engineering contractor who prepares the detailed design, as well as process know-how of the process licensor.

Therefore, detailed specifications of the plants will vary depending on the process and engineering contractor selected. However, in any case, there is little economic difference between these processes. Thus consumption of raw materials and utilities in a typical ammonia manufacturing process and urea manufacturing process may be used as the basis for conceptual design of plants and facilities in the Complex for