THE FINAL REPORT
FOR
THE FEASIBILITY STUDY
ON
EFFECTIVE UTILIZATION OF BANKO COAL
IN
THE REPUBLIC OF INDONESIA

Volume II

March 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of the Republic of Indonesia, the Japanese Government decided to conduct a feasibility study on Effective Utilization of Banko Coal and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA has sent to Indonesia a study team headed by Mr. Takehiko Sato, the Institute of Energy Economics, Japan, as many as eighteen times during the period of five years from May 9, 1984 to December 20, 1988.

The team has had a series of discussions with concerned officials of the Government of the Republic of Indonesia, and conducted field surveys, gasification tests, and so on. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the development of the project and to the promotion of friendly relations between our two countries.

I wish to express my sincerest appreciation to the concerned officials of the Government of the Republic of Indonesia for their close cooperation extended to the team.

March, 1988

Kensuke Yanagiya
President
Japan International Cooperation Agency

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ATTACHMENT

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Chapter 5

Acronyms and Abbreviations

Acronyms and Abbreviations

A

A : ampere
A.B.D.: apparent bulk density
AC : alternating current
AECI : African Explosives and Chemical Industries
AER : anion exchange resin
AFB : atmospheric fluidized bed
A/F ratio : air fuel ratio
A.M. : as mined
API : American Petroleum Institute
A/S : air separation
ASTM : American Society for Testing Materials
A.T. : ambient temperature

B

BASF : Badische Anilin und Soda-Fabrik AG
BFW : boiler feed water
B/L : buttery limit
BOD : biochemical oxygen demand
BOE : barrel of oil equivalent
BOF : basic oxygen furnace
BOT : build, operate and transfer
BPD : barrel per day
BPPT : Badan Pengkajian dan Penerapan Teknologi (Agency for the Assessment and Application of Technology)
B.S. : booster station
BTU : british thermal unit
BWE : bucket wheel excavator

C

°C : centigrade degree

CAT (cat): catalyst
CB : circuit breaker
CBR : California bearing ratio
CEC : California Energy Commission
CER : cation exchange resin
cf : cubic feet
CFB : circulating fluidized bed
CGCC: coal gasification combined-cycle
C/H : carbon/hydrogen
c.i.f. : cost, insurance and frieght
cm : centimeter
CMRC: Coal Mining Research Center
COD : chemical oxygen demand
CPEs : centrally planned economies
CRT : cathode ray tube
cSt : centistokes
CT : current transformer
C/T : cooling tower
C.V. : calorific value
CW : cooling water

D

d : day
d.a.f. : dry ash free
DC : direct current
DCF : discount cash flow
DDA : Detroit Diesel Allison
d, d.b. : dry base
DDC : Detroit Diesel Corporation
DME : dimethyl ether
DMT : dimethyl terephthalate
DO : dissolved oxygen
DOC : Directorate of Coal
DPMA: Directorate Penylidikan Masalar Air
DS : disconnection switch

DTG : dimethyl ether-to-gasoline
DWT : dead weight ton

E

EIRR : economic internal rate of return
ELB : earth leakage breaker
EOR : enhanced oil recovery
EP : end point
EPDC : Electric Power Development Co., Ltd.

F

FBB : fluidized bed combustion boiler
FBC : fluidizedbed combustion
F.C. : fixed carbon
FDF : forced draft fan
FFV : flexible fuel vehicle
FG : fuel gas
FIRR : financial internal rate of return
FLG : flare gas
FOB : free on boad
FW : fire water
FY : fiscal year

G

g : gram
G : gauge pressure
gal : gallon
GHSV : gaseous hourly space velocity
G.L. : ground level
GM : General Motors
GNP : gross national product
GPT : ground potential transformer
G/T : gas turbine

H

H	:	height
h	:	hour
ΔH	:	rising smoke height
He	:	effective stack height
HMctt	:	high speed magnetic contactor
Ho	:	actual stack height
HP	:	high pressure, horse power
HPS	:	high pressure steam
HRSG	:	heat recovery steam generator
H.W.L	:	highest water level
Hz	:	hertz

I

IA	:	instrument air
IBP	:	initial boiling point
ICI	:	Imperial Chemical Industries PLC
ID	:	inside diameter
IDCP	:	interest during construction period
IDF	:	induced draft fan
IEA	:	International Energy Agency
IER	:	ion exchange resin
IFP	:	Institute Francais du P'etrole
IGT	:	Institute of Gas Technology
IRR	:	internal rate of return
IW	:	industrial water

J

JICA	:	Japan International Cooperation Agency
JIS	:	Japan Industrial Standard

K

kg	:	kilogram
kg/cm^2G	:	kilogram per square centimeter gauge
KHD	:	KHD Humboldt Wedag AG, Klöckner Humboldt Deutz

KVA : kilovolt ampere

L

ℓ : litre

LBS : load breaker switch

LD50 : median lethel dose

LHSV : liquid hourly space velocity

LIBOR: London interbank offering rate

LNG : liquefied natural gas

LOI : loss of ignition

LP : low pressure

Lp : sound level (dB(A))

LPC : low pressure steam

LPG : liquefied petroleum gas

LV : linear velocity

Lw : power level (dB(A))

L.W.L.: lowest water level

M

m : meter

M-Alkali : methyl orange (red) - alkali

MAN : Maschinen-fabrik Augsburg Nürnberg

mBOE : million BOE

MCB : motor circuit breaker

MEFOS : Metallurgical Research Institute, Lurea, Sweden

mg/ℓ : miligram per liter

m^3/H : cubic meter per hour

MIGAS : Direktorat Jenderal Minyak dan Gas Bumi

Mil. : million

MILE : methanol in large engines

MIP : Molten iron pure gas

MITI : Ministry of International Trade and Industry

MJ/H : megajoule per hour

ML : meter level

mℓ : millilitre

MM : million

mm : millimeter
MMA : methyl methacrylate
MMUS$: million US dollars
Mo : moisture
MON : motor octane number
MTBE : methyl tertiary butyl ether
MTG : methanol-to-gasoline
MW : megawatt
μ : micron
μS/cm : micro siemens per square centi-meter

N

NA : not available
NEDO : New Energy & Industrial Technology Development Organization
NFPA : National Fire Protection Association
N-Hex : normal hexane extracted
Nm : newton-meter
Nm^3 : normal cubic meter
NOx : nitrogen oxides

O

OECF : Overseas Economic Cooperation Fund
OPEC : Organization of Petroleum Exporting Countries
Op. Year : operation year

P

PAC : polyaluminum chloride
PC : prestressed concrete
PCB : polychlorinated biphenyl
PE : polyethylene
PERTAMINA : Perusahaan Pertambangan Minyak dan Gas Bumi National (state-owned oil company)
PF : power fuse
PFD : process flow diagram
PH (pH): hydrogen-ion concentration
PHC : prestressed high grade concrete

PID : piping & instrumentation diagram

PLC : programable logic controller

PLN : Perusahaan umum Listrik Negara
(the state electric corporation)

ppb : part per billion

ppm : part per million

PPTM : Pusat Pengembangan Teknologi Mineral

PTB : Perum Tambang Batubara (the state coal corporation)

PTBA : PT Tambang Batubara Bukit Asam (the state coal corporation Bukit Asam mine)

PT unit: potential transformer unit

PUSPIPTEK: Pusat Pengembangan Ilmn Pengatahuan dam Teknologi (The National Center for Research, Science and Technology Project)

PUSRI: state-owned fertilizer company

R

RACC: Research Association for C_1 Chemistry

RAPAD: Research Association for Petroleum Alternative Development

R & D: research and development

REPELITA: Rencana Pembangunan Lima Tahun
(Five-Year Development Plan)

RON : research octane number

Rp : Rupiah

rpm : rotation per minute

S

SA : service air

SASOL: South African Synthetic Oil Limited

SC : steam condensate

SCF : standard conversion factor

SCP : single cell protein

SDAB : Svensk Drivmedelsteknik AB (Swedish Motor Fuel Technology Co.)

SG : synthesis gas

S.J. : Suban Jeriji

SMI : Sumitomo Metal Industries Ltd.

SOx : sulphur oxides

S.P.P. : steel pipe pile
SS : suspended solids (mg/ℓ)
S/T : steam turbine, shovel and truck
STG : synthesis gas-to-gasoline
ST'M : steam
SW : service water

T

t : ton
TCE : ton coal equivalent
tcf : trillion cubic feet
TDC : top dead center
TDS : total dissolved solids
TEL : tetraethyl lead
TLV : threshold limit value
TOC : total organic carbon
TOE : ton oil equivalent
TR : transformer
TVA : Tennessee Valley Authority
tWh : tera watt hour
t/y : ton per year

V

V : volt
VCB : vacuum circuit breaker
V.M. : volatile matter
Vol. : volume
VVVF : variable voltage variable frequency device

W

WHSV : weight hourly space velocity
Wt : weight
W/T : water treatment
WW : waste water

Y

y : year

¥ : Yen

Z

ZCT : zero current transformer

9. ESTABLISHMENT OF MASTER PLAN

9-1 EVALUATION OF COAL BASINS AS RAW MATERIAL FOR SYNTHESIS GAS PRODUCTION

9-1-1 Product Gas Amount

Effective components of product gas for synthesis gas are carbon monoxide gas (CO) and hydrogen gas (H_2).

Amounts of these effective gases varied with coal quality.

Fig. 9-1-1 shows the effect of coal quality on the amount of effective product gas.

Among three kinds of coal, gasification of N.W. Banko coal gives the biggest amount of effective gas because of the lowest total moisture, lowest ash content and higher C content in the feed coal.

In case of N. Suban Jeriji coal, effective gas volume is the smallest due to the lowest C content in the feed coal.

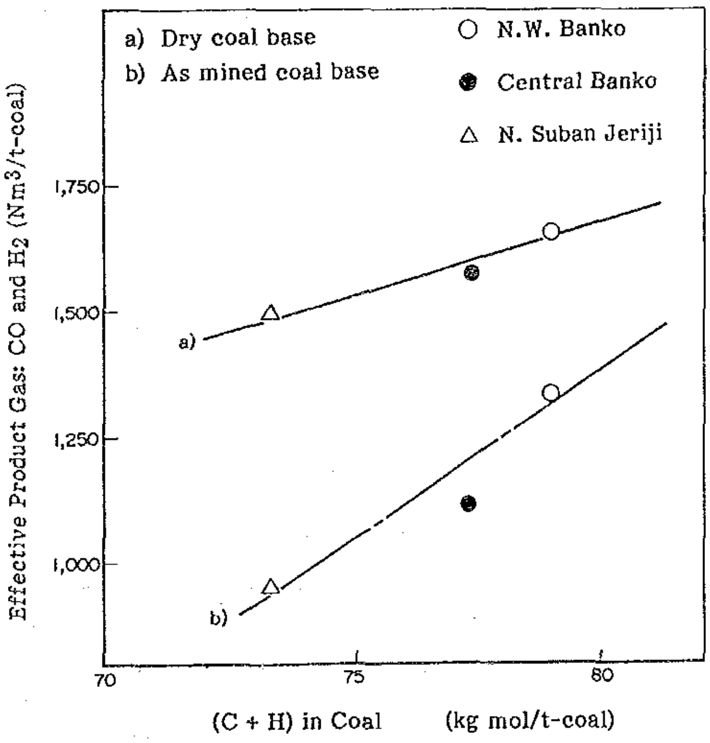


Fig. 9-1-1 Effect of Coal Quality on Effective Product Gas Volume

9-1-2 Oxygen Consumption

Another important factor on the evaluation of coal basins is the consumption of blowing oxygen for gasifying the coal.

Some coal has higher content of oxygen in the coal and this oxygen reduces the oxygen consumption for gasification.

However, the coal with higher oxygen has usually lower carbon content and so it produces a smaller amount of effective gas.

Fig. 9-1-2 shows the effect of coal quality on the consumption of blowing oxygen.

N. Suban Jeriji coal with higher oxygen consumes smaller amount of blowing oxygen, but produces a smaller amount of effective gas.

On the other hand, N.W. Banko coal shows the opposite tendency to N. Suban Jeriji coal.

Fig. 9-1-3 shows the blowing oxygen consumption per unit volume of effective gas.

It is indicated that these three kinds of coal are nearly identical in the oxygen consumption required to produce unit volume of effective gas.

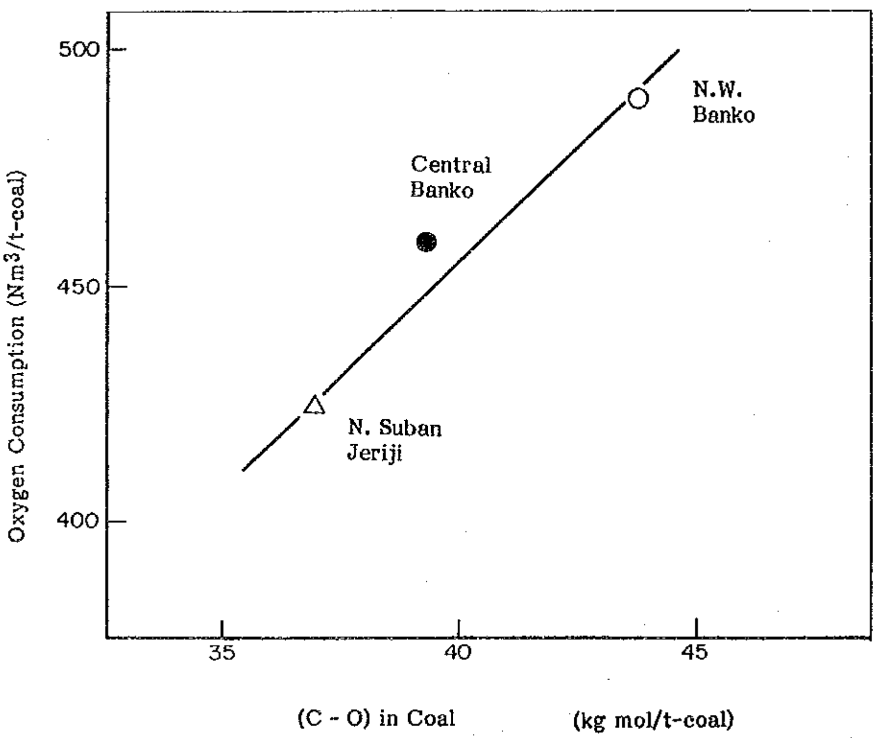


Fig. 9-1-2 Effect of Coal Quality on Oxygen Consumption

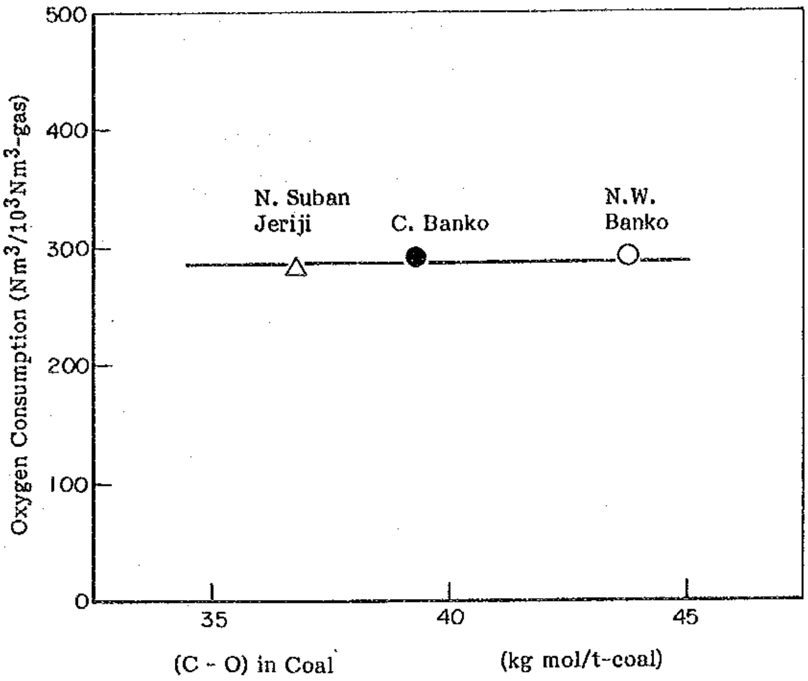


Fig. 9-1-3 Effect of Coal Quality on Oxygen Consumption per Unit Volume of Effective Gas

9-1-3 Evaluation of Coal Basins

In order to evaluate coal basins as raw material for synthesis gas production, gas production costs for three kinds of Banko coal were calculated basing on the following assumptions:

- Same coal cost as mined
- Same coal processing capacity
- Same total equipment cost and labor cost
- Same utility consumption for operation
- Gas production cost for N.W. Banko coal is 100 as a basis
- Material balance in Table 8-3-8

Table 9-1-1 shows the relative production cost per unit volume of effective gas.

The amount of effective gas produced for the gasification of N.W. Banko coal is 1.20 times as much as for C. Banko coal in the as-mined-coal basis and is 1.38 times as much as for N. Suban Jeriji coal.

The difference in the amount of effective gas production affects significantly on the gas production cost.

Gas production cost is the cheapest in the gasification of N.W. Banko coal, so that N.W. Banko coal seems to be the most favorable for the synthesis gas production and C. Banko coal follows next.

Table 9-1-1 Relative Production Cost of Effective Gas (Unit: %)

	N.W. Banko	Central Banko	North Suban Jeriji
Coal cost	20.0	24.0	27.7
O_2 cost	28.0	27.6	26.7
Scrap cost	1.5	1.5	1.6
Lime cost	0.5	2.3	1.7
Fixed capital cost Labor cost Utility cost Interest, etc.	50.0	52.4	55.0
Total production cost	100.0	107.8	112.7

9-2 ESTABLISHMENT OF MASTER PLAN

9-2-1 Basis for Master Plan

(1) Product

Out of the possible derivatives for this project shown in Fig. 9-2-1, Methanol and Urea would be taken up for the Master Plan under the following circumstances.

i) Fuel methanol is the most prospective product in Indonesia, since it can be used as alternative fuel to gasoline, kerosene and diesel oil.

ii) Although the demand forecast in Section 5-4 pointed out that the market of urea is inferior to that of methanol, the case of methanol/urea co-production would be studied for evaluation of economics.

iii) Single Cell Protein and MTG Process (gasoline through methanol) are put aside because SCP and MTG processes are the downstreams of the methanol plant and should be studied as an independent project at the place where the site conditions are much better than those in Banko area.

iv) Other products produced directly from synthesis gas or indirectly through methanol, such as ethanol, ethylene, acetic acid, ethylene glycol, or MTBE, are left out of consideration because of rather small demand in Indonesia or premature technologies for producing them.

(2) Market and Sales Price

The following market scale would be basic criteria of the Master Plan.

i) The scale of domestic market for fuel methanol in Indonesia is expected to be around 0.85 million tons per year in 2000, and around 3 million tons in 2005, if fuel methanol would be supplied at the selling price of 175 $/ton.
However, some of market may be shared by fuel methanol produced from natural gas.

ii) The scale of domestic market for urea will be around 5 million tons per year in 2000.
On the other hand, the production capacity of urea in 1990 is estimated to be 5.6 million tons per year. Therefore, additional urea plants constructed will be for the purpose of export.

iii) With regard to the capacity of electric power generation plant, supply for public use will not be considered, because PLN has already constructed the power plant of 65x2 MW in near Banko area.

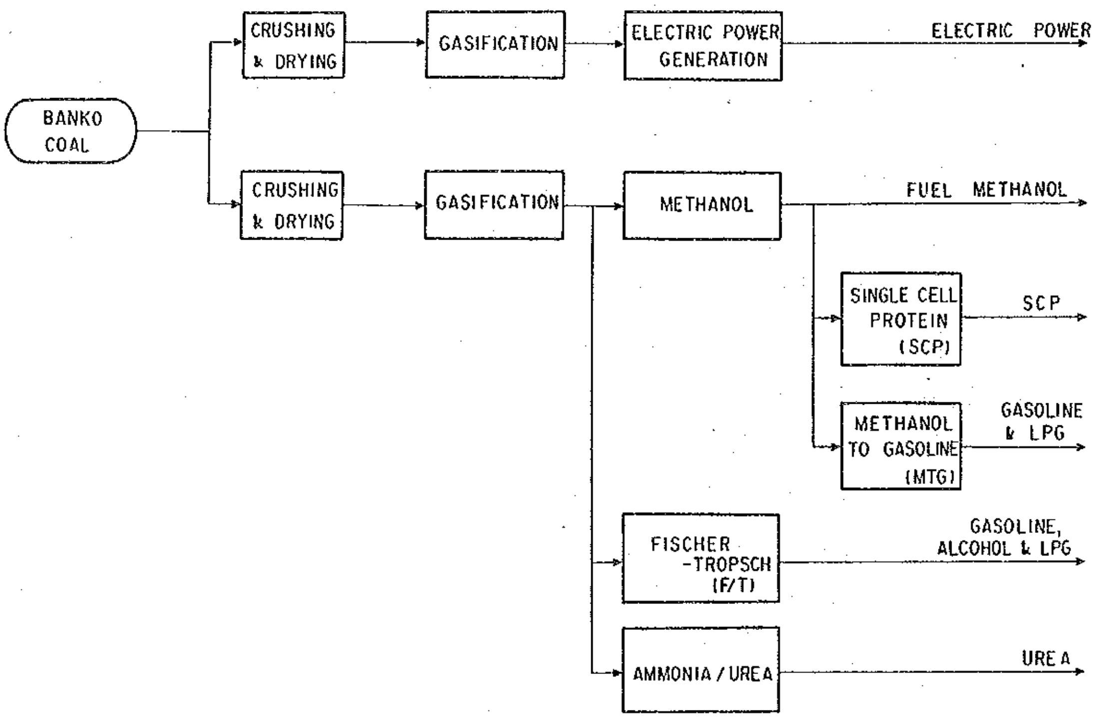


Fig. 9-2-1 Possible Products by Effective Utilization of Banko Coal

(3) Plant Capacity

Plant capacity of each unit will be selected based on the following;

i) Coal mining capacity should be about three to six million tons per year, since it is economical capacity proven in commercialized open cut mines.

ii) Plant capacity of derivatives should be commercially proven and good enough for Indonesian market.

These considerations have led to the plant capacities mentioned below;

i) Coal mining; 3.7 million ton/year

ii) Gasification Plant; 3.2 million ton/year

iii) Fuel Methanol Plant; 4,500 ton/day

iv) Urea Plant; 1,750 ton/day (Methanol of 3,560 ton/day will be co-production)

v) Electric Power Generation Plant; To be in equal capacity to the power requirement in the plants including coal mine.

(4) Mining Area

The coal gasification tests carried out in the 2nd stage have proven that any coal obtained from N.W. Banko, Central Banko and N. Suban Jeriji can be gasified without any technical difficulty.

As discussed in Section 9-1, N.W. Banko coal is the most superior from the economic viewpoint for production of synthesis gas, and is to be selected for the Master Plan.

On the other hand, there may be another plan to utilize N.W. Banko coal besides this Project. Therefore, the N. Suban Jeriji coal will be studied as alternative design coal.

(5) Design Coal

Based on the coal analyses in the 2nd stage, N.W. Banko coal data are to be applied to the Master Plan. The mechanical design of the coal gasification plant, however, is to use the N. Suban Jeriji data.

(6) Plant Site

N.W. Banko coal which causes spontaneous combustion and contains 27% of moisture as mined denies long distance transportation from the technical and economic viewpoint.

Needless to say, a mine mouth coal processing is more economical than a seaside coal processing which needs coal transportation of 200 km by train, if equipment transportation to mine mouth for plant construction work is available at a reasonable cost.

Therefore, the possibility of equipment transportation will be carefully studied for the selection of a plant site.

9-2-2 Case Study for Master Plan

In order to establish the proposed Master Plan, a case study has been prepared as per the following.

(1) Derivatives

As discussed in Section 9-2-1, fuel methanol and urea production are taken up out of possible products for the proposed Master Plan and the following two cases were set up.

Case 1 is to produce only fuel methanol with a plant capacity of 4,500 tons per day and can be defined as base case, since fuel methanol is expected to be the most prospective derivative of Banko coal.

Case 2 is to produce 3,560 tons per day of methanol as well as 1,750 tons per day of urea through ammonia. However, a viability of this case will mainly depend on a production cost of urea since PUSRI has large urea production facilities starting from cheap natural gas in Palembang and there is enough amount of natural gas resources to produce urea but not enough for export as LNG.

For selection of derivatives for the proposed Master Plan, an independent economic evaluation for both cases has been carried out on the basis of same capacity of 3.2 million ton-coal/y for coal gasification plant.

Because fuel methanol is the dominant product in both cases, the selling price of fuel methanol was assumed and fixed at 175 $/ton from world-wide trend in recent years. As to the selling price of urea, three cases were estimated from the worldwide trend to grasp the effect of urea price. Other parameters and assumptions for financial analysis were same for both cases.

Results for the case study are summerized in Table 9-2-1.

It is understood from the above mentioned economic comparison that, as far as IRR is concerned, Case 2 can compare with Case 1 in case of higher urea price.

(2) Electricity Generation Plant

For the electricity generation plant, two cases are studied for the Master Plan.

Case A is to generate a required amount of electricity for the gasification complex utilizing CGCC (Coal Gasification Combined Cycle).

Table 9-2-1 Results of Preliminary Financial Analysis

Case	Case 1*	Case 2**		
Selling Price of products	Methanol 175 $/t	Methanol 175 $/t Urea 100 $/t	Methanol 175 $/t Urea 150 $/t	Methanol 175 $/t Urea 200 $/t
IRR on Total Investment	13.5%	10.6%	12.3%	13.8%
First Year to Have Profit before Tax (Year from Operation Starts)	3rd	6th	3rd	3rd
Clear off of Accumulated Loss (Year from Operation Starts)	5th	12th	7th	4th
Pay off of All the Debts (Year from Loan Raised)	12th	14th	12th	12th

* cited from Interim Report, May 1986
** cited from Interim Report, July 1987

Case B covers the same capacity of electricity generation as Case A but by utilizing fluidized bed combustion boiler.

For selection of electricity generation method, an independent economic evaluation on the electricity generation method has been carried out on the basis of 900 MW of gross generating capacity.

The main parameters and assumptions are as follows:

i) Gross Generating Power : 900 MW

ii) Net Generating Power
   a) CGCC system : 835 MW
   b) FBB system : 818 MW

iii) Average Load Factor : 66% (Average in Indonesia)

iv) Electricity Selling Price : 98 Rp/kWh
(including distribution cost and sales overhead)

v) Ex-plant Price estimated from Selling price

a) Sales in Jakarta : 43 Rp/kWh at sending end
: 53 "

b) Sales in Banko : 64 "
: 78 "

Results for the case study are summerized in Table 9-2-2.

Table 9-2-2 Results of Preliminary Financial Analysis on Electricity Genration Plant (900 MW)

	Case A* (CGCC)		Case B** (Fluidized Bed Boiler)	
Ex-plant Price of Electricity	64 Rp/kWh (11.55 ¥/kWh)	78 Rp/kWh (14.08 ¥/kWh)	64 Rp/kWh (11.55 ¥/kWh)	78 Rp/kWh (14.08 ¥/kWh)
IRR on Total Investment	13.5%	17.0%	14.0%	17.5%
First Year to Have Profit before Tax (Year from Operation Starts)	3rd	2nd	2nd	1st
Clear off of Accumu-lated Loss (Year from Operation Starts)	5th	2nd	3rd	1st
Pay off of All the Debts (Year from Loan Raised)	12th	12th	12th	12th
Minimum Selling Price (IRR = Interest Rate)	46 Rp/kWh (8.31 ¥/kWh)		44.7 Rp/kWh (8.08 ¥/kWh)	

Note * ; cited from Interim Report, July 1987
** ; cited from Interim Report, March 1988

It is turned out from the above mentioned economic comparison that Case B is slightly advantageous compared with Case A. Therefore, fluidized bed combustion boiler is to be selected for the Master Plan.

(3) Availability of Coal and Water Supply

Coal and water are major materials to be supplied for the production from outside of the plants.

1) Coal Supply

According to the rough estimation of coal consumption by each case and type of coals, the coal consumption is as follows:

(Million tons per year)

	Case-1 (Methanol only)	Case-2 (Methanol and Urea)
N.W. Banko	3.7	4.0
N. Suban Jeriji	5.2	5.6

In view of abundant coal preserves mentioned in Chapter 6, both cases seem to be viable for more than 50 years of project life.

2) Water Supply

According to the rough unit calculation of water consumption, the raw water requirement is expected to be around 1.0 tons per second against which the dry season discharge of Enim River is estimated at 22.5 tons per second. In view of abundant discharge of the River, water supply would not constitute a restriction to the Master Plan.

9-2-3 Establishment of Master Plan

(1) Overall Evaluation of Master Plan

Further studies have been carried out as follows to establish the Proposed Master Plan.

1) Conformity with Indonesian Policy

Both fuel methanol and urea production will conform with;

- Energy policy

- Industrialization policy
- Transmigration policy

2) Prospect for Demand

Although the demand for methanol as a raw material for other chemicals will not increase in a great degree as is stated in Section 5-4, it would drastically increase if fuel methanol be accepted as fuel in Indonesia (Section 5-5). In this sense it is advantageous to produce fuel methanol.

Export of fuel methanol seems also to be a promising market, though the amount of export depends on its production cost as well as international market price.

The fuel methanol from this Project must compete in foreign markets with those being produced in the Middle East and Oceania from cheap natural gas.

There will be a gradually increasing demand for urea. The competitiveness of urea from Banko coal will, however, depend on its production cost since Indonesia has abundant natural gas resources and the price of natural gas for urea production is controlled in considerably cheap level by the Government policy.

3) Distribution Network

Fuel methanol is intended for use at small stationary electricity generation facilities as well as by automobiles like buses and trucks on fixed service routes. Since no distribution network for fuel methanol exists at the moment, a big investment will be required in order to establish a completely new system.

On the other hand, in principle, an existing distribution network can be used for urea, even though it may have to be reinforced.

4) Transportation

Pipeline and shipping/loading facilities including tankages for fuel methanol must be constructed. Also methanol tanker fleet, tank trucks, etc. must be prepared for the transportation of fuel methanol. These will require a big investment. In case of the urea production, an improvement of existing railway or construction of a new railway between Banko and Palembang would be necessary.

5) Competitive Plant

Although the methanol plant in Bunyu Island started operation in 1986, it will not be a competitive plant considering its capacity of 330,000 tons/year and location. On the other hand, urea production facilities in Palembang with much better site condition than in Banko, cheap natural gas and huge production capacity naturally cause disadvantage to urea from this project in terms of production cost.

6) Technology Development

Gasification of Banko coal has been proven to be technologically feasible by the coal gasification test at PUSPIPTEK.
Many plants in the world are producing methanol and urea from natural gas. There would be no difficulty in replacing natural gas with synthesis gas from coal.

7) Construction

Equipment and construction materials will be unloaded at Palembang and hauled for 200 km to the plant site. This means that the construction work will not be so easy especially in constructing both methanol and urea plants at the same time due to a large amount of work and transportation.

8) Operation and Maintenance

Since both methanol and urea plants exist in Indonesia, no difficulties would be found either in operation or maintenance. Evidently, however, difficulties will increase significantly if both methanol and urea plants are constructed and put into operation.

9) Employees

Bringing a significant increase in employment opportunities, Case 2 of methanol/urea co-production will conform with Indonesian policy although it will also give rise to a problem with employing numbers of well-qualified workers for operation and maintenance.

10) Investment Cost

Construction of a high pressure facility such as urea plant in addition to methanol plant will naturally increase the investment cost, even if the capacity of methanol plant is reduced, causing the difficulty of fund raising.

11) Prospect for Economic Viability

According to the preliminary economic evaluation, Case 1 of methanol production seems to be advantageous.

Overall evaluation on master plans is summarized in Table 9-2-3 which suggests that Case 1, producing methanol alone, is advantageous.

Table 9-2-3 Overall Evaluation on Master Plans

	Case-1 (Fuel Methanol)	Case-2 (Fuel Methanol and Urea)
1. Conformity with Indonesian Policy	o	o
2. Prospect for Demand		
- Domestic	o	o and △
- Export	o	o and x
3. Distribution Network	x	x and o
4. Transportation	o	o and x
5. Competitive Plant	o	o and x
6. Technology Development	o	o and o
7. Construction	△	x
8. Operation and Maintenance	△	x
9. Number of Employees	△	o
10. Investment Cost	△	x
11. Economic Viability	o - △	△ - x
12. Total Evaluation	o - △	△ - x

o : Good △ : Average x : Poor

(2) Proposed Master Plan

1) Plant Configuration

Fig. 9-2-2 illustrates plant configuration of the proposed Master Plan.

2) *Sales Plan of Fuel Methanol*

According to Section 5-5, the demand forecast of fuel methanol in Indonesia shows rapid increase amounting to 0.85 million tons per year in 2000, 3 million tons per year in 2005 and 13 million tons in 2010. Furthermore, export of fuel methanol could be expected additionally.

The demand forecasts for fuel methanol predicted through BPPT model and IEE model, as shown in Section 5-3 and 5-5, reflect (i) growth in GNP, (ii) changes expected in the industrial structure and standard of living, and (iii) changes expected in oil prices, and are predicted in a manner and at levels generally accepted. If one considers the possibility of export, this forecast should be understood to be a reasonable prediction for use as a basis for a sales plan of fuel methanol. However, in view of the lead time required to convert fuel source in the existing internal combustion engines in Indonesia and to build grass-root fuel methanol distribution net-work system, above mentioned prediction should be considered to be too optimistic as actual demand of fuel methanol.

Users of petroleum fuel may not change their cars into methanol specification until they have reasonable prospects for benefit by using fuel methanol and availability of fuel methanol at any time and place, even if the Government intends to introduce fuel methanol. Some parts of predicted demand may be supplied from natural gas.

Taking into consideration above mentioned impacts on the predicted demand, a sales plan for the Project was established as shown in Fig. 9-2-3.

Above sales plan is based on the following considerations:

i) At least, 5 years of time difference between demand forecast and sales plan should be considered.

ii) The start of the production will be year 2000.

iii) Phased construction of three steps will be considered to follow gradual increase of fuel methanol demand.

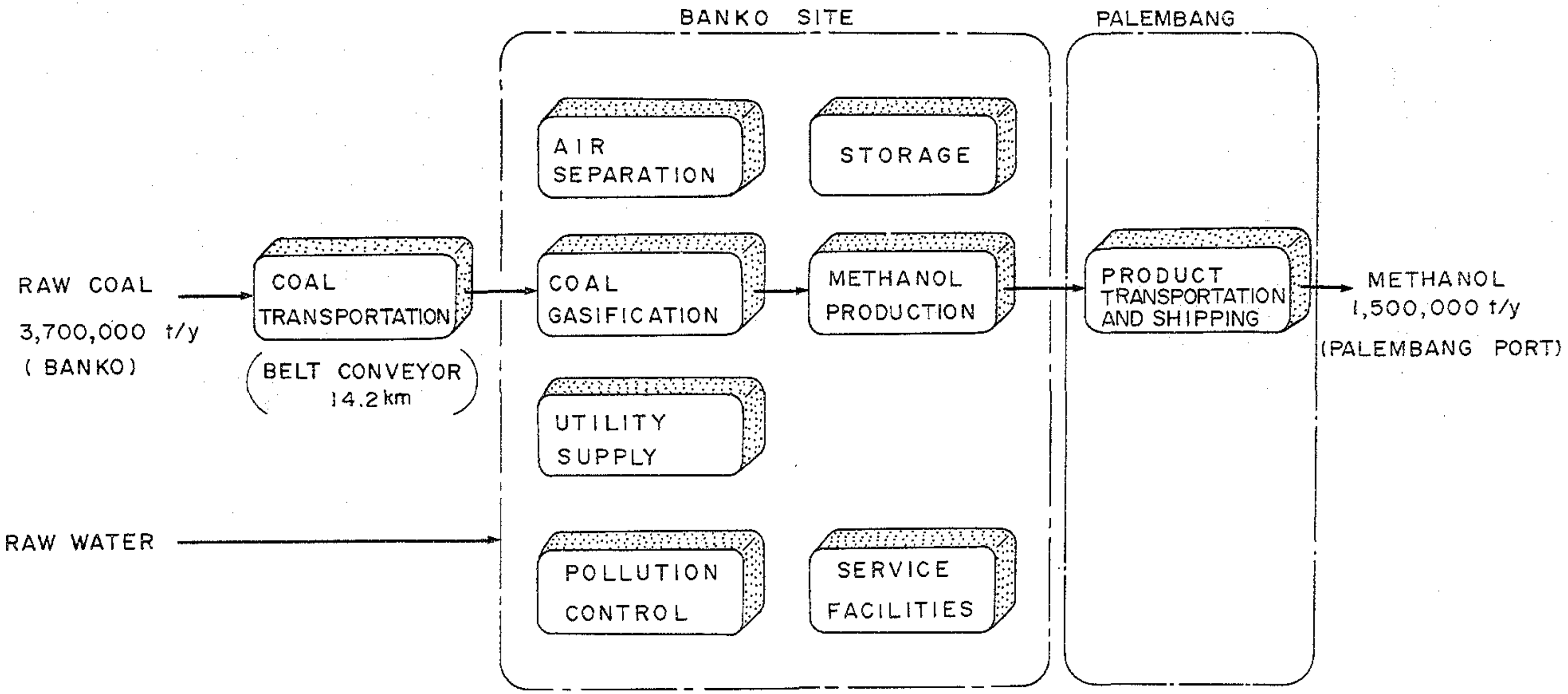


Fig. 9-2-2 Overall Block Flow Diagram

iv) Available running load would be 70% in the first year, 90% in the second year and 100% in and after the third year in a technical standpoint of view.

v) Market development, including political measures for modification of cars and installation of methanol stations, would be proceeded by the Government prior to the start-up of the Project facilities.

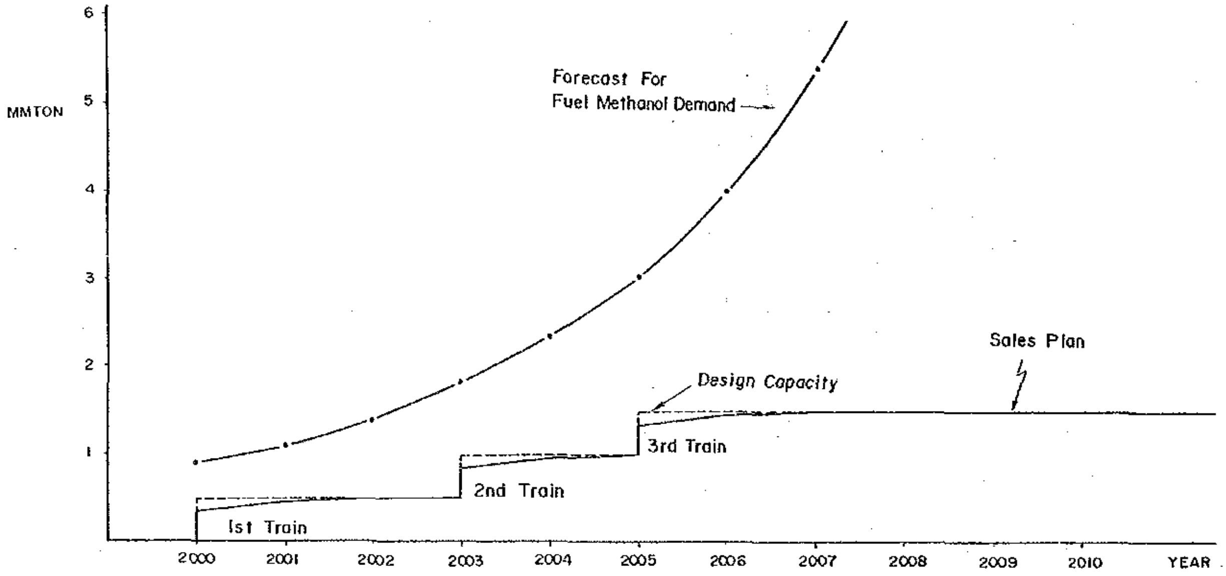


Fig. 9-2-3 Sales Plan

3) Unit Capacity and Construction Schedule

Unit capacity and construction schedule are shown in Table 9-2-4. The plants in the proposed Master Plan will be at least divided into three units because phased construction is preferable in view of a gradual increase of fuel methanol demand. To simplify engineering, operation and maintenance work, each unit would be the same design and capacity. However, some of the facilities such as common building, belt conveyer and product pipeline as well as service facilities may be single train in view of economics.

Table 9-2-4 Construction and Production Schedule

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2015	2025	2035
Forecast for Methanol Demand (10^3t)					850	1,100	1,400	1,800	2,400	3,000	4,000	5,400	7,200	9,600	12,900
Plant Construction															
Train 1	△	—	—	○											
Train 2					△	—	○								
Train 3							△	—	○						
Design Capacity (10^3t)															
Train 1					500	500	500	500	500	500	500	500	500	500	500
Train 2								500	500	500	500	500	500	500	500
Train 3										500	500	500	500	500	500
Total					500	500	500	1,000	1,000	1,500	1,500	1,500	1,500	1,500	1,500
Operating Factor (%)															
Train 1					70	90	100	100	100	100	100	100	100	100	100
Train 2								70	90	100	100	100	100	100	100
Train 3										70	90	100	100	100	100
Production/Sales (10^3t)															
Train 1					350	450	500	500	500	500	500	500	500	500	500
Train 2								350	450	500	500	500	500	500	500
Train 3										350	450	500	500	500	500
Total					350	450	500	850	950	1,350	1,450	1,500	1,500	1,500	1,500

10. CONCEPTUAL DESIGN OF PROPOSED MASTER PLAN

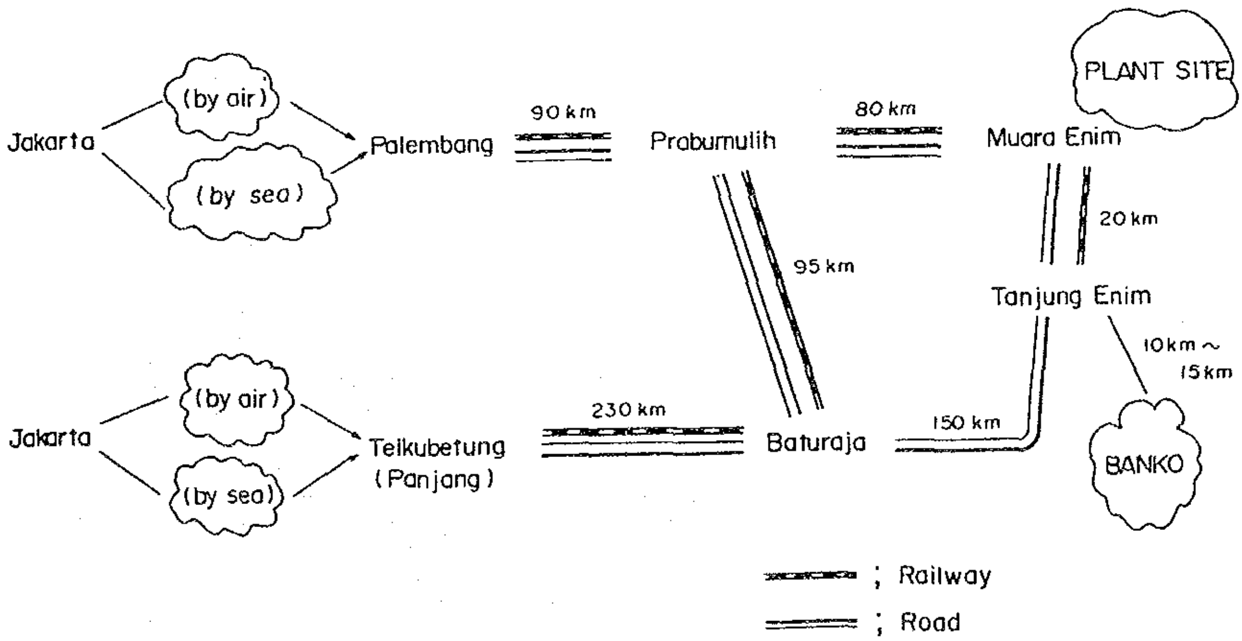
10-1 CIRCUMSTANCE OF BANKO AND ITS SURROUNDINGS

This section introduces the circumstance of Banko and its surroundings such as location and traffic, population and facilities, climate, port and river which are the basis to determine the plant location and configuration as well as to carry out the overall conceptual design.

10-1-1 Location and Traffic

Banko area (at 104° east longitude and 3°40' south latitude) lies 10-15 km to the southeast of Tanjung Enim, stretching for 10-20 km in gentle undulation with a clump of bushes in South Sumatra Province. (See Fig. 10-1-1)

Tanjung Enim, a small town with a population of 5,000, is 190 km away or a 4-hour-drive from Palembang, and 20 km south of Muara Enim.



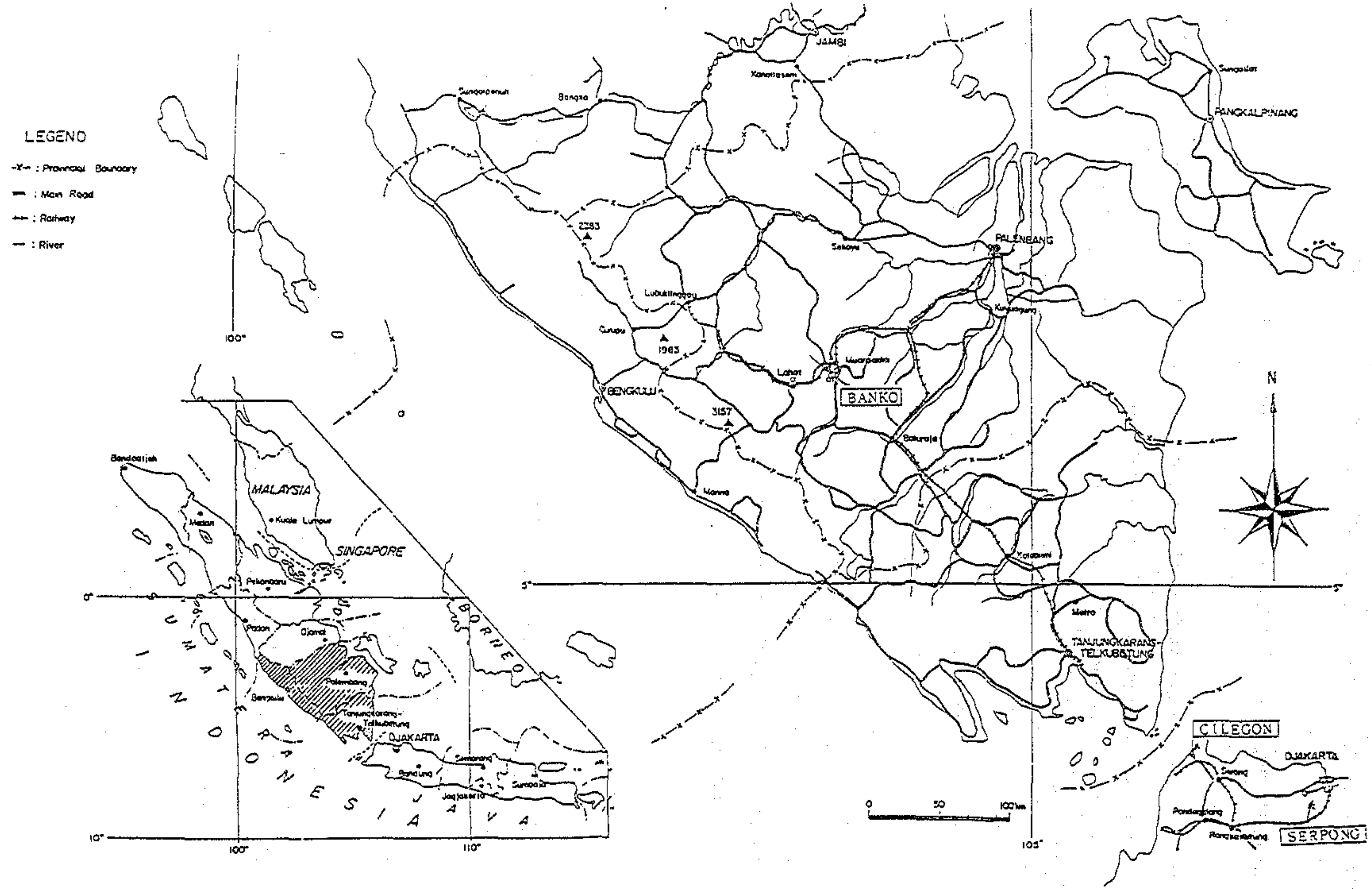
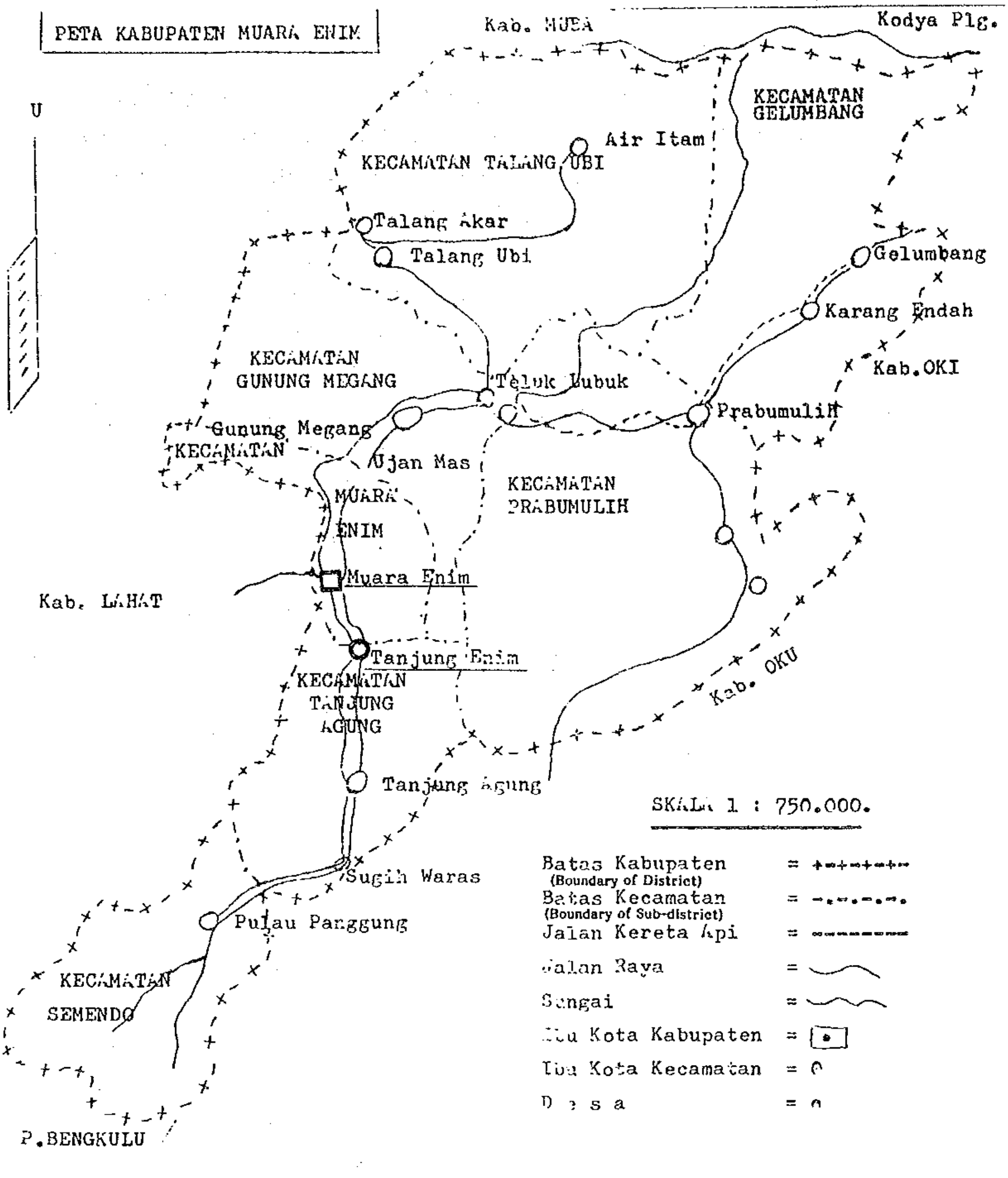


Fig. 10-1-1 Location of Banko



Source; KABUPATEN MUARA ENIM, DALAM ANGKA, 1982

Fig. 10-1-2 Map of Muara Enim District

10-1-2 Population and Facilities

Muara Enim District, which Banko area belongs to, is divided into 7 sub-districts as depicted in Fig. 10-1-2. Table 10-1-1 shows the population, number of villages and the conditions of public facilities for each sub-district.

On the opposite side of Tanjung Enim across the Enim River, the Bukit Asam Coal Mining Company (P.T.B.A) is producing about 1,700,000 tons per year of steam coal and anthracite, and its expansion project is under way, aiming at an annual production of 3,000,000 ton-coal in the final stage.

In the vicinity of P.T.B.A., Bukit Asam Power Station (65,000 kW × 2) was constructed and started operation in 1987.

10-1-3 Climate

Lying close to the equator, this area is in a tropical climate having two seasons throughout the year; a dry season from May to October, and a rainy season from November to April.

Some climate data are shown in Table 10-1-2 and Table 10-1-3.

Table 10-1-1 Population and Public Facilities of Muara Enim District

Sub-district	Semendo	Tanjung Agung	Muara Enim	Genung Megang	Talang Ubi	Prabumulih	Gelumbang	Total
Area, km^2	900	850	475	1,900	1,850	2,150	1,450	9,575
Population, persons (*1)	33,251	69,352	44,128	48,596	96,408	146,729	88,450	526,914
Density, persons/km^2 (*1)	37	82	93	26	52	68	61	55
No. of Villages	31	32	20	23	41	48	66	261
No. of Schools								
· Elementary	38	54	42	37	70	99	92	432
· Jr. High School	4	6	6	4	10	10	6	46
· High School	1	3	6	1	3	7	1	22
No. of Hospitals	—	1	1	—	1	2	—	5
(No. of Beds)	(—)	(unknown)	(28)	(—)	(20)	(115)	(—)	(163)
No. of Medical Clinics	3	5	4	5	5	11	9	42
No. of Mosques	93	98	45	48	111	217	98	710
No. of Hotels	0	2	4	0	2	7	0	15

Source; (*1) : KABUPATEN/KOTAMADYA DATI II, MUARA ENIM, MARET 1988

Others : KABUPATEN MUARA ENIM, DALAM ANGKA, 1982

Table 10-1-2 Climate of Muara Enim and Tanjung Enim

	1972-77(*1) (Muara Enim)	March, 1983(*2) (Tanjung Enim)	August, 1984(*2) (Tanjung Enim)
1. Ambient temperature			
Monthly average (°C)	24.9	27.7	27.4
Monthly maximum (°C)	33.5	34.0	33.5
Monthly minimum (°C)	20.3	21.5	20.0
2. Relative humidity			
Monthly average (%)	82.0	78.2	72.8
Monthly maximum (%)	90.0	99.0	99.0
Monthly minimum (%)	71.0	48.0	41.0
3. Wind velocity			
Average (m/sec)		2.5	2.8
Maximum (m/sec)		8.0	8.0

Source; (*1) PLN B.A. DESIGN REPORT
(*2) HYDROLOGY FIELD PROGRAM, BACOMDAT PROJECT

Table 10-1-3 Rainfalls at Muara Enim (1980)

	Rainfall in mm	No. of Rainy Days
January	726	19
February	396	18
March	419	22
April	422	26
May	172	5
June	106	8
July	89	9
August	175	11
September	293	13
October	193	13
November	432	20
December	344	18
Total	3,767	182

Source; HYDROLOGY FIELD PROGRAM, BACOMDAT PROJECT

10-1-4 *Land and Soil*

The soil in South Sumatra consists of 11 kinds as shown in Table 10-1-4. According to the soil investigation report for P.T.B.A. coal feeder project in Tanjung Enim, the soil layer from the ground surface to a 6 meter depth is silty clay and tuffaceous silt, stiff, brown colored.

Table 10-1-4 Soil in South Sumatra

Soil	Area
Organosol	along the East coast and the middle of land
Litosol	along the edge story soil of Ranau lake in the mountain of Instrusi and the fracture of Bukit Barisan
Aluvial	along the River Musi, Lematang, Ogan and Komering, and the slope of Bukit Barisan
Grey Hidromerf	in the area of Musi Rawas and Muara Enim
Hlei Humus	see orgasonol
Regsol	around the east coast story soil of the edge of Ranau lake and the cone of cocanous
Andosol	all new and old vulcan cane, this kind of soil is generally found at a height of more than 100m above sea level
Rendzina	Baturaja surrounding
Letesol	in the area where no dry season of the month exists
Leteritik	in the plains of Martapura and Bangka
Podzolik	in the plains as well as in the mountains of Bukit Barisan

Source; Provincial Office of South Sumatra

10-1-5 Port

The port of Palembang is located on the Musi River approximately 100 km upstream from its river mouth at the Bangka Strait, which is the passage between South Sumatra and Bangka Island. Outline of the Port of Palembang is shown in Fig. 10-1-3.

Annual dredging keeps the depth of Musi River over 7 meters. Fig. 10-1-4 shows a dredger working at the port.

In general, ships with a draft less than 5 meters can enter the river during low tide whereas ships with a maximum length of 180 meters and a draft not exceeding 7 meters can safely reach Palembang during high tide. (The average difference between low and high tides is 3 meters.)

Generally, the port is accessible to 10,000 DWT (dead weight-ton) vessels with a maximum draft of 7 meters. Larger vessels might be accommodated depending on their load and water conditions.

At the port of Palembang, the products of this Project are to be loaded on to tankers or freighters for further delivery. According to the Head Office of the Port Authority of Palembang, methanol shipping terminal could be built in the area adjacent to the existing Palm Oil terminal facing the Musi River.

Several living houses exist in the recommended site surrounded by a crowded residential area. In order to construct the methanol shipping terminal in this area, the pipeline must be installed through the city of Palembang after crossing the Musi River, or through the city of Pladju before crossing the Musi River directly up to the shipping terminal. It is not practical, however, to install the pipeline through Palembang or Pladju because both of them are crowded. Instead, it would be more realistic to construct the shipping terminal adjacent to the PERTAMINA refinery in Pladju and install the pipeline alongside the existing PERTAMINA pipeline from Prabumulih to Pladju although PERTAMINA's close cooperation would be required.

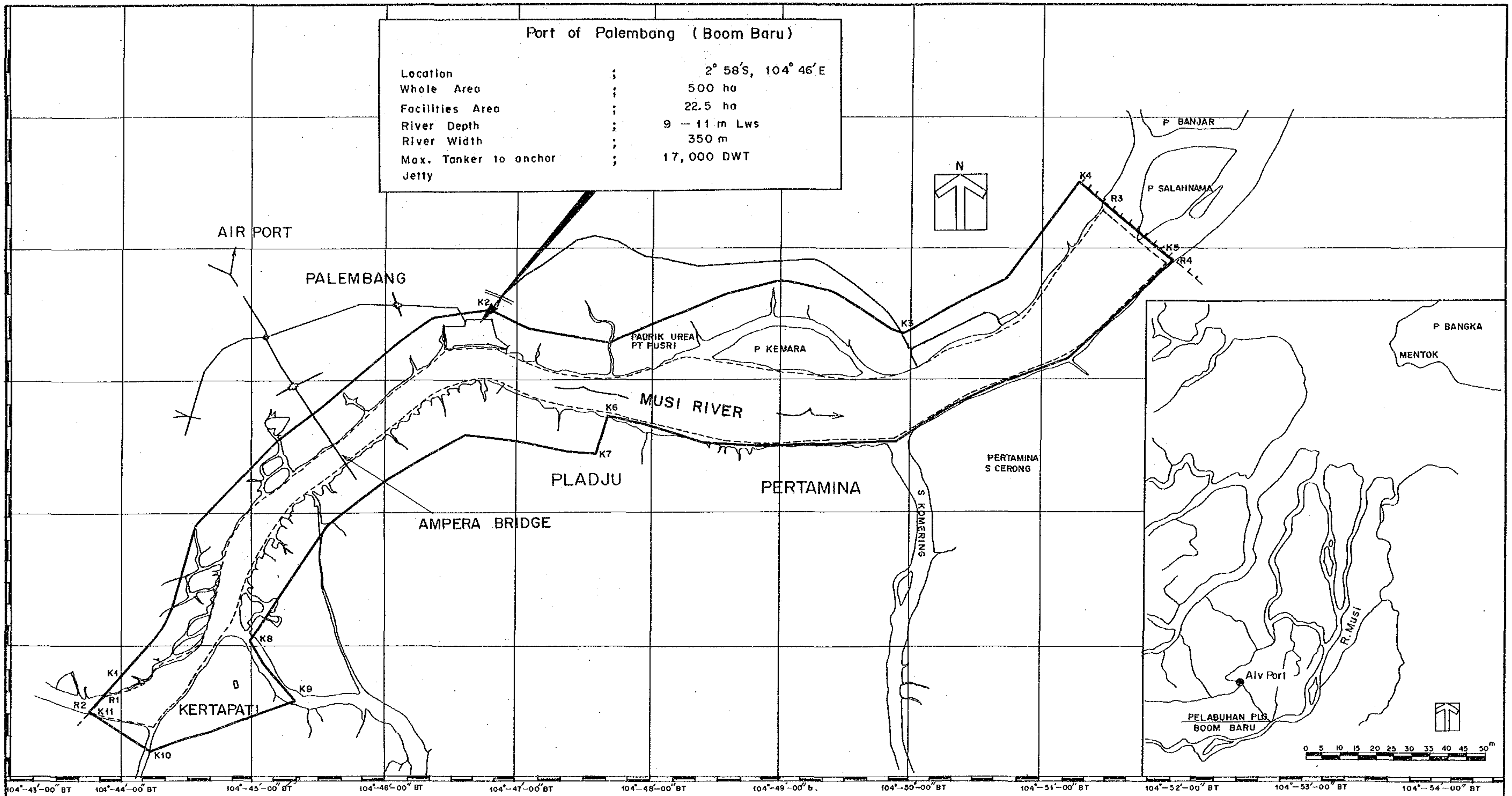


Fig. 10-1-3 Port of Palembang and its Surroundings

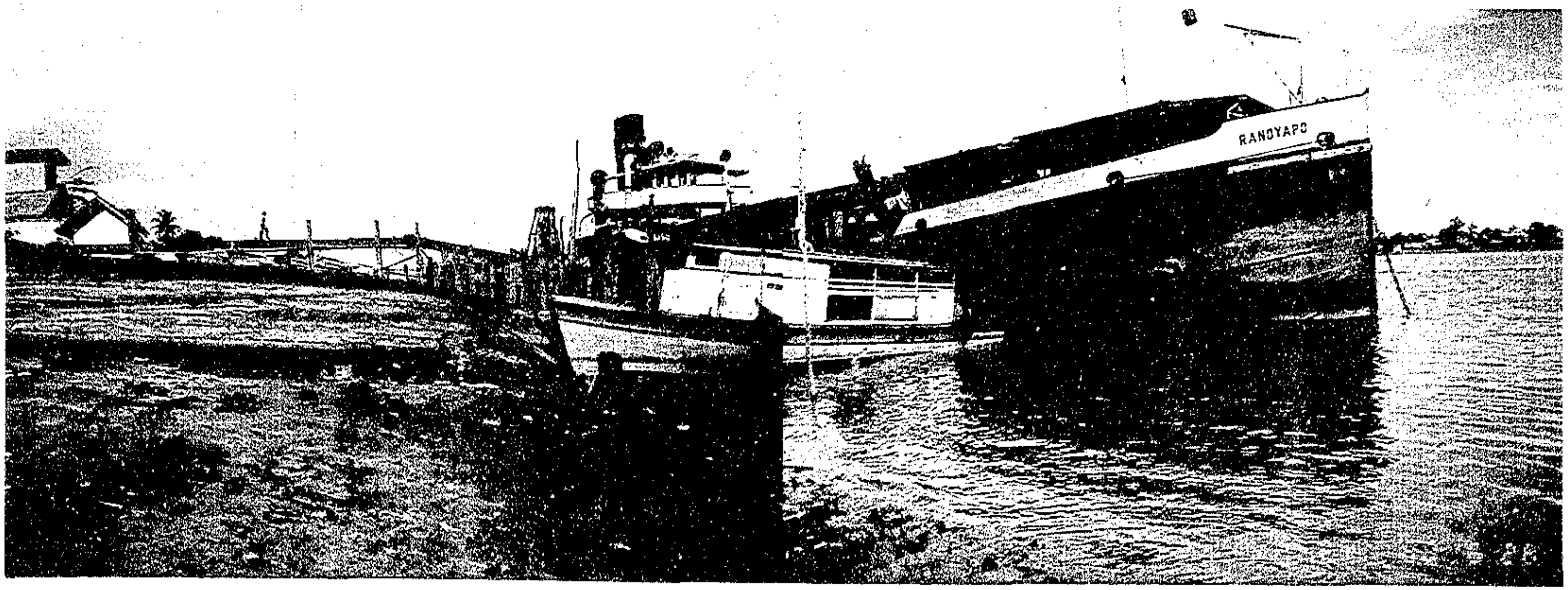


Fig. 10-1-4 A Dredger at the Port of Palembang

10-1-6 River

As transportation means and water resources for the plant, the river condition largely affects the economic aspect of the Project.

A continuous riverway route exists between Palembang and N.W. Banko by way of the Musi River, Lematang River, and finally the Enim River.

(1) *The Musi River*

The large Musi River is a broad, flat, slow water course with a relatively gentle bend. The average width of this river between Palembang and Muara Lematang, 87 km upstream from Palembang (Boom Baru), is about 370 m. Only one overhead obstruction along the route up to Muara Lematang is the Ampera bridge located approximately 3 km upstream from Boom Baru. Vertical clearance between the center span and the water surface was 11.5 m on 28 June 1988. Considering the highest water level caused by high tide or rainy season, minimum vertical clearance is estimated at 9 m.

(2) The Lematang River

The Lematang River extends 187 km upstream to the junction of the Enim River at Desa Muara Enim. The average width of Lematang River below Muara Enim is about 140 m. There are numerous sharp bends where the river impacts exposed bedrock ledges and diverts its course. At these points, the river narrows to approximately 50 m (in dry seasons) and becomes swifter and deeper.

Two overhead obstructions exist along the course up to Tanjung Priok. The first one is the Teluk Lubuk bridge built in April 1987 and located in Teluk Lubuk approximately 111 km upstream from Muara Lematang. The vertical clearance of the bridge measured on 26 June 1988, i.e. dry season, was 9.8 m and was estimated at about 7.3 m in rainy season as per a local villager's word.

Since the Lematang River is generally shallow especially upstream from Kuripan, about 91 km from Muara Lematang, it will be almost impossible to transport heavy equipment during a dry season even by a barge with shallow draft. On the other hand, small clearance of the Teluk Lubuk bridge restricts the maximum height of equipment less than 5 meters.

The second obstruction along the Lematang River is a small suspension bridge in Tanjung Priok. The clearance of the suspension bridge was 6.2 m on 25 June 1988, and will be around 4 meters in rainy seasons.

(3) The Enim River

The Enim River is smaller, shallower and steeper than the Lematang River. Besides, several bridges with small clearance will obstruct barges sailing up with large equipment. Therefore, it is not practical to use the Enim River as a transportation route.

Fig. 10-1-5 shows the approximate location of the places where the hydrographic data shown in Fig. 10-1-6 and Table 10-1-5 were taken, as well as the river depth measured by Bukit Asam Mine Contractors in October 1981.

Fig. 10-1-8 and Table 10-1-6 show the pictures related to the rivers and the data of bridges respectively. The location of the pictures and bridges mentioned above are shown in Fig. 10-1-7.

In terms of water resource, the flow rate of the Lematang River seems to be sufficient enough even in dry seasons because the water requirement in the plant is nearly 1 m^3/sec. or 3,600 ton/hour.

As for the quality of the river water, however, only limited data have been obtained from PLN B.A. as shown in Table 10-1-7. Detailed analysis of the Lematang River water should be carried out and reflected in the plant design in the Basic Engineering stage of the Project.

Table 10-1-7 River Water Analysis
(by PLN B.A. in June, 1988)

PH value		6.32 – 7.56
Total hardness (ppm $CaCO_3$)		14.5 – 15
Total alkalinity (ppm $CaCO_3$)		28
Total dissolved solid (ppm)		125
SiO_2	(ppm)	41
PO_4	(ppm)	0.1
Ca	(ppb)	6.0
Fe	(ppb)	3.0

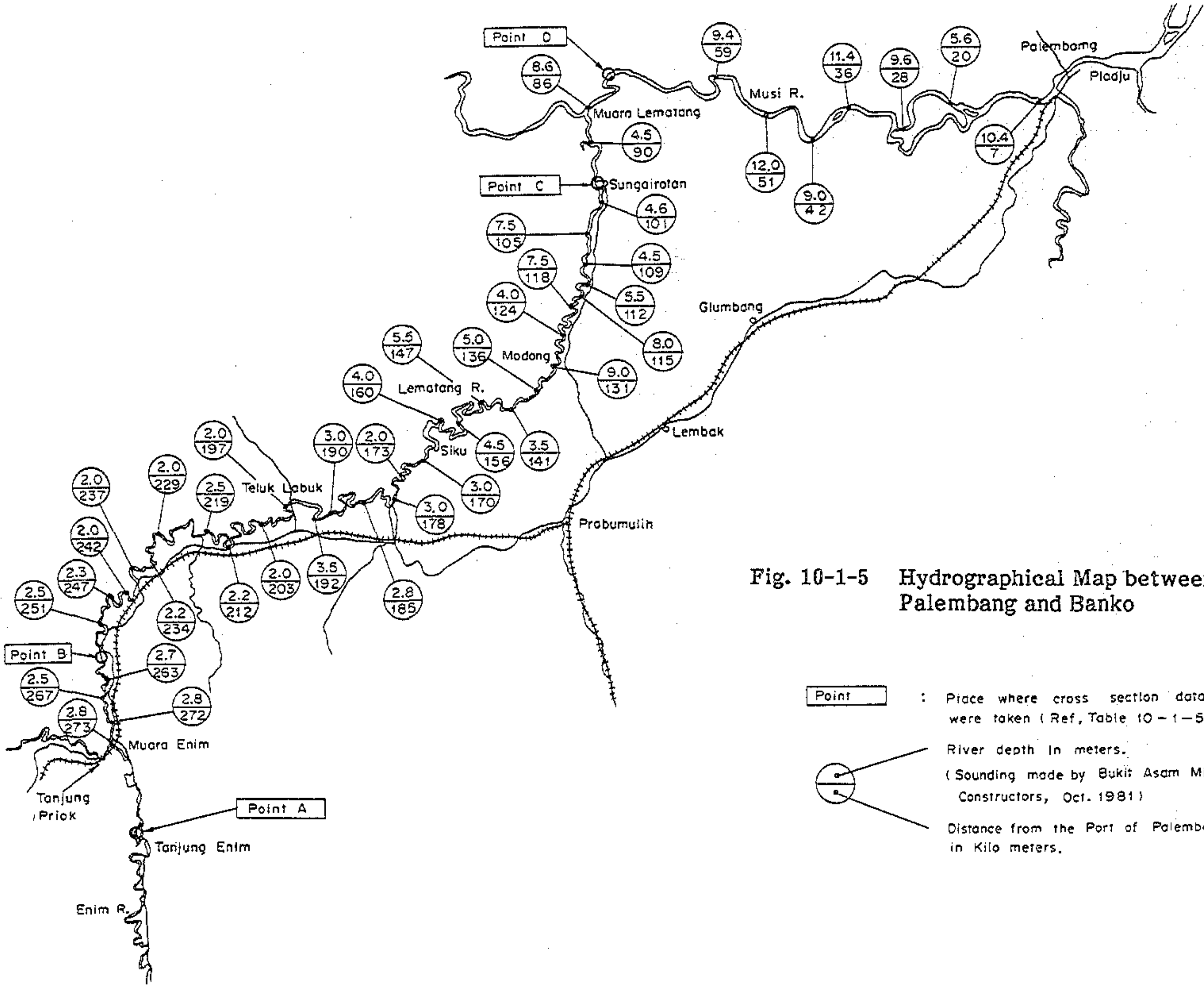


Fig. 10-1-5 Hydrographical Map between Palembang and Banko

Point : Place where cross section data were taken (Ref, Table 10-1-5)

River depth in meters. (Sounding made by Bukit Asam Mine Constructors, Oct. 1981)

Distance from the Port of Palembang in Kilo meters.

Table 10-1-5 Hydrographic Data of Rivers

(November, 1985)

Point	A	B	C	D
Place River Location	Lingga Enim 15km up- stream of Muara Enim	Pinang Belarik Lematang 10km down- stream of Muara Enim	Sungairotan Lematang 170km down- stream of Muara Enim	Tebing Abang Musi 79km up- stream of Palembang Port (Boom Baru)
Width, m Depth (Max.) Velocity m/sec. Flow Rate (estimated, m^3/sec.)	67 2.1 0.58 49	99 3.6 0.82 208	93 6.4 0.84 398	390 8.1 0.84 2,302

See also Fig. 10-1-5 for the location of point A, B, C and D.

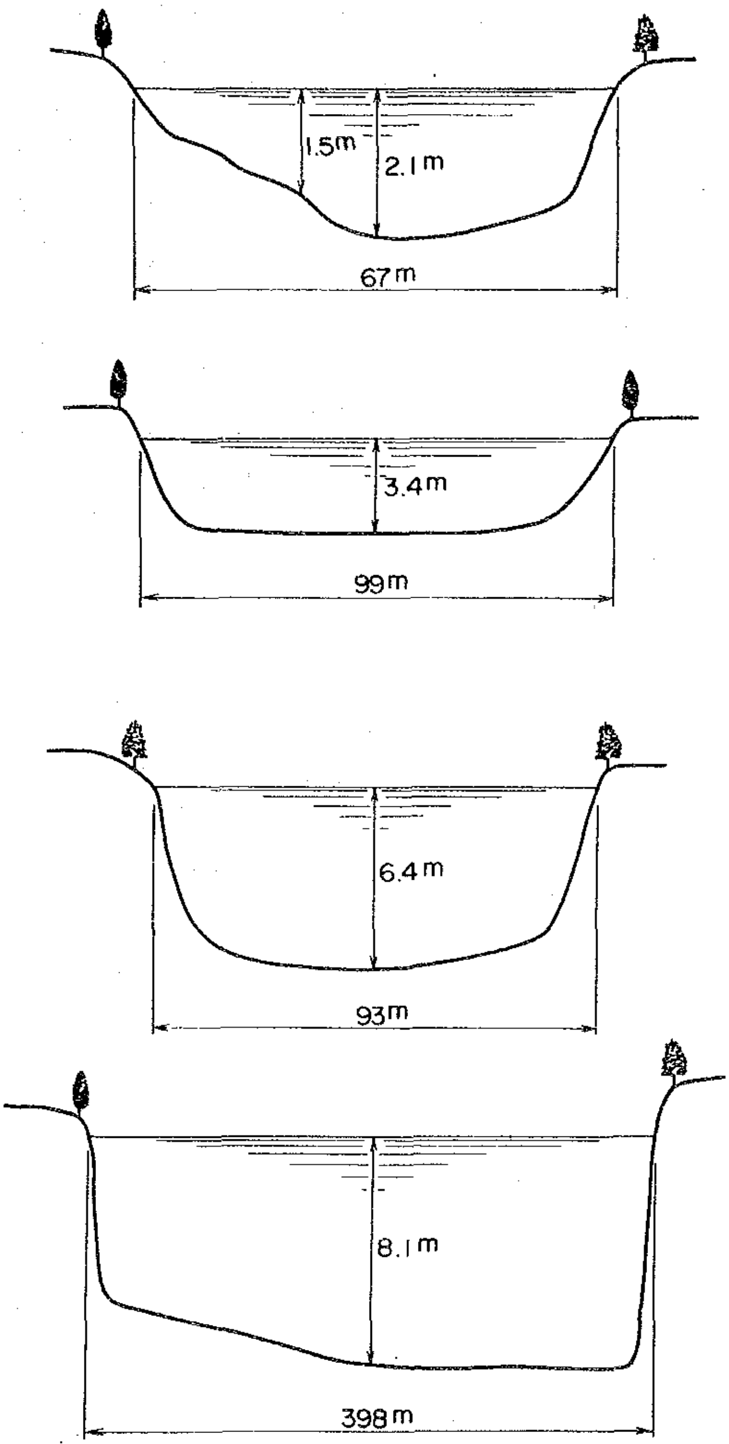
Source; DIRECTRAT PENYELIDIKAN MASALAR AIR (DPMA)

Point A
(Lingga)
Scale ;
V = 1 : 100
H = 1 : 1,000

Point B
(Pinang Belarik)
Scale ;
V = 1 : 250
H = 1 : 1,500

Point C
(Sungairotan)
Scale ;
V = 1 : 250
H = 1 : 1,500

Point D
(Tebing Abang)
Scale ;
V = 1 : 250
H = 1 : 5,000



Source; DIRECTRAT PENYELIDIKAN MASALAR AIR (DPMA)

Fig. 10-1-6 Cross Section of Rivers (November, 1985)

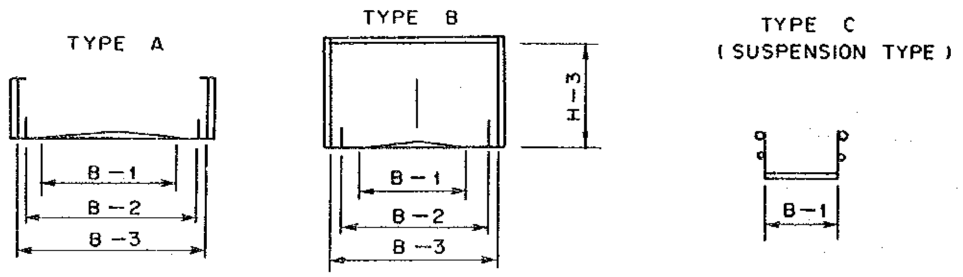
Table 10-1-6 Data of Bridges

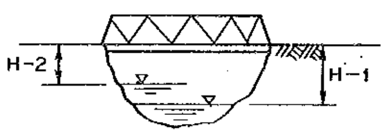
Unit : Meters

No.	Point	Type	B-1	B-2	B-3	H-1	H-2	H-3
1	Ampera	A				11.5	8.8	-
2	Kertapati	B		-	5.6			3.6
3	Niru	B	7.0	7.0	9.0	7.5		6.0
4	Teluk Lubuk	B	6.0	6.0	7.0	9.8	7.3	5.3
5	Uncertain	A	4.0	4.0	4.0			-
6	Rekukem	A	5.2	6.0	7.2	7.0		-
7	Teberau	A	5.9	5.9	7.2			-
8	Baru	A	5.9	5.9	7.2	6.5		-
9	Muara Enim	B		5.3		8.0	2.0	4.0
10	Tanjung Priok	C	-	1.1	-	6.2	4.2	-
11	Simpang Harahan	C	-	1.0	-	8.4	4.2	-
12		Viaduct	5.3	11.0	-	-		5.1
13	PLN B.A.	A				8.5	1.0	-
14	Tanjung Enim	B				6.7		

Note 1) Bridge locations are shown in Fig. 10-1-7 with corresponding numbers.

2) Bridge type A, B and C are as shown below.





H-1 : In dry season (measured in June, 1988)

H-2 : In rainy season (estimated)

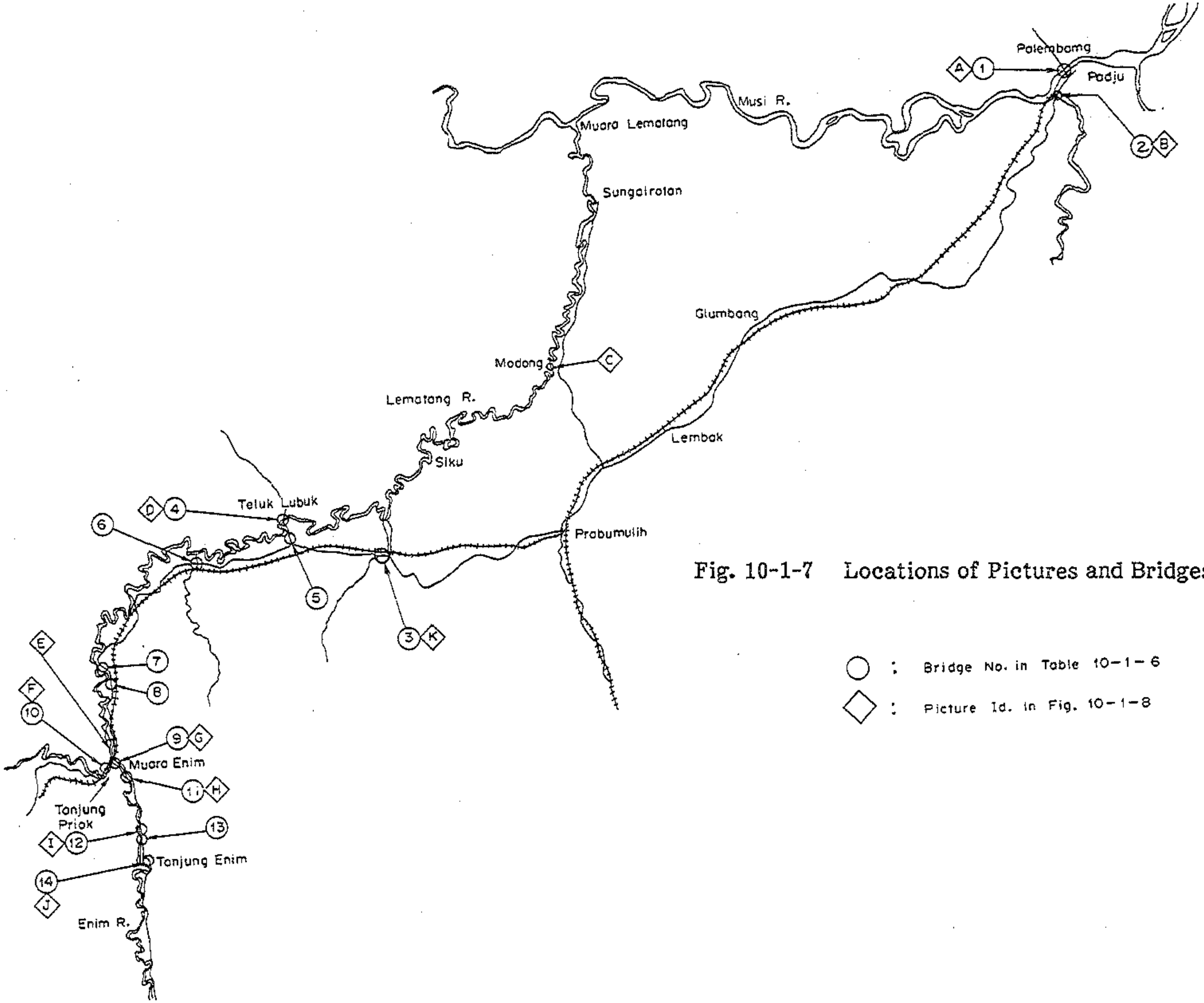
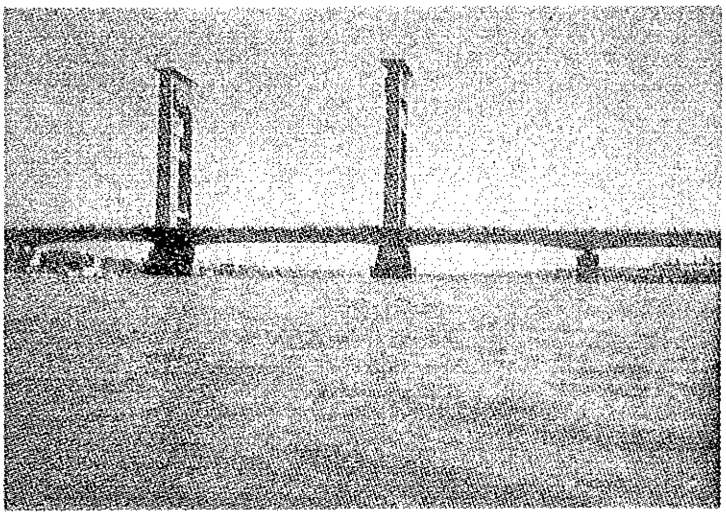


Fig. 10-1-7 Locations of Pictures and Bridges

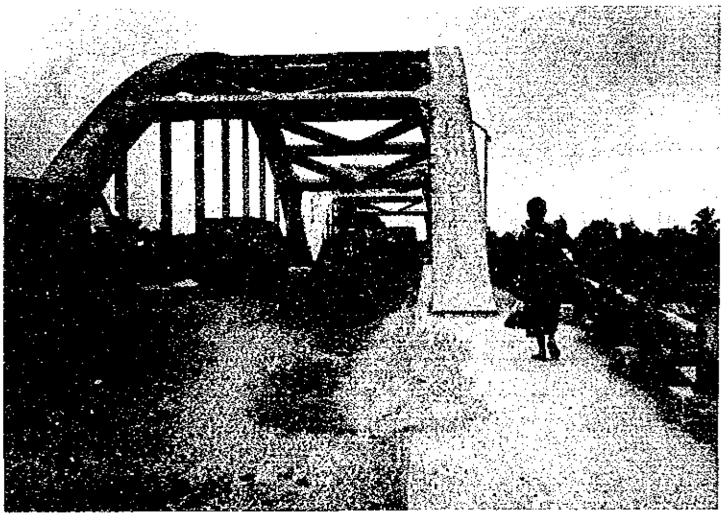
Picture A

Ampera Bridge at Palembang, the only bridge over this route



Picture B

Kertapati Bridge



Picture C

PERTAMINA pipeline crossing the Lematang River at Modong

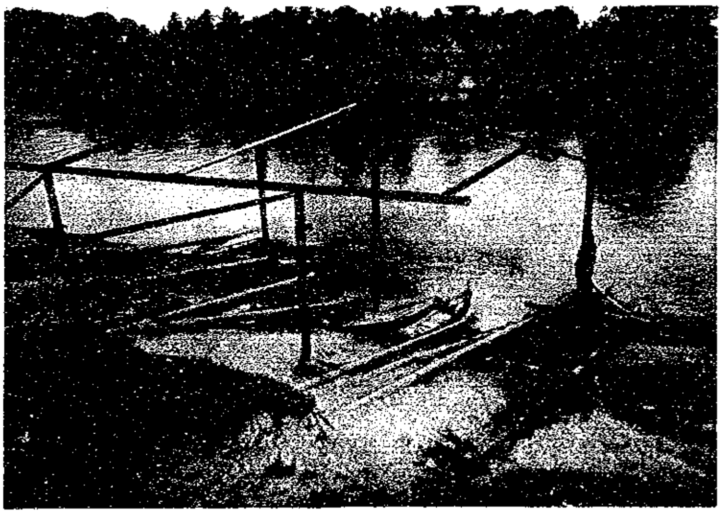
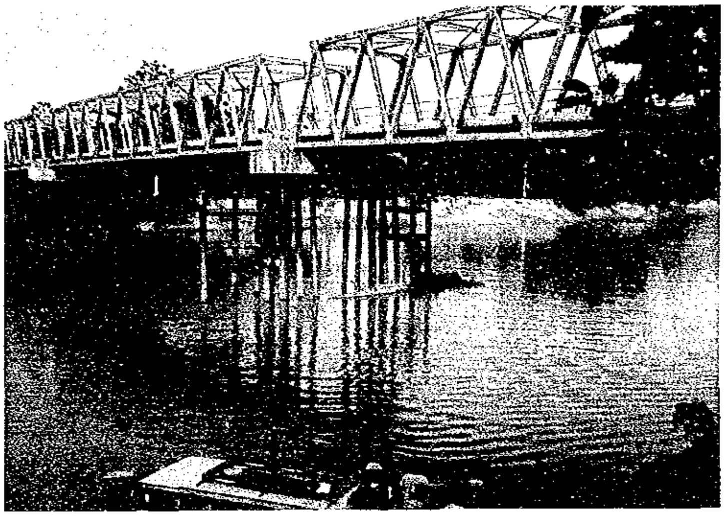


Fig. 10-1-8 Pictures Related to Rivers and Bridges (A - K)

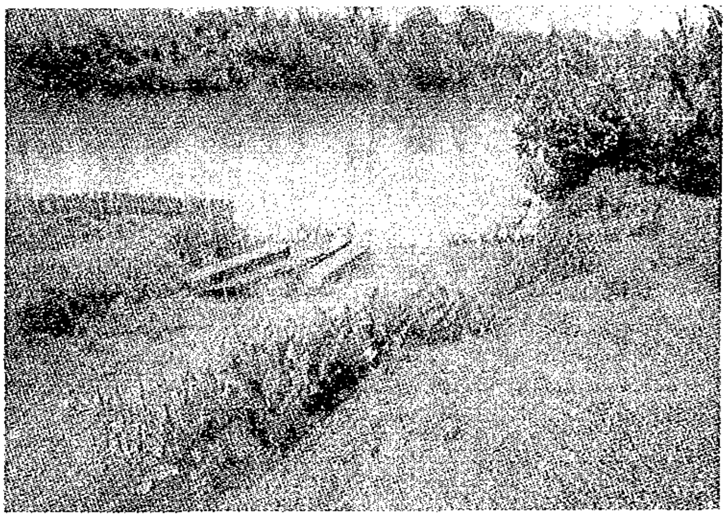
Picture D

Teluk Lubuk Bridge



Picture E

A Jetty at Desa Muara Enim where 150-ton-container was unloaded

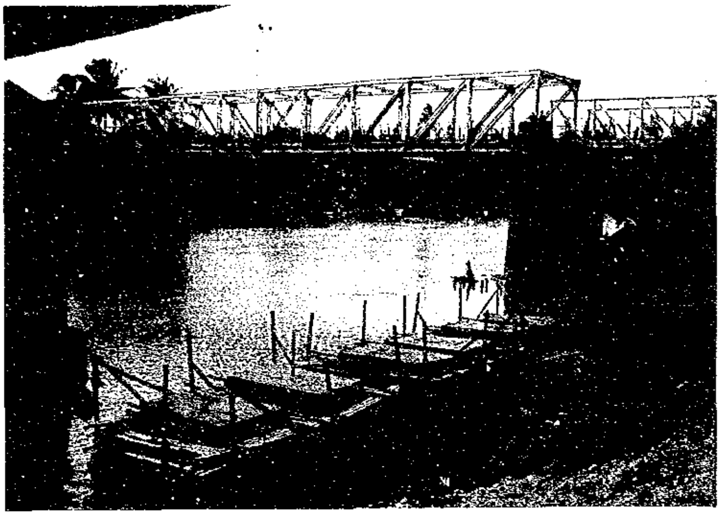


Picture F

A suspension bridge over the Lematang River at Tanjung Priok

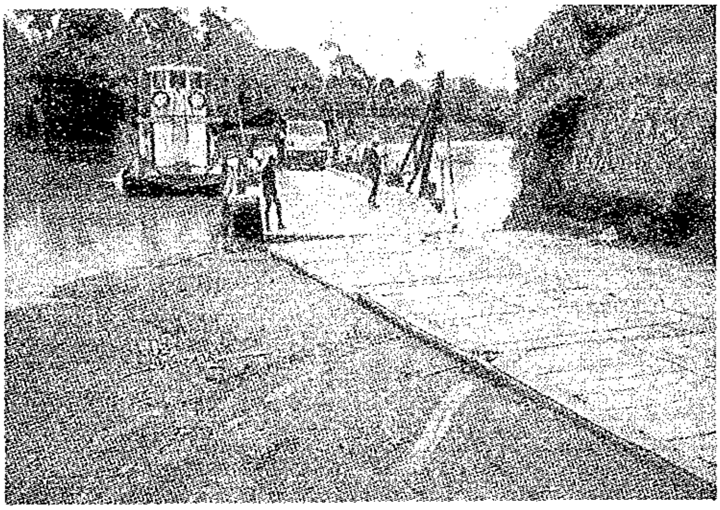
Picture G

Muara Enim
Bridge over
the Enim River



Picture G

A Jetty in use
by Pertamina

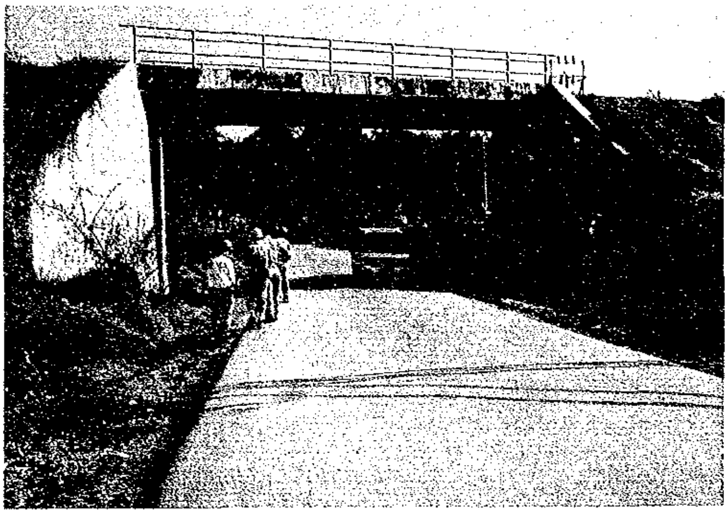


Picture H

A suspension
bridge over the
Enim River at
Simpan
Harapan

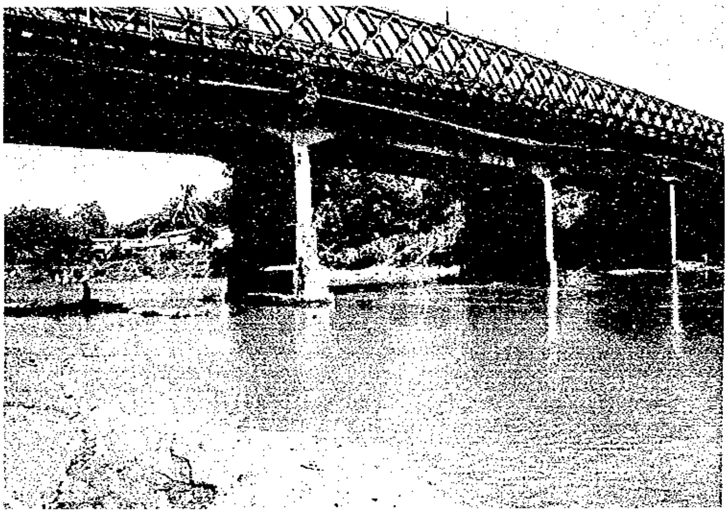
Picture I

A viaduct between Muara Enim and Tanjung Enim



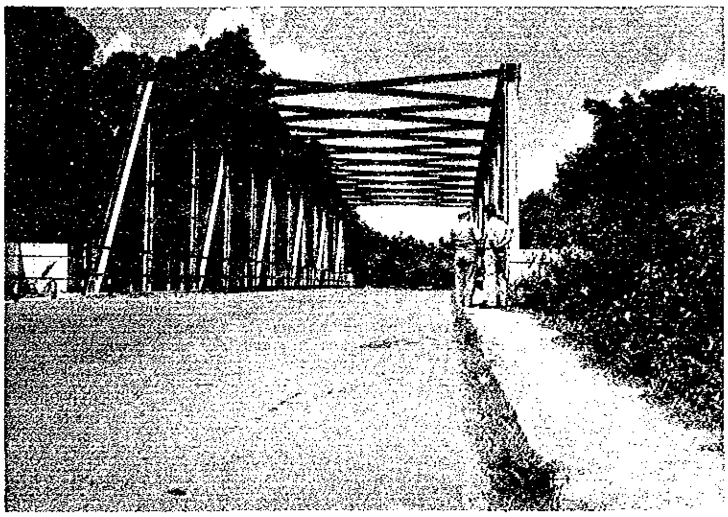
Picture J

Tanjung Enim Bridge over the Enim River



Picture K

Niru Bridge



10-2 BASIS OF CONCEPTUAL DESIGN

Conceptual design of facilities necessary for the development and utilization of Banko coal shall be carried out in accordance with the following basic policies.

10-2-1 General

1) The basic objective in design shall be to achieve the required coal and its derivative production at minimum capital cost for the project, consistent with reliability, safety and other defined policies.

2) Since this Feasibility Study aims at the industrialization of the plant at some ten years from now on, the most advanced technologies of prototype stage should be adopted, even if the technology has no commercial application at present.

3) Applying excessive safety factors should be avoided in order to obtain the most probable result of the Feasibility Study.

4) The project as a whole and all sub-systems and components shall be designed for the minimum capacities necessary to achieve reliable production.

5) The reliability of sub-systems and components shall not be less than the reliability of the system as a whole.

6) Electricity and fuel methanol shall be used as energy sources in preference to oil-based fuels, unless there is a clear economical advantage in favour of the use of oil-based fuel.

7) Consideration shall be given to the standardization of equipment and components in the interests of reduced maintenance.

8) The Project shall provide maximum employment opportunities consistent with the need to maintain productivity and cost effectiveness.

9) The Project shall make provision for the thorough training of Indonesian personnel in all aspects of operation and maintenance.

10) Specifications for equipment, instrumentation, electricity and civil work should have enough accuracy to enable the estimation of construction cost.

11) Design shall allow for maximum Indonesian material and equipment with proper capability, service and price.

12) Environmental, health and human ecological considerations shall be in accordance with rules and regulations as well as generally accepted practices in Indonesia.

13) Design, construction, operation and maintenance shall comply with the relevant rules, regulations and laws of the competent authorities of the Government of Indonesia.

14) Standard specifications and codes of practice acceptable for use in design are those of Japan.

15) All information concerning the Project, not in the public domain, shall be considered strictly confidential.

10-2-2 Feed Coal

(1) Coal Quality as Mined

		North West Banko	North Suban Jeriji
C	(%)	36.0	25.1
V.M.	(%)	33.6	28.8
Ash	(%)	2.8	3.6
Mo	(%)	27.6	42.5
Total	(%)	100.0	100.0
HV	(kcal/kg)	4,650	3,150

(2) Coal Quality at Plant Gate

After received in a bunker hopper, mined coal is crushed into appropriate size and then carried to the plant site by a belt conveyor system.
During above mentioned pretreating and transportation, some of moisture will

vaporize naturally resulting coal quality at a plant gate as follows.

Table 10-2-1 Coal Quality at Plant Gate

	North West Banko	Central Banko	North Suban Jeriji
Mo (as mined)	(27.6)	(36.7)	(42.5)
Mo (Plant gate)	23.1	25.3	26.8
C	38.3	34.6	32.0
V.M.	35.6	34.4	36.6
Ash	3.0	5.7	4.6
Total	100.0	100.0	100.0

The data of coal from N.W. Banko will be used as the overall design basis. However, mechanical design of the coal gasification plant will use the data of coal from N. Suban Jeriji as the design basis.

Note: 1) Overall material balance will be calculated by using the data of both coal.

Note: 2) The gasification plant will be designed to accommodate processing of both N.W. Banko and N. Suban Jeriji coal. Other plants will be designed for N.W. Banko coal only.

Note 3) Utility facilities will be designed for N.W. Banko coal.

Note 4) Economic evaluation will be made for N.W. Banko coal.

Note 5) Coal mining costs will be estimated for both coal basins.

10-2-3 Utilities

(1) General

All the utilities except raw water and coal are to be generated inside the coal gasification complex at the following conditions.

HP Steam	:	480°C, 65 kg/cm^{2}G
LP Steam	:	156°C, 3.5 kg/cm^{2}G
BFW	:	125°C
C. Water	:	32°C (Supply)/42°C (Return)

Steady operation of utility facilities is required in order to keep the minimum supply of utilities necessary to achieve the safe shutdown of the process plants in case of emergency such as power failure, stoppage of industrial water receiving, etc.

Countermeasures for utilities stabilization and safety are to be considered as follows.

i) Preparing for the unexpected stoppage of industrial water from the off-site facilities, the industrial water system is to be provided with a required minimum capacity of pit.

ii) Important equipment should consist of two or more equivalent units which will run in parallel.

iii) Besides electrical motors, diesel engines are to be installed to drive equipment required to maintain operation in case of power failure in order to maintain the safety of the plants.

Also in order to prepare for a long period power failure, diesel generators are to be provided to supply electricity to important instrumentation facilities and equipment necessary for diesel engine operation.

(2) Boiler and Electricity Generation

In order to minimize the coal consumption, efficient utilization of energy should be considered:

i) Facilities which do not need high level energy sources are to utilize LP Steam in principle.

ii) Waste heat recovery should be incorporated at a maximum in the coal gasification plant by heating BFW up to 290°C, 75 kg/cm^{2}G.

Saturated HP steam recovered in the process will be furthermore superheated in the power plant up to 480°C, 65 kg/cm^{2}G (HP Steam)

iii) Residual fuel gas from the methanol plant is to be used in the boiler.

iv) Large-size compressors in the air separation, and methanol plants are to be driven by steam turbine instead of electric motor.

(3) Cooling Water System

A centralized cooling tower is to be installed in the utilities center to supply cooling water to each plant except the coal gasification plant.
Attention should be paid to the selection of a sterilizer agent which allows the blow down water to be discharged to the river.
Moreover, a pond should be provided in order to store and cool the blow down water before discharge as well as to prevent accidental discharge of methanol.

10-2-4 Plant Location

A riverside area close to the mine is to be selected as the plant site and four areas were proposed in the study. (See Fig. 10-2-1 and Fig. 10-2-2).
Features of each area are as follows.

(1) Desa Muara Enim (15 Km northwest of Banko)

Desa Muara Enim would be the most favoarable for the plant site for the following reasons:

1) Location near the mining area.

2) *Possibility of river transportation of heavy equipment in rainy season.* (Heavy equipment for PLN B.A. was unloaded at Desa Muara Enim).

3) Free land is available near the riverside. (This allows easy intake of river water).

(2) Tanjung Priok

Tanjung Priok has worse conditions than Desa Muara Enim in terms of equipment transportation.
Two low bridges crossing Lematang River and Enim River deny equipment transportation to the Tanjung Priok.
In addition, Tanjung Priok has disadvantages as follows:

1) Lack of free flat area

2) Surrounded by crowded residential area

3) Both coal and methanol transportation must cross the Enim River.

(3) N.W. Banko

Although N.W. Banko is favoured with potential free land and is located near coal mining site, other factors may not support this site, i.e.:

1) Longest land transportation of equipment through the road from Muara Enim to N.W. Banko which encounters several small and low bridges.

2) Water availability is poor compared with other sites because of high bank and low discharge rate of the Enim River.

(4) Teluk Lubuk

Teluk Lubuk is in the best condition for equipment transportation. Also, free land is available near the riverside.
A disadvantage exists, however, in that the belt conveyor system must be the longest of four cases. Therefore, Teluk Lubuk will be selected only if equipment transportation is restricted by the existence of the Teluk Lubuk bridge.

Considering every factor summarized in Table 10-2-2, Desa Muara Enim is selected as the plant site.

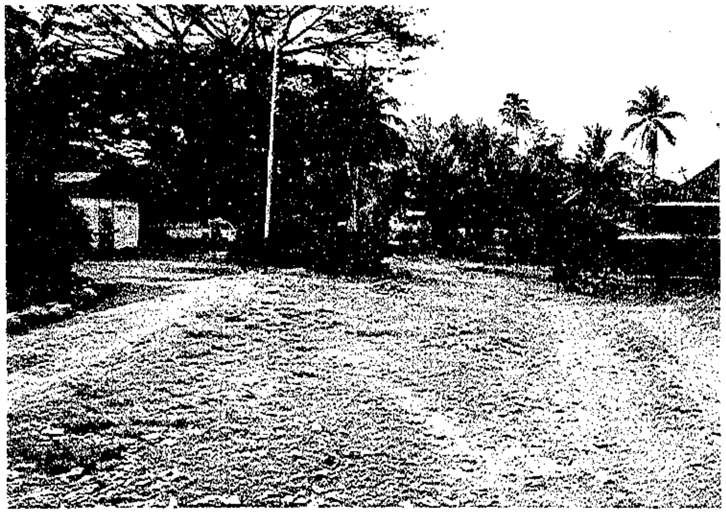
Table 10-2-2 Comparison of Possible Plant Site

Item \ Site	Desa Muara Enim	Tanjung Priok	N.W. Banko	Teluk Lubuk
Product delivery	Poor	Poor	Poor	Average
Coal transportation	Good	Average	Excellent	Poor
Space and topography	Good	Poor	Good	Good
Soil condition	Unknown	Unknown	Unknown	Unknown
	(Generally good for construction)			
Water availability	Good	Average	Poor	Good
Infrastructure	Average	Average	Poor	Poor
Equipment transportation	Average	Poor	Poor	Average
Construction easiness	Poor	Poor	Poor	Poor
Total rank	A	C	C	B

Fig. 10-2-1 Possible Plant Site Locations

Desa Muara Enim

N.W. Banko



Tanjung Priok

Teluk Lubuk

Fig. 10-2-2 Proposed Plant Sites

10-2-5 Equipment Transportation

Since the transportation of brown coal is very difficult and costly, the coal gasification complex is to be located as near as possible to the coal mining site. Therefore, the condition of the equipment transportation route is an important factor as well as the plant site condition and plant design since it affects the economic aspect of the project.

(1) Transportation Means

After the equipment manufactured in Japan and/or other countries is shipped to the Port of Palembang, there are two ways to transport the equipment further from Palembang to the plant site, i.e. by land through Sumatra Highway and by water through the Musi and Lematang Rivers.

1) Land Transportation

Equipment transportation from Palembang to the plant site via road is much more difficult than river transportation. Basically, the Sumatra Highway is paved but there are still many rough sections with many large potholes. Besides, many small and weak bridges will restrict the maximum size of equipment carried by trailer.

As a general rule, cargos lighter than 35 tons will be transported via road. The land transportation of equipment exceeding 35 tons is not recommended because it requires the reinforcement of almost all the bridges through the route and consequently costs too much.

2) River Transportation

Only cargos heavier than 35 tons are to be transported by water.

As mentioned in Section 10-1-6, a continuous riverway route exists between Palembang and Muara Enim which allows the transportation of the heavy equipment such as the methanol synthesis reactor with a 490 ton weight, on the following conditions:

i) Actual transportation is to be scheduled only in the rainy season because a tugboat sailing will require minimum 3.5 meter river depth which is as shallow as 1 meter in the upstream part of Teluk Lubuk in the dry season.

Detailed river depth survey should be conducted in the project implementation stage especially for the portion between Teluk Lubuk and Muara Enim.

ii) The height of the equipment during transportation by barge is to be less than 5 meters considering the clearance of the Teluk Lubuk bridge.

To summarize, transportation by way of water course up to Muara Enim is advantageous and to be selected for heavy equipment.

(2) Transportation Plan

1) Shipment

Cargos are to be loaded on to freighters at the ports in Japan or other countries, such as Yokohama, Hiroshima or Hakata whichever are closer to the manufacturing factories and to be shipped to the Port of Palembang (See Fig. 10-2-3).
Considering the water depth and transshipment at the Palembang Port to barges in rotation, a 10,000 DWT class freighter is suitable.

2) Transshipment

At the Port of Palembang, the cargos are to be transshipped to six flat barges moored in the Port (See ① and ② in Fig. 10-2-4) consisting of the following.

3,000 DWT (20 m × 60 m × 4.2 m) : two
1,000 DWT (15 m × 45 m × 3.0 m) : four

Heavy cargos are to be transshipped on to the trestle prepared on a barge (See ① a in Fig. 10-2-4).
Unloading work will take about 3 days/voyage.

3) Barge Towing

Each barge is to be towed by one tug boat (single towing) for about 270 km to the unloading site through the Musi and the Lematang River (See ③ in Fig. 10-2-4).
Considering the river depth, a 750 HP class barge is to be selected.

4) Equipment Unloading

A slope jetty and a floating barge are to be provided at the unloading site to cope with the fluctuation of water level.
Heavy cargo is to be rolled off by a dolly through a slope jetty while general cargos are to be unloaded to a trailer or a truck by a crawler crane installed on the floating barge. (See ④ in Fig. 10-2-4).

5) Transportation to the Plant Site

After rolled off from a barge, heavy cargo is to be subsequently transported by a dolly to the plant site and to be unloaded near the installation point.
General cargos are to be carried by a trailer or a truck into the temporary storage area in the plant site for unloading by a crane or a forklift truck.
Cranes and vehicles for inland transportation are listed in Table 10-2-3.

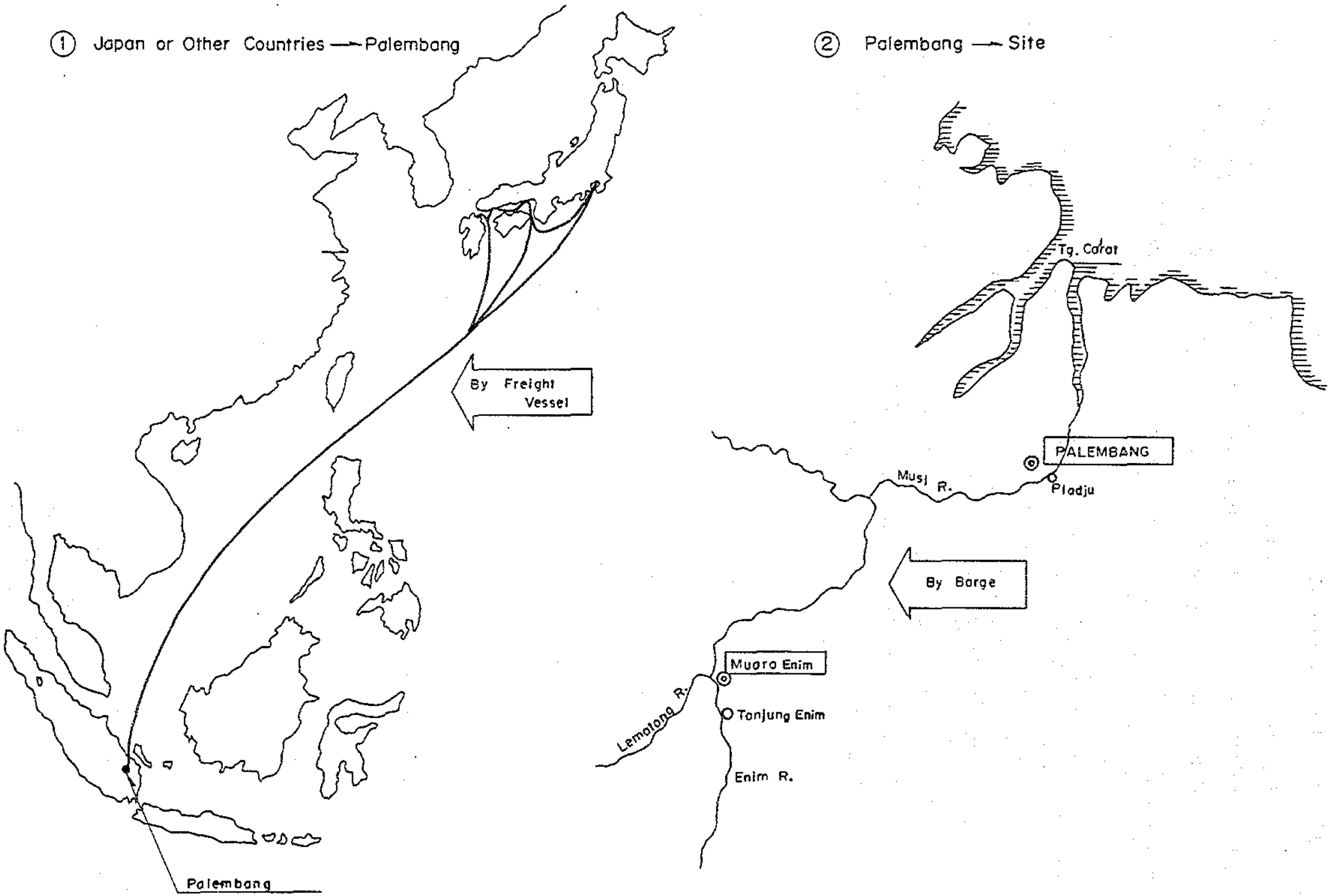
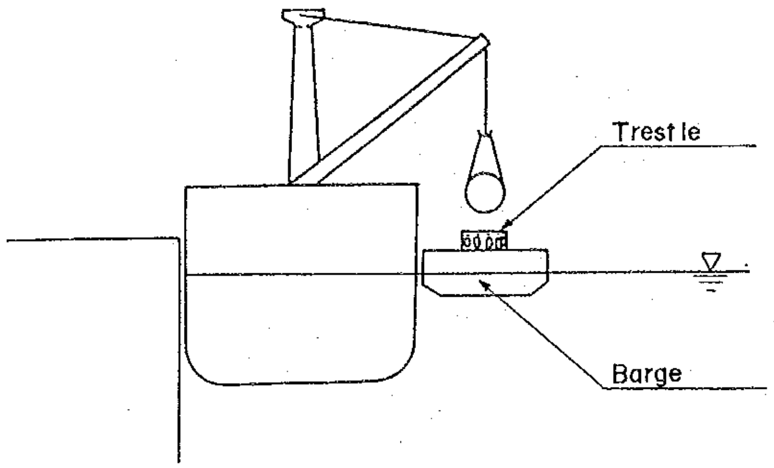


Fig. 10-2-3 Transportation Route Map

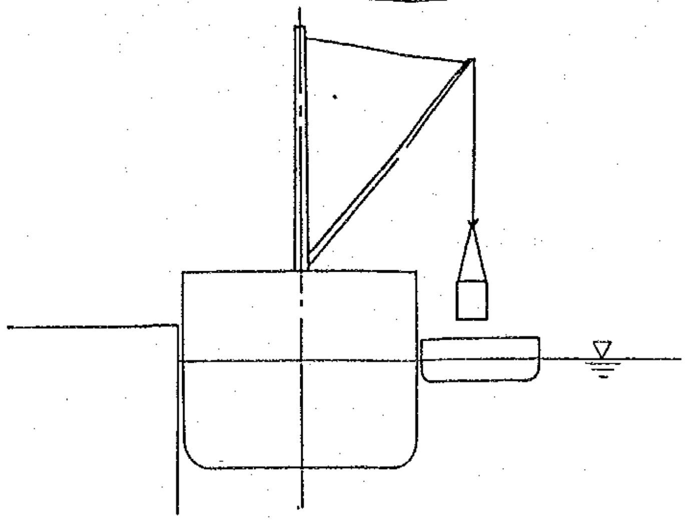
REV. NO.	DATE	DESCRIPTION	SIGN

(1) Unloading at Palembang

a. Heavy Cargo

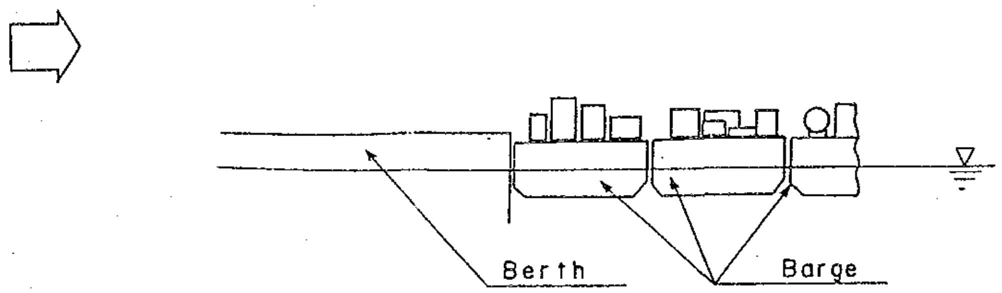


b. General Cargo



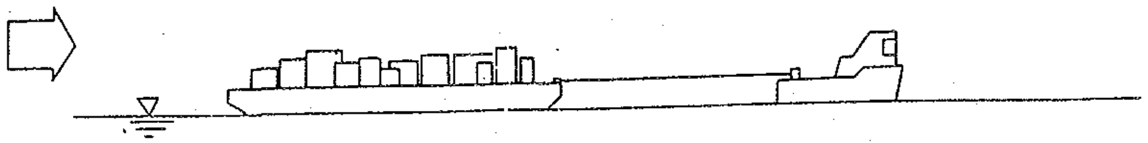
(2) Barge Mooring to Berth

at Palembang Port



(3) Barge Towing

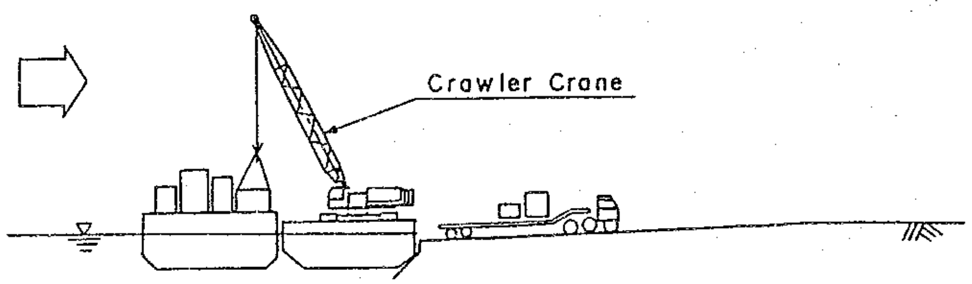
Single towing



Palembang → Site (270km)

(4) Unloading General Cargo

a. By Crane on Barge



(4) Unloading General Cargo

b. By Crane on Ground

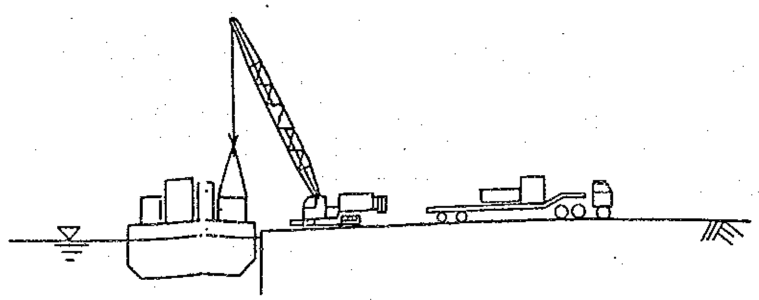


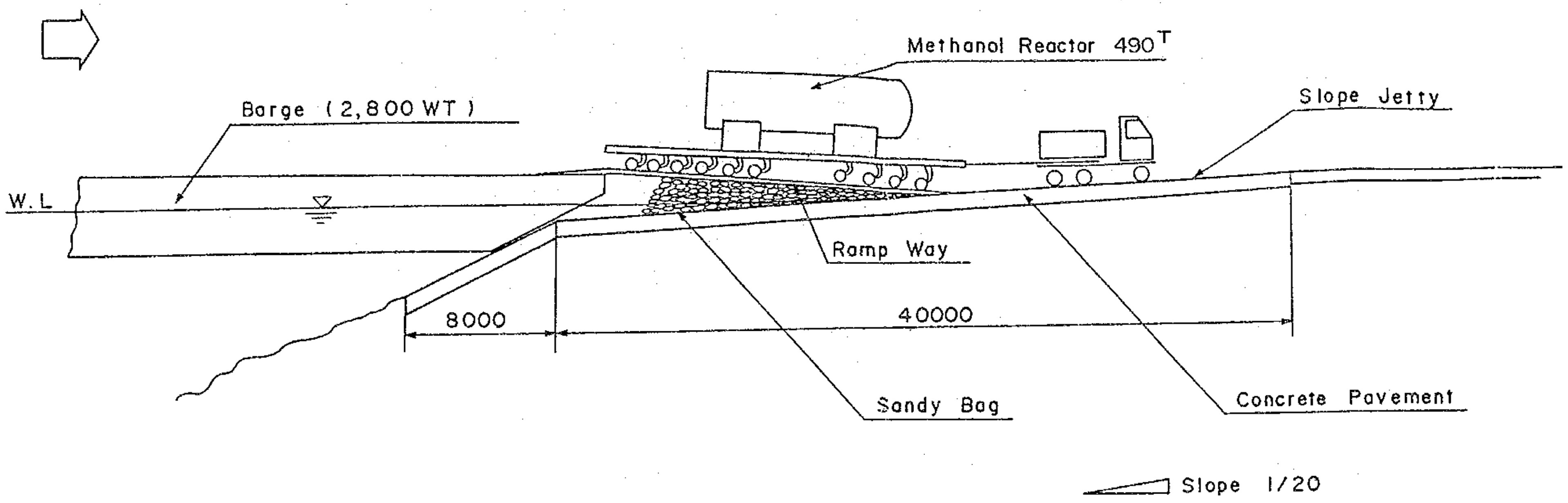
Fig. 10-2-4 Transportation Plan (1/2)

APP'D		JAPAN INTERNATIONAL COOPERATION AGENCY
CHK'D		
DRW'N		
TRC'D		
SCALE	DATE	DWG.NO.

REV. NO.	DATE	DESCRIPTION	SIGN

④ Unloading Heavy Cargo

a. Max. High Water Level



b. Low Water Level

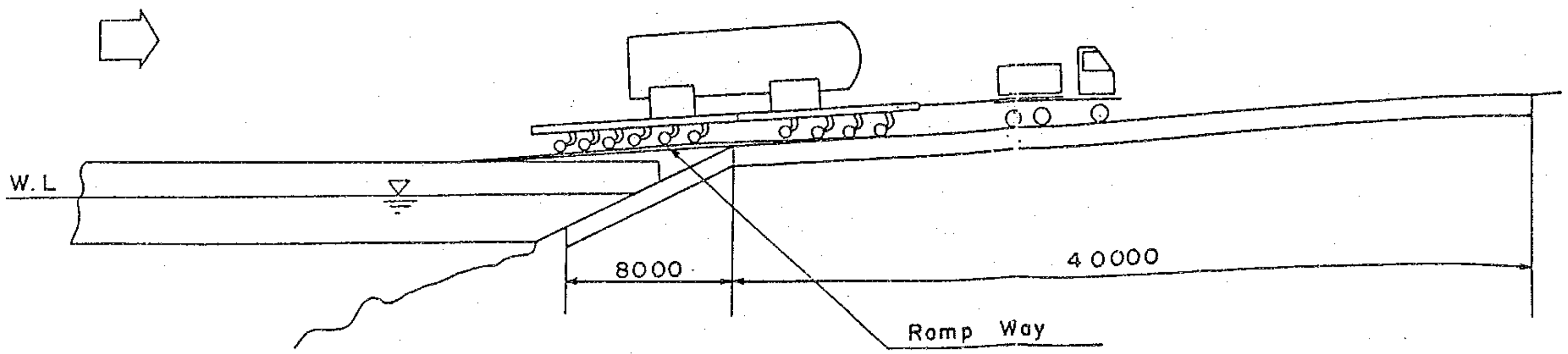


Fig. 10-2-4 Transportation Plan (2/2)

APP'D		JAPAN INTERNATIONAL COOPERATION AGENCY
CHK'D		
DRW'N		
TRC'D.		
SCALE	DATE	DWG.NO.

Table 10-2-3 Cranes and Vehicles for Inland Transportation

1.	100t Crawler Crane	2 units
2.	80t Crawler Crane	1 unit
3.	35t Truck Crane	1 unit
4.	5t Fork Lift	1 unit
5.	3t Fork Lift	1 unit
6.	Unit Dolly	4 units
7.	Tractor	2 units
8.	60t Trailer	2 units
9.	30t Trailer	3 units
10.	20t Trailer	1 unit
11.	10t Truck	1 unit
12.	6t Truck	1 unit
13.	Sedan	2 units
14.	Jeep	2 units
15.	Motor Bicycle	3 units

10-2-6 Waste Disposal and Pollution Control

(1) Waste Water Disposal

Since the plant site belongs to the upstream district of the Musi and Lematang Rivers, the discharge of waste water containing toxic substance will inevitably cause wide area water pollution. Much attention must be paid to avoid such a serious problem.

1) Separate sewerage should be provided for clean and dirty water. The dirty or contaminated water is to be treated by ordinary methods such as API oil separator, biological contact oxidation method and coagulating sedimentation.

2) In order to prevent thermal pollution as well as contamination, a pit or a reservoir is to be provided to store and cool the clean waste water before disposal.

3) In addition to regularly discharged water, a large amount of waste water may be let out from the plants in case of emergency, and is to be tentatively sent to a pond of appropriate size and then treated for disposal.

(2) Solid Wastes Disposal

Solid wastes generated in the coal gasification complex are dust and slag from the coal gasification plant, and ash from the fluidized bed boiler. Since all of them are harmless, they will be carried to and discarded in the mined-out area of coal mine.

(3) Air Pollution Control

In general, major materials causing air pollution are sulfur oxide and nitrogen oxide contained in the flue waste gas. Basically, special measures against air pollution such as de-SO_X or de-NO_X facilities will not be required in this project for the following reasons:

i) The sulfur content of Banko coal is small.

ii) Each combustion facility in the plants is provided with dedusting equipment.

iii) The flue gas from fluidized bed boiler contains small amounts of SO_X and NO_X.

However, the plant design is to reflect the environmental assessment in Chapter 12 based on the evaluation of every flue waste gas as well as other gases to be vented from the plants.

10-2-7 Basic Design Data

(1) Site Conditions

1) Site Location

Desa Muara Enim

2) Site Conditions

Soil bearing power: 5 ton/m^2

Pile bearing power:

PHC, 300 mmφ, L=13 m ; 35 ton/piece

PHC, 400 mmφ, L=13 m ; 50 ton/piece

3) Earthquake

i) High pressure gas facility

$Fe = 0.15 \times \beta_1 \times \beta_2 \times \beta_3 \times \beta_4 \times W$

where; Fe = Design static horizontal seismic force

β_1= Important grade coefficient (0.5 - 1.0)

β_2= Area coefficient (0.4 - 1.0)

β_3= Surface soil amplification coefficient (1.4 - 2.0)

β_4= Multiplying factor of horizontal response (1.0 - 3.14)

W = Weight of component

ii) Dangerous substance handling facility (tank)

$Fe = 0.15 \times v_1 \times v_2 \times v_3 \times W$

where; Fe = Design static horizontal seismic force

v_1= Area correction factor (0.7 - 1.0)

v_2= Soil correction factor (1.5 - 2.0)

v_3 = Multiplying factor of natural period of tank
W = Weight of component

iii) Building (on the ground)

$$Fe = Ci \times W = Z \times Rt \times Ai \times Co \times W$$

where; Fe = Design static horizontal seismic force
Ci = Design base shearing force coefficient
Z = Z value (earthquake activity, etc. 0.7 - 1.0)
Rt = Rt value (vibration character, etc.)
Ai = Ai value (surface soil shearing force, heights of building)
Co = Standard shearing force coefficient (0.2, 0.3)
W = Weight of component

(2) Climatic Conditions

1) Ambient Temperature

Monthly maximum temperature	:	33.5°C
Monthly minimum temperature	:	20.3°C
Monthly average temperature	:	24.9°C

2) Relative Humidity

Monthly maximum humidity	:	99 %
Monthly minimum humidity	:	48 %
Monthly average maximum humidity	:	90 %
Monthly average minimum humidity	:	71 %

3) Barometric Pressure

Monthly average maximum	:	1,012 milli-bar
Monthly average minimum	:	1,008 milli-bar
Monthly average	:	1,010 milli-bar
Design	:	1,010 milli-bar

4) Wind

Wind direction	:	N.W.; 20 %, S.E.; 27%
Average wind velocity	:	4 m/sec.
Maximum wind velocity	:	21 m/sec.

5) Rainfall

Average rainfall :	maximum	;	432	mm/month
	minimum	;	89	mm/month
	yearly value	;	3,767	mm/year
Maximum rainfall		;	205	mm/24hr.
Average rainydays:	maximum	;	26	days/month
	minimum	;	5	days/month
	yearly value	;	182	days/year

6) Other Provisions

Winterizing	:	Not required
Snowfall	:	Not required
Marine exposure	:	Not required
Sand storm	:	Not required
Lightning	:	Required

(3) Material Conditions

1) Coal (Plant feed)

Design base : North West Banko Coal

Quality	:	Ash	;	3.0 %
		Volatile matter	;	35.6 %
		Total sulphur	;	0.7 %
		Moisture	;	23.1 %
		Sodium oxide in ash	;	6.2 %
		(Sodium oxide below 40 m	;	up to 20 %)
		Fixed carbon	;	38.3 %
Size			;	-40 mm

2) Calcined Lime	:	Component	;	95 % CaO
		Size	;	10 - 25 mm
3) Scrap Iron	:	Component	;	+90 % Fe
		Size	;	5 - 25 mm
4) Fe-Al	:	Component	;	60 % Fe, 40 % Al
		Size	;	5 - 25 mm

(4) Utility Conditions (at the battery limit of each facility)

1) Oxygen : Purity ; 99.5 % over
Temperature ; ambient
Pressure ; 10 kg/cm^2G

2) Nitrogen : Purity ; 98.0 % over
Temperature ; ambient
Pressure ; 6 kg/cm^2G

3) Steam

High pressure steam : Pressure ; 65 kg/cm^2G
Temperature ; 480°C

Low pressure steam : Pressure ; 3.5 kg/cm^2G
Temperature ; 156°C

4) River Water (Industrial water)

Temperature	: below ambient
Pressure	: 6 kg/cm^2G
PH value	: 6.3 - 8.0
Total hardness	: 10 - 20 ppm $CaCO_3$
Total alkalinity	: 20 - 40 ppm $CaCO_3$
Total dissolved solid	: 100 - 150 ppm
SiO_2	: 20 - 50 ppm
PO_4	: 0.1 - 1 ppm
Ca^{++}	: 5 - 10 ppm
Fe	: 2 - 6 ppm

5) Cooling Water

Temperature (in/out)	: 32°C/42°C
Pressure (in/out)	: 5.0 kg/cm^2 / 3.0kg/cm^2
PH value	: 6.8 - 8.5
Total dissolved solids	: 100 - 200 ppm
M-Alkali	: 20 - 60 ppm
Fe_2O_3	: below 2 ppm
SiO_2	: 30 ppm
$KMnO_4$ consumption	: below 5 ppm

Total hardness	:	30 - 40 ppm
Turbidity	:	below 20

6) Boiler Water

Temperature	:	125°C
Pressure	:	vessel head (1.4 kg/cm^{2}G)
PH value	:	8.5 - 9.5 (25°C)
Fe	:	below 0.02 ppm
C	:	below 0.01 ppm
SiO_2	:	below 0.02 ppm
$KMnO_4$ consumption	:	0
Total hardness	:	0
O_2	:	below 0.007 ppm
Electric conductivity	:	below 0.3 μS/cm at 25°C
Oil	:	negligible

7) Potable Water (Drinking and service water)

Temperature	:	below atmospheric temperature
Total coli-form bacterium	:	negative in 100 ml
General bacterium number	:	below 100/ml
Odor and taste	:	clear and negligible
Color and turbidity	:	below 1 mg/l
Soluble matter	:	below 1,000 mg/l
PH value	:	6.5 - 9.0
Total hardness	:	5 - 10 dH
$KMnO_4$ consumption	:	below 10 ppm
Cl^-	:	250 ppm
SO_4^-	:	250 ppm
Ammonium N., nitrite N.	:	no detection
Nitric N.	:	20 ppm
Ferrous	:	0.2 ppm
Manganese	:	0.1 ppm
Fluorine	:	1 - 1.5 ppm
Lead	:	0.05 ppm
Arsenic	:	0.05 ppm

Copper : 3.0 ppm
Zinc : 5.0 ppm
Magnesium : 125 ppm
H_2S : no detection

8) Fire-fighting Water

Temperature : ambient
Pressure : 10 kg/cm^{2}G
Water category : river water

9) Electric Power (at the battery limit)

i) Primary feeder : 3,300 V, 3 phases, 3 wires, 50 Hz.

ii) Standard voltage ratings for each equipment

Service	kW range		Utilization voltage	Phase	Hz
Motor	below	0.37	220	1	50
	0.37	190	440	3	50
	200	3000	3300	3	50
Instrument			120	1	50
Outdoor lighting			220	1	50
Indoor lighting			220	1	50
High bay building			440	1	50
Receptacle, power services			440	3	50
Convenience outlet			220	1	50
			440	1	50

iii) Frequency and voltage variations

Frequency : normal ; ± 0.1 Hz
extreme abnormal ; ± 1.5 Hz
Voltage : maximum ; ± 5%

10) Compressed Air

Instrument air	: Temperature	;	ambient
	Pressure	;	4 kg/cm^2G
	Dew point	;	0°C
Service air	: Temperature	;	ambient
	Pressure	;	2.5 kg/cm^2G

(5) Waste Conditions

Conditions of waste water and waste gas have been decided as follows based on the environmental assessment described in Chapter 12.

1) Waste Water

Cadmium and its compounds		;	0.1 mg/l
Cyanide compounds		;	1.0 mg/l
Phosphor organic compounds		;	1.0 mg/l
Lead and its compounds		;	1.0 mg/l
Chromium sexivalent compounds		;	0.5 mg/l
Arsenic and its compounds		;	0.5 mg/l
Total mercury		;	0.005 mg/l
Alkylmercury		;	no detection
PCB		;	0.003 mg/l
pH value		;	5.8 - 8.6
BOD, COD		;	160 mg/l
	day average	;	120 mg/l
SS		;	200 mg/l
	day average	;	150 mg/l
N-hexane extract	mineral oil	;	5 mg/l
	vegetable oil	;	30 mg/l
Phenols		;	5 mg/l
Copper		;	3 mg/l
Zinc		;	5 mg/l
Ferrous solution		;	10 mg/l
Manganese solution		;	10 mg/l
Chromium		;	2 mg/l
Fluorine		;	15 mg/l

Total coli-form bacterium			
	day average	;	3,000 /cm^3
Nitrogen		;	120 mg/l
	day average	;	60 mg/l
Phosphorus		;	16 mg/l
	day average	;	8 mg/l

2) Waste Gas

Chlorine	;	30 mg/Nm^3
Hydro-chloric acid	;	80 mg/Nm^3
Fluorine	;	15 mg/Nm^3
Lead and its compounds	;	10 mg/Nm^3
NOx	;	350 mg/Nm^3
Dust	;	0.7 g/Nm^3
Sulphur oxide	;	K = 5

$q = K \times 10^{-3} \times He^2$

where q = sulphur oxide (Nm^3/hr)

He = height of discharge (m)

10-3 OVERALL SCHEME OF PROPOSED MASTER PLAN

10-3-1 Overall System and Material Balance

The overall material balances for N.W. Banko coal and for N. Suban Jeriji coal are shown in Fig. 10-3-1 and Fig. 10-3-2 respectively.
The utility balance studied for N.W. Banko coal is shown in Fig. 10-3-3 and Table 10-3-1.

Table 10-3-1 Coal and Utility Balance

Coal & Utilities	Unit	Coal Gasification	Methanol & Utility	Electric Power	Coal Mining	Infra-structure
Coal	t/h	316		148	–464	
Electricity	MW	36	75	–111		
IW	t/h	210	3,210	55	500	90
CW	t/h	0	78,170	11,060		
BFW	t/h	330	357	903		
HP Steam	t/h	–	771	–771		
LP steam	t/h	60	196	–256		
Steam condensate	t/h	–56	–910	–189		
Fuel gas	MJ/h	67.4×10^3	-537.9×10^3	470.5×10^3		
Limestone	t/h	8.6		4.5		
Iron scrap	t/h	3.4				
Dirty waste water	t/h	0	–155	–36		
Clean waste water	t/h	–210	–940	–55		
Ash	t/h	0		–9.9		
Slag	t/h	–11				
Overburden	m^3/h				–1,080	

Fig. 10-3-4 shows the utility water system.
HP Steam is consumed to drive steam turbines for air compressors, oxygen compressors and a nitrogen compressor in the Air Separation Plant, and raw gas compressors in the Methanol Plant. LP Steam is mainly consumed by process heaters and deaerators in each plant. Saturated HP Steam (75 kg/cm^2G, 290°C) is by-produced in the Coal Gasification Plant, sent to the Boiler Plant and superheated up to 65 kg/cm^2G, 480°C.

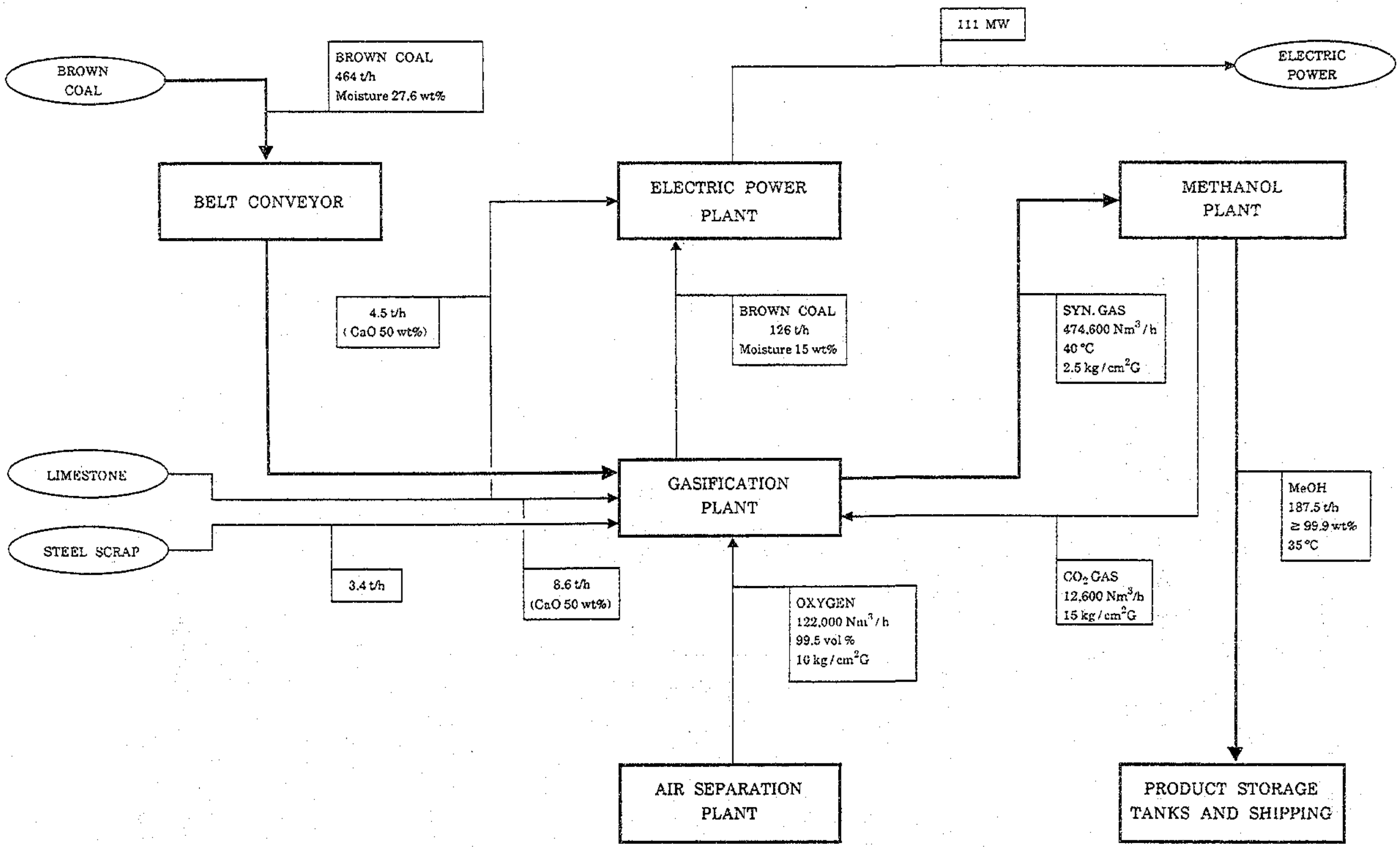


Fig. 10-3-1 Overall Material Balance (for N.W. Banko coal)

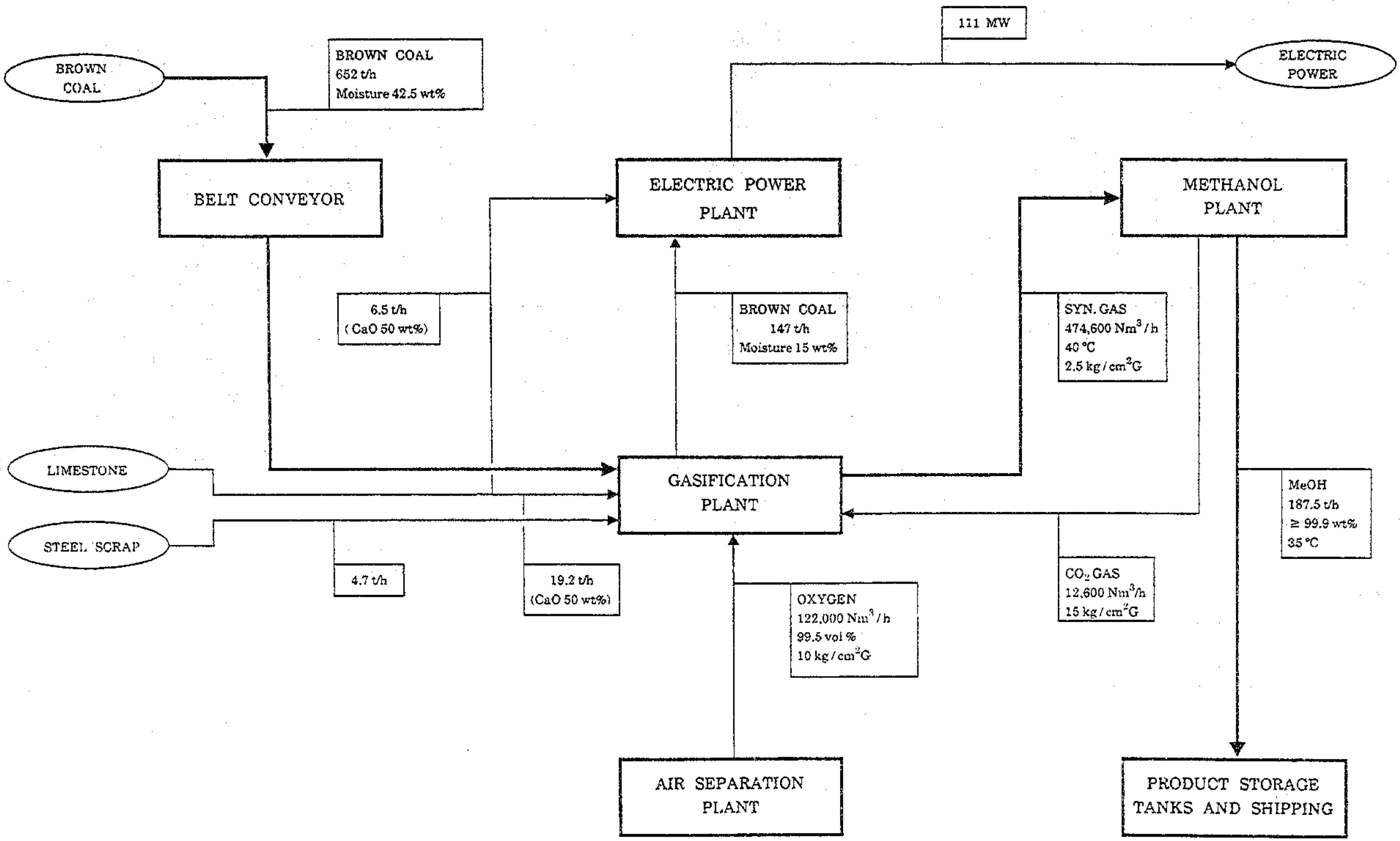


Fig. 10-3-2 Overall Material Balance (for N. Suban Jeriji coal)

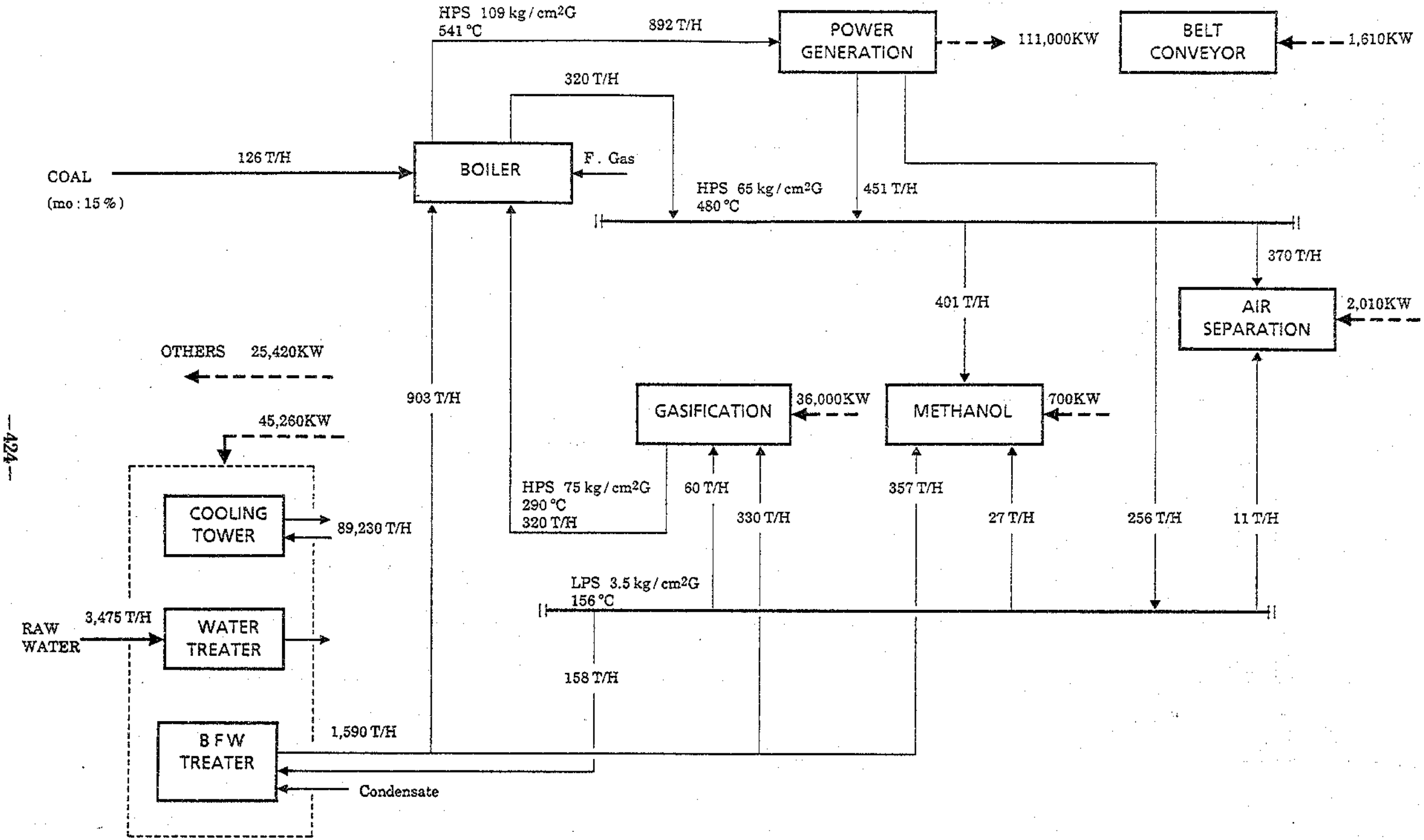


Fig. 10-3-3 Utility Summary

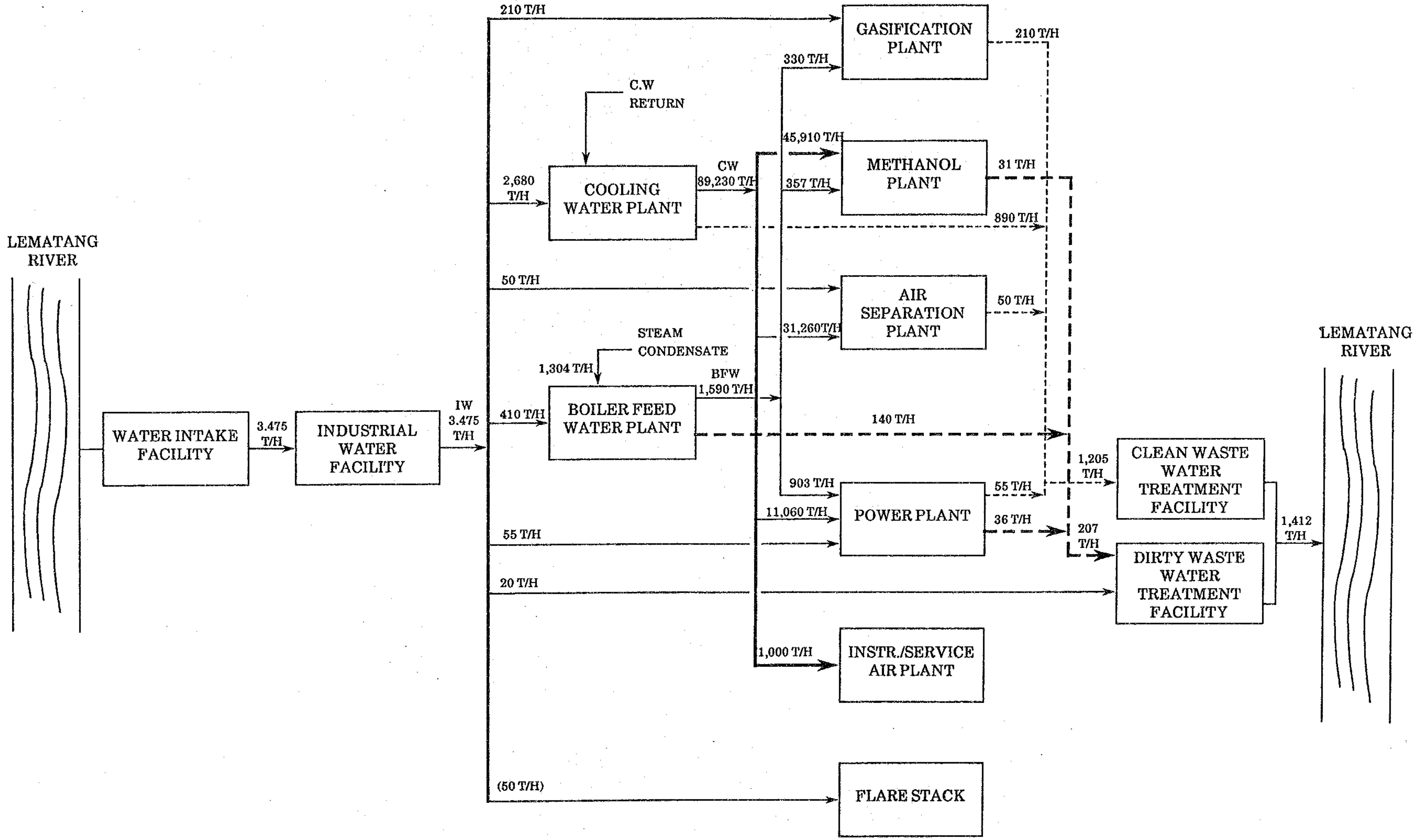


Fig. 10-3-4 Utility Water System

JAPAN INTERNATIONAL COOPERATION AGENCY

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10-3-2 Configuration of the Facilities and Specification of Components

The component facilities for the proposed methanol production complex are shown in Table 10-3-2.

The capacity of one train was determined taking the following factors into account:

i) Maximum transportable weight and size of equipment

ii) Necessity of phased stage construction directed by the product methanol demand build-up

iii) Security of supply of product

iv) Annual maintenance work required

Proposed plant capacity is:

1,500 t/24 hr/train × 3 train × 8,000 hr/year = 1,500,000 t/year

Table 10-3-2 Plant Configuration

1) Belt Conveyor System
   - Primary Crusher/Feeder
   - Overland Coal Conveyor

2) Coal Gasification
   - Coal Storage and Handling
   - Coal Pretreatment
   - Coal Gasification
   - Gas Cooling/Dedusting
   - Calcination

3) Methanol Plant
   - Gas Compression
   - Gas Treating
   - Methanol Synthesis
   - Methanol Distillation

4) Air Separation Plant
   - Air Separation
   - Oxygen Compressor
   - Nitrogen Compressor

5) Utility System
   - Power Generation
   - Power Distribution
   - Steam Boiler
   - Water Cooling
   - Raw Water Intake/Pretreatment
   - Instrument/Service Air Supply

6) Pollution Control/Safety System
   - Waste Water Treatment
   - Solid Waste Disposal
   - Flare Stack
   - Fire Fighting

7) Storage
   - Product Tank
   - Chemicals Tank
   - LPG Tank
   - Fuel Methanol Tank
   - Lubricating Oil Tank

8) Service Facilities
   - Administration Office
   - Laboratory
   - Warehouse
   - Accommodation
   - Cafeteria
   - Leisure Center
   - Mosque
   - Communication System
   - Maintenance Shop
   - Service Water Supply

9) Product Transportation
   - Product Pipeline
   - Booster Station
   - Product Shipping Terminal