THE REPUBLIC OF THE PHILIPPINES

FEASIBILITY STUDY ON COAL-FIRED THERMAL ELECTRIC POWER DEVELOPMENT PROJECT IN LUZON ISLAND

SUMMARY

MARCH 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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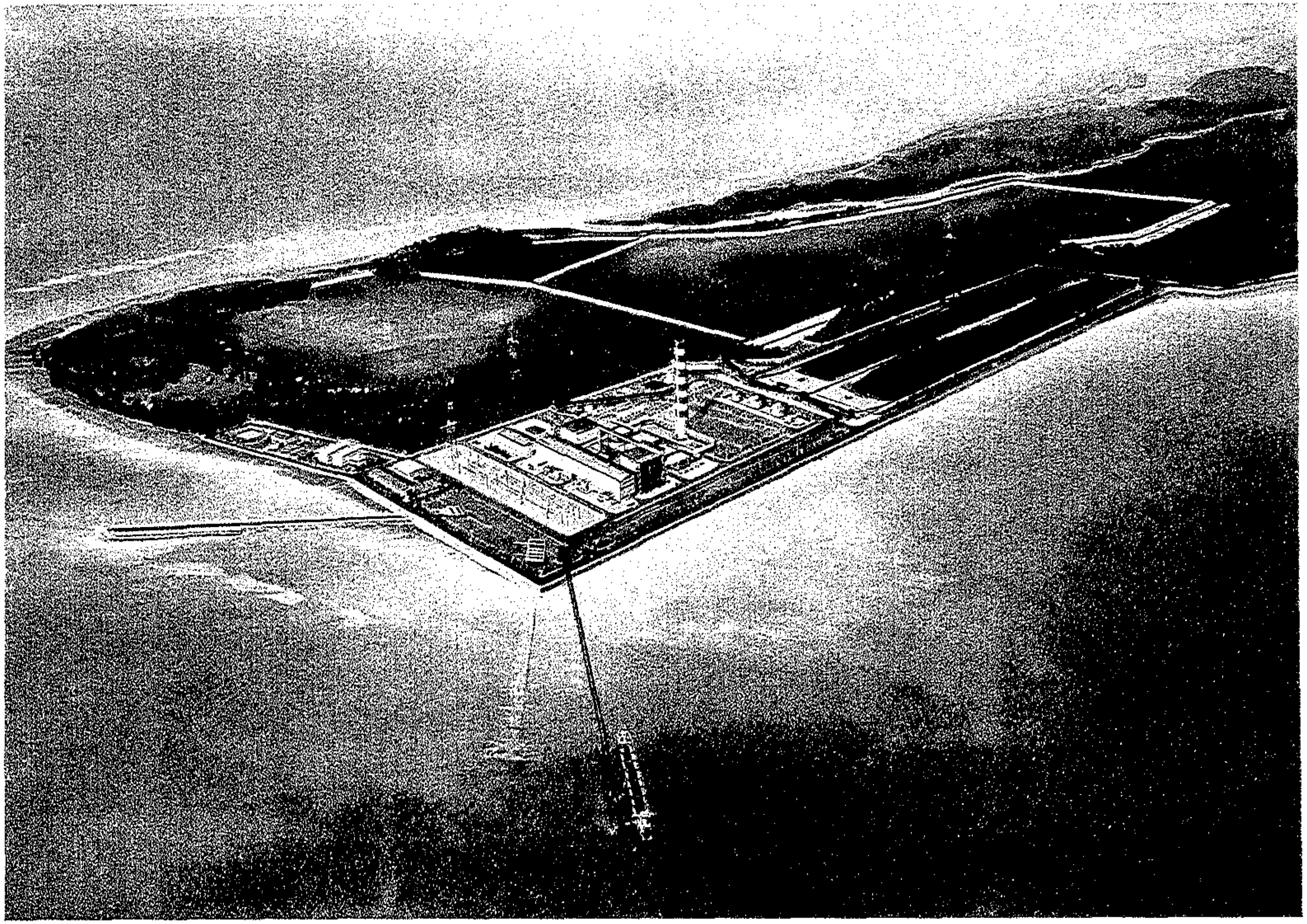
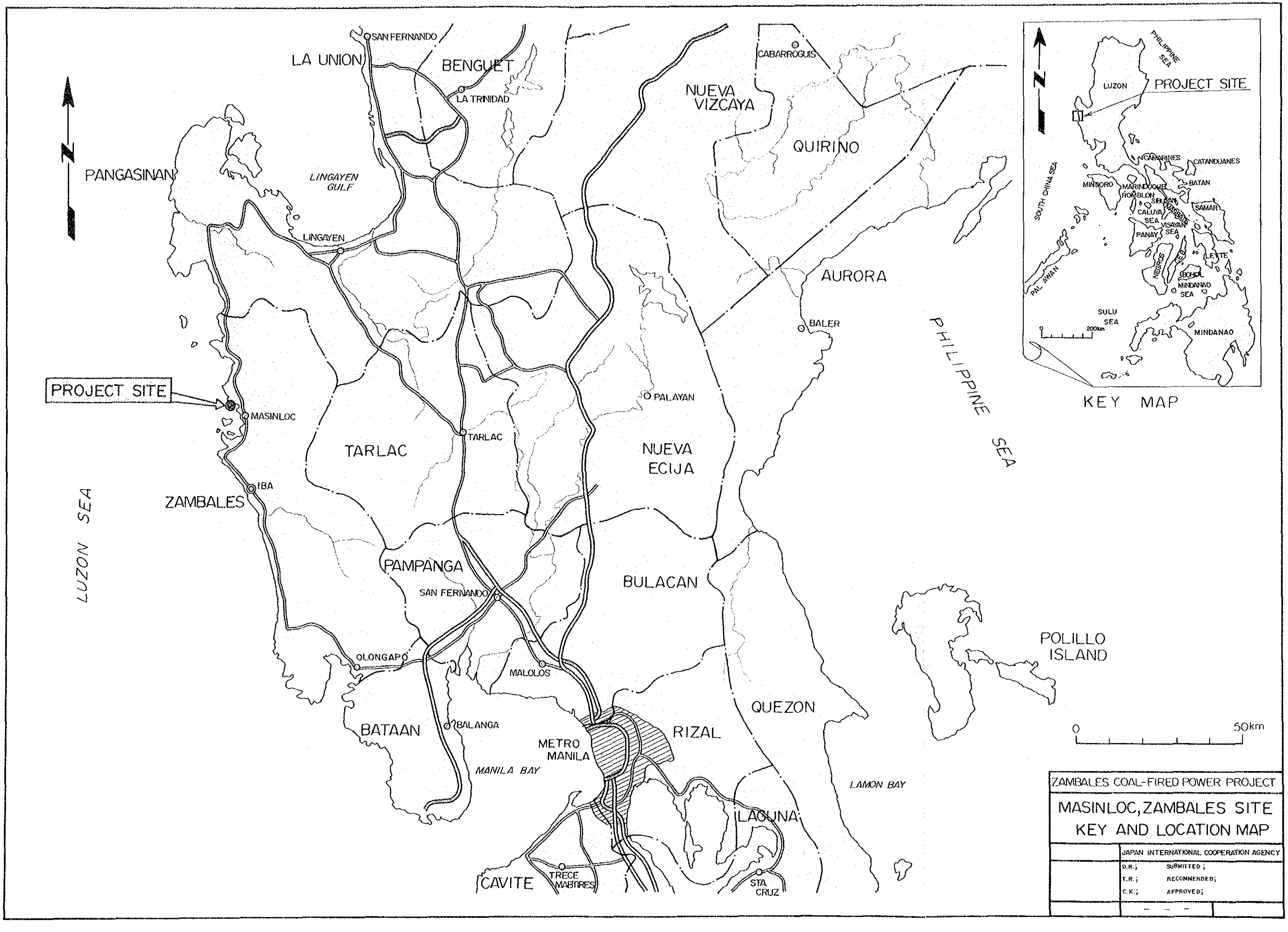
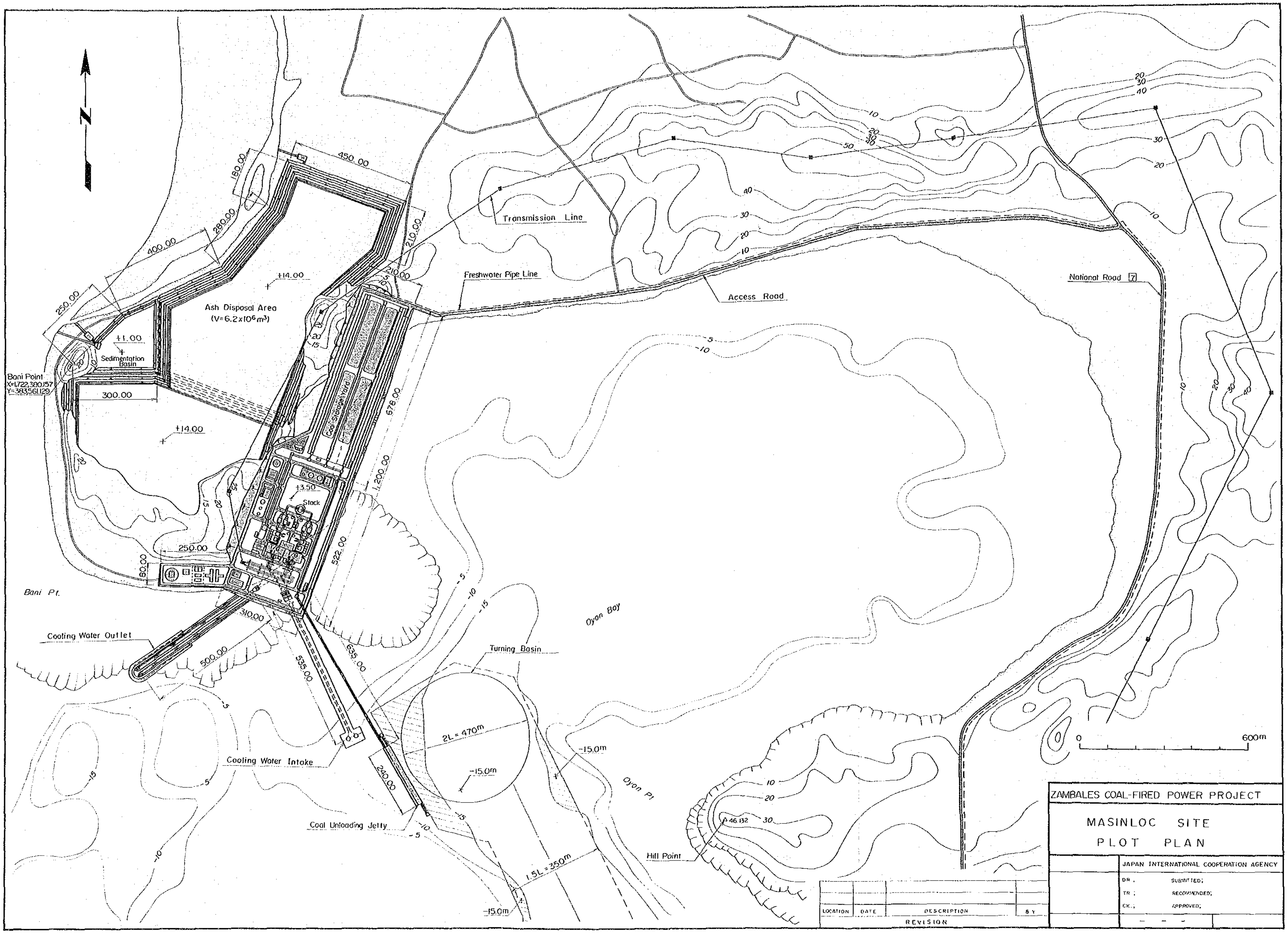
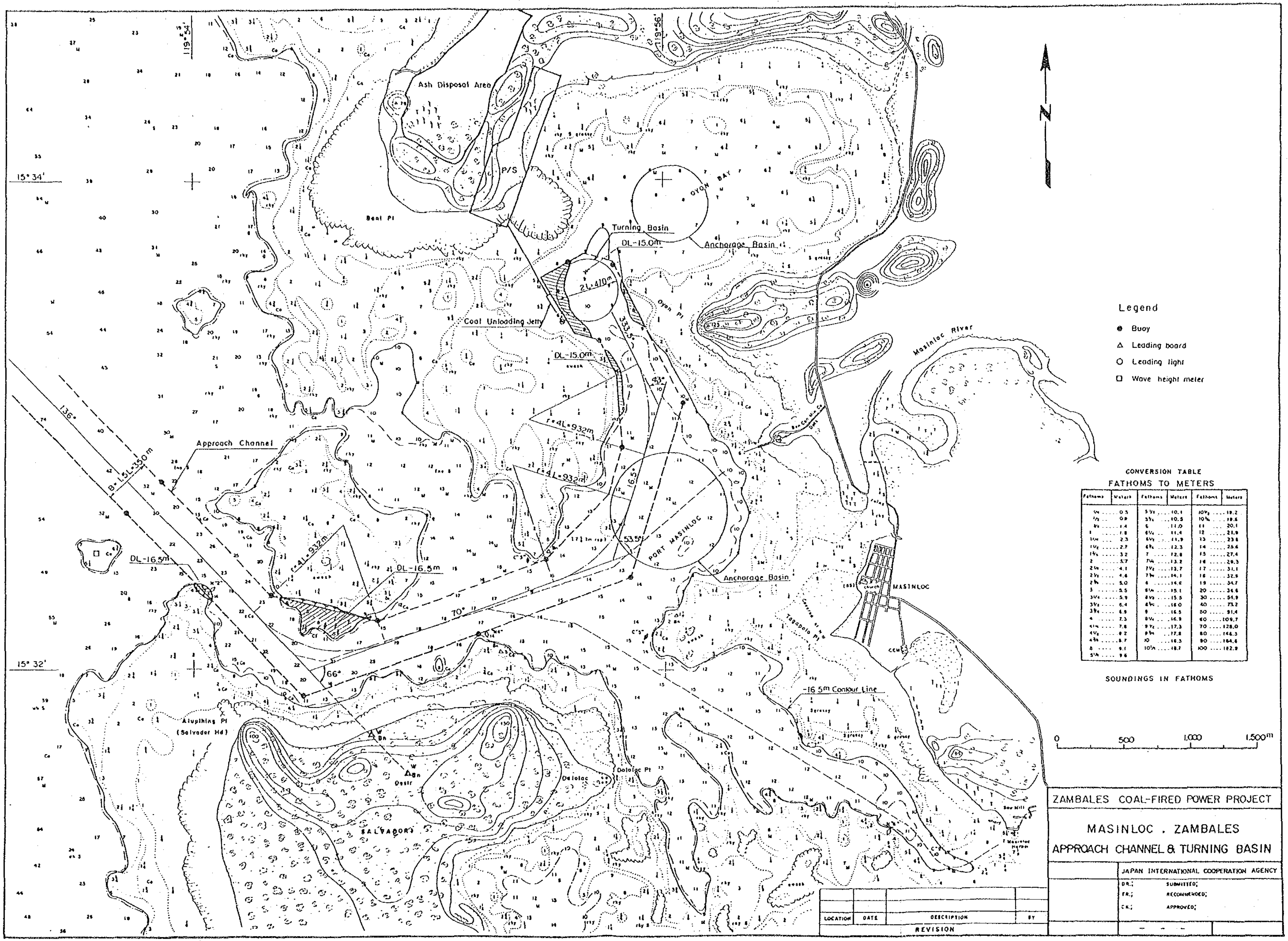


Zambales Coal-Fired Thermal Power Plant



SAN FERNANDO
LA UNION
BENGUET
LA TRINIDAD
CABARROGUIS
NUEVA VIZCAYA
QUIRINO
PANGASINAN
LINGAYEN GULF
LINGAYEN
AURORA
BALER
PHILIPPINE SEA
PROJECT SITE
MASINLOC
PALAYAN
TARLAC
NUEVA ECIJA
IBA
ZAMBALES
LUZON SEA
PAMPANGA
BULACAN
SAN FERNANDO
OLONGAPO
MALOLOS
POLILLO ISLAND
QUEZON
BATAAN
BALANGA
METRO MANILA
RIZAL
MANILA BAY
LAMON BAY
LAGUNA
CAVITE
TRECE MARTIRES
STA CRUZ
0
50km
KEY MAP
LUZON
PROJECT SITE
PHILIPPINE SEA
SOUTH CHINA SEA
CAMARINES
CATANDUANES
MINDORO
MARINDUQUE
BATAN
ROMBLON
SAMAR
CALUYA SEA
VISAYAN SEA
PANAY
NEGROS
LEYTE
BOHOL
MINDANAO SEA
PALAWAN
SULU SEA
MINDANAO
200km
ZAMBALES COAL-FIRED POWER PROJECT
MASINLOC, ZAMBALES SITE
KEY AND LOCATION MAP
JAPAN INTERNATIONAL COOPERATION AGENCY
D.R.;
SUBMITTED;
T.R.;
RECOMMENDED;
C.K.;
APPROVED;


N
450.00
180.00
280.00
400.00
250.00
210.00
210.00
Ash Disposal Area
(V=6.2x10⁶m³)
+14.00
+1.00
Sedimentation Basin
Bani Point
X=1,722,300.157
Y=383,561.129
300.00
+14.00
Coal Storage Yard
678.00
1,200.00
+3.50
Stack
522.00
250.00
60.00
Bani Pt.
310.00
Cooling Water Outlet
500.00
535.00
635.00
Turning Basin
2L=470m
-15.0m
-15.0m
Cooling Water Intake
240.00
Coal Unloading Jetty
1.5L=350m
-15.0m
Oyon Bay
Oyon Pt
Hill Point
46.132
Transmission Line
Freshwater Pipe Line
Access Road
National Road 7
0
600m
ZAMBALES COAL-FIRED POWER PROJECT
MASINLOC SITE
PLOT PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY
DR.:
TR.:
CK.:
SUBMITTED;
RECOMMENDED;
APPROVED;
LOCATION
DATE
DESCRIPTION
BY
REVISION



CONVERSION TABLE

FATHOMS TO METERS

Fathoms	Meters	Fathoms	Meters	Fathoms	Meters
1/4	0.5	5 1/2	10.1	10 1/2	19.2
1/2	0.9	5 3/4	10.5	10 3/4	19.6
3/4	1.4	6	11.0	11	20.1
1	1.8	6 1/4	11.4	12	21.9
1 1/4	2.3	6 1/2	11.9	13	23.8
1 1/2	2.7	6 3/4	12.3	14	25.6
1 3/4	3.2	7	12.8	15	27.4
2	3.7	7 1/4	13.2	16	29.3
2 1/4	4.1	7 1/2	13.7	17	31.1
2 1/2	4.6	7 3/4	14.1	18	32.9
2 3/4	5.0	8	14.6	19	34.7
3	5.5	8 1/4	15.1	20	36.6
3 1/4	5.9	8 1/2	15.5	30	54.9
3 1/2	6.4	8 3/4	16.0	40	73.2
3 3/4	6.9	9	16.5	50	91.4
4	7.3	9 1/4	16.9	60	109.7
4 1/4	7.8	9 1/2	17.3	70	128.0
4 1/2	8.2	9 3/4	17.8	80	146.3
4 3/4	8.7	10	18.3	90	164.6
5	9.1	10 1/4	18.7	100	182.9
5 1/4	9.6				

SOUNDINGS IN FATHOMS

ZAMBALES COAL-FIRED POWER PROJECT

MASINLOC . ZAMBALES

APPROACH CHANNEL & TURNING BASIN

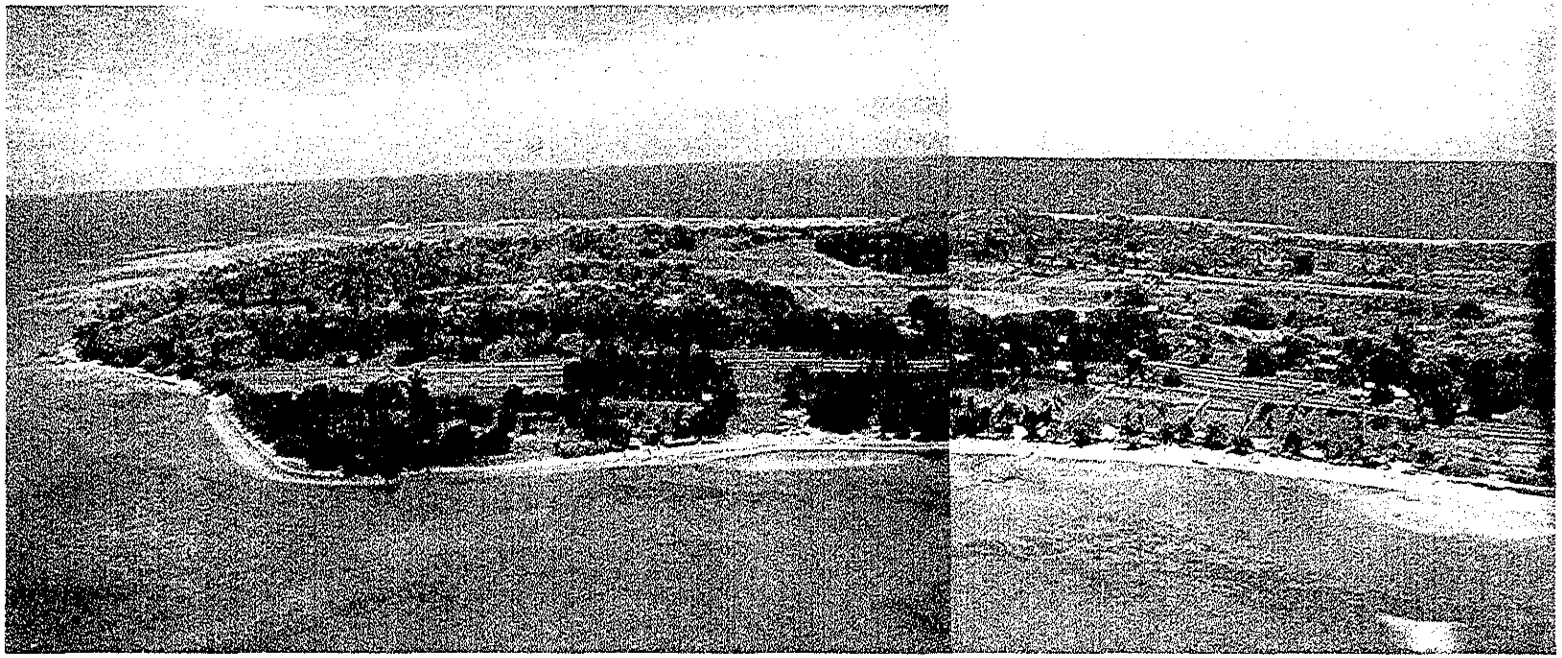
JAPAN INTERNATIONAL COOPERATION AGENCY

DR.: SUBMITTED:
TR.: RECOMMENDED:
CK.: APPROVED:

LOCATION	DATE	DESCRIPTION	BY

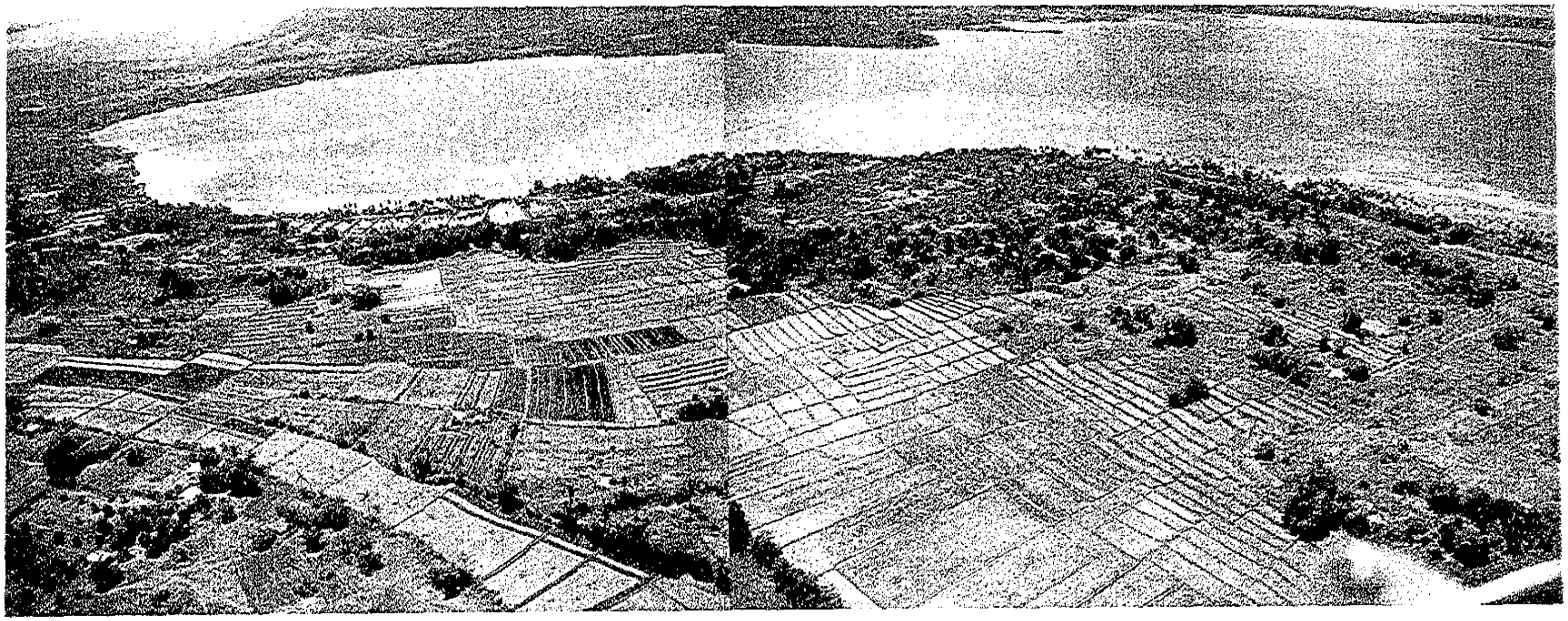
REVISION

SHEET NO. OF



SITE–A Masinloc, Zambales
Bird's-Eye View of the Zambales Site

SITE–A Power Station & Coal Storage Yard



SITE–A In-land Ash Disposal Area & Oyon Bay

COAL-FIRED THERMAL ELECTRIC POWER DEVELOPMENT PROJECT IN LUZON ISLAND

SUMMARY

(Contents)

INTRODUCTION

National Power Corporation (NAPOCOR) requested the Japanese Government in 1988 to conduct a feasibility study for a coal-fired thermal power plant project of 2 x 300 MW for the purpose of promoting electric power development plan in Luzon Island. Japan International Cooperation Agency (JICA) concluded an Implementing Arrangement with NAPOCOR to perform this request of NAPOCOR, and started local work (including site recomnaisance) from March, 1989.

The first stage of this study is site selection from among the three (3) predetermined sites.

The second stage consisted of estimation of the construction cost and construction schedule including preliminary design of the plant facilities as well as performing economic evaluation and financial analysis.

This study is divided into work in the Philippines and work performed in Japan. The local work is undertaken mainly with the cooperation of persons concerned in NAPOCOR.

OUTLINE OF THE PROJECT PLAN

1.	Name of the Project	Zambales Coal-Fired Power Project
2.	Location of the Site	Barangay Bani, Masinloc, Zambales
3.	Installed Capacity	600 MW (2 x 300 MW)
4.	Annual Utilization Factor	70%
5.	Thermal Efficiency	36% (annual average)
6.	Main Fuel	Coal: as design basis, indigenous coal and overseas coal are assumed to be blended 50/50 weight percent. Semirara coal is assumed as indigenous. Lemington coal (Australia) is assumed as overseas coal.

	(Semirara)	(Lemington)
Heat value (as received basis)	4,000 Kcal/kg	6,524 Kcal/kg
Ash Contents	12%	10.39%

7.	Annual Coal Consumption	1,600,000 ton (2 x 840,000 ton/unit)
8.	Coal Storage Capacity	300,000 ton (maximum)
9.	Size of Coal Carrier	60,000 DWT (for overseas coal) 5,000 DWT (for indigenous coal)
10.	Annual Ash Generation	208,000 m^3
11.	Required Site Area	Total: 106 ha.
12.	Required Fresh Water	2,600 m^3/day (maximum)
13.	Cooling Water	25 m^3/sec
14.	Schedule of Taking Over	May, 1996 (No.1 unit) November 1996 (No.2 unit)
15.	Estimated Construction Cost	Total : US$750 million

1. Background of the Project

(1) Economic Background

The economic environment of the Philippines has been rapidly recovering since 1987 and the gross domestic product recorded a growth of 6.6% in 1988. The power demand of the Luzon grid has also been rapidly growing since 1987 and has miraculously grown by 9.2% in 1988. On the other hand, the installed capacity of the Luzon grid is 4,100 MW as of 1988, but the dependable capacity is only about 3,200 MW. Therefore, even if the projects as formulated by NAPOCOR in the Power Development Program (June, 1988) were to be completed as scheduled, an electric power shortage of approximately 125 MW is expected in 1995. It would therefore be necessary to urgently plan for an expansion of the power generating source.

(2) Background of the Request

In 1986, the Philippine government decided to mothball the nuclear power plant. This decision has accelerated electric power shortage condition and NAPOCOR had implemented an emergency measure of employing gas turbines to cope with this predicament. On the other hand, in order to undertake a full scale development of electric power source in accordance with the energy policy, coal-fired power project development was planned in the outskirt of Manila in 1987 and a preliminary study was conducted on several possible sites. As a result, a request was made to the Japanese government to select an optimum site from the three (3) proposed sites located in Masinloc Zambales, San Juan Batangas and Limay Bataan, and to conduct a feasibility study of the development project including preliminary design.

(3) Energy Policy

The energy policy of the Philippines is directed towards the

i) Promotion of energy diversification,
ii) Development of domestic energy resources.

This policy aims to reduce the dependency on oil. Upon the receipt of such policy target, the development plan for the coal-fired thermal power project was aggressively examined in the electric power development plan. It is planned to develop 3,000 MW of coal-fired power project up to the year 2000 in the Luzon grid.

(4) Effects of the Project Development

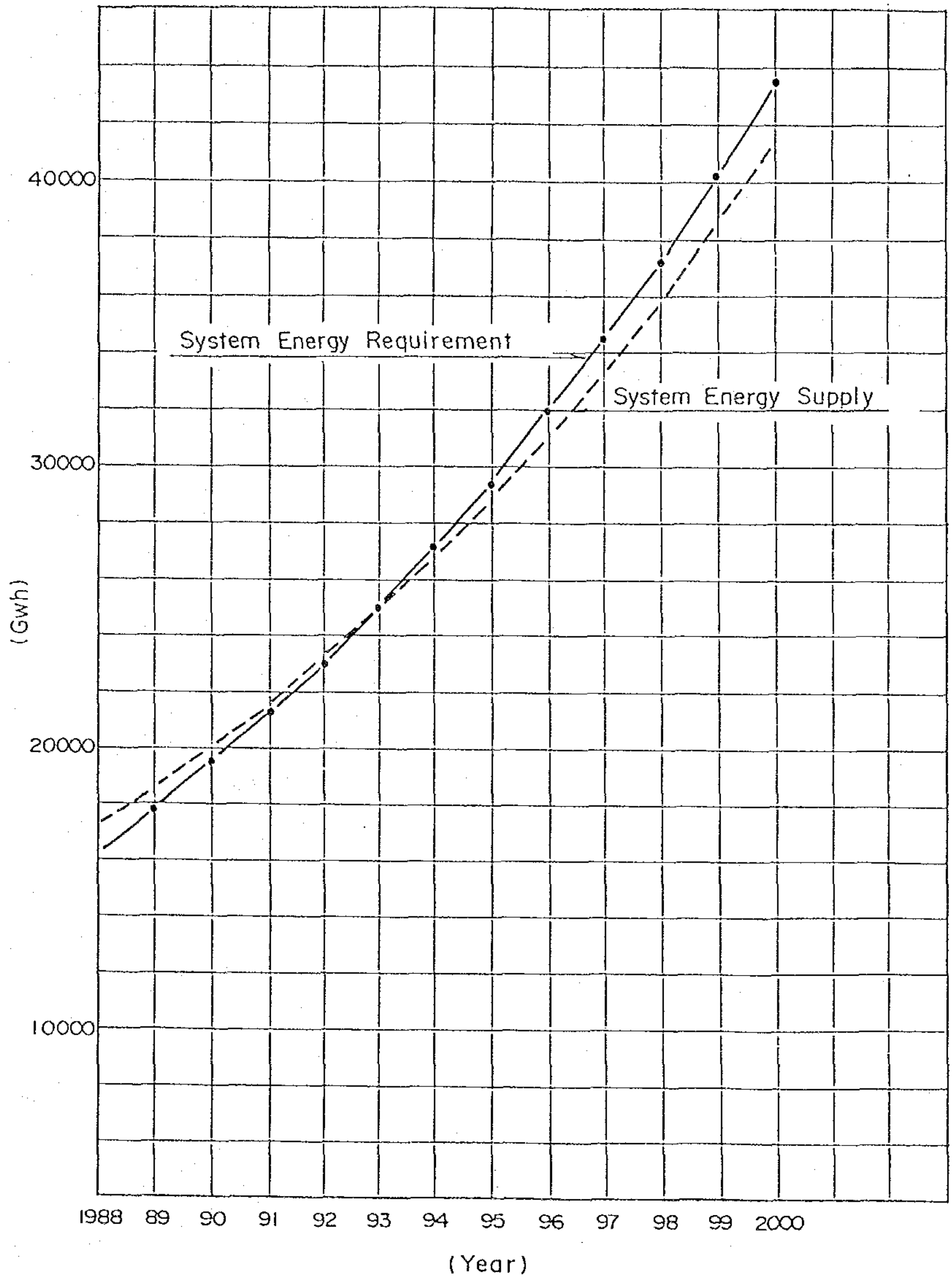
It is generally said that the economic effects created by electric power development are approximately 2.5 times. In this project, the policy is to use indigenous coal, and the impact that this would have on the coal industry is expected to be enormous. At the same time it is intended to use overseas coal to supplement the shortage of indigenous coal. This is expected to stimulate the development of the domestic coal industry. Also, the size of vessels to be used in ocean transportation of overseas coal will also have an influential effect on the local industries. Adjacent to Masinloc where this project is proposed to be located the Coto chromite mine is presently operating and is contributing to the promotion of local industries. Selecting this site for the power plant will require maintaining infrastructure including harbor facilities, specially for Masinloc. This is expected to contribute to the stabilization of the social foundation of the community.

2. Load Forecast and System Analysis

Load forecasting was carried out based on the assumption that all of the plans will be completed as planned. Even in this case, however, electric power supply will become short by about 42 GWh in 1993 and it will be necessary in 1996 to construct new power plants with an output of 713 GWh (equivalent to 160 MW). Luzon Grid Energy Balance is shown in Fig. 2.1.

Power system analysis was carried out based on the assumption that power source development up to 1996 is implemented as planned and the development of 2 x 300 MW units is executed at the Masinloc site. As a result of this analysis, the new transmission line now being considered by NAPOCOR is adequate to transmit 600 MW. From the viewpoint of thermal capacity of conductors of the transmission line, however, it is considered advisable to select conductors having more allowance. Luzon Grid Power Flow in 1996 shows in Fig. 2.2.

Fig. 2.1 Luzon Grid Energy Balance (kWh Balance)



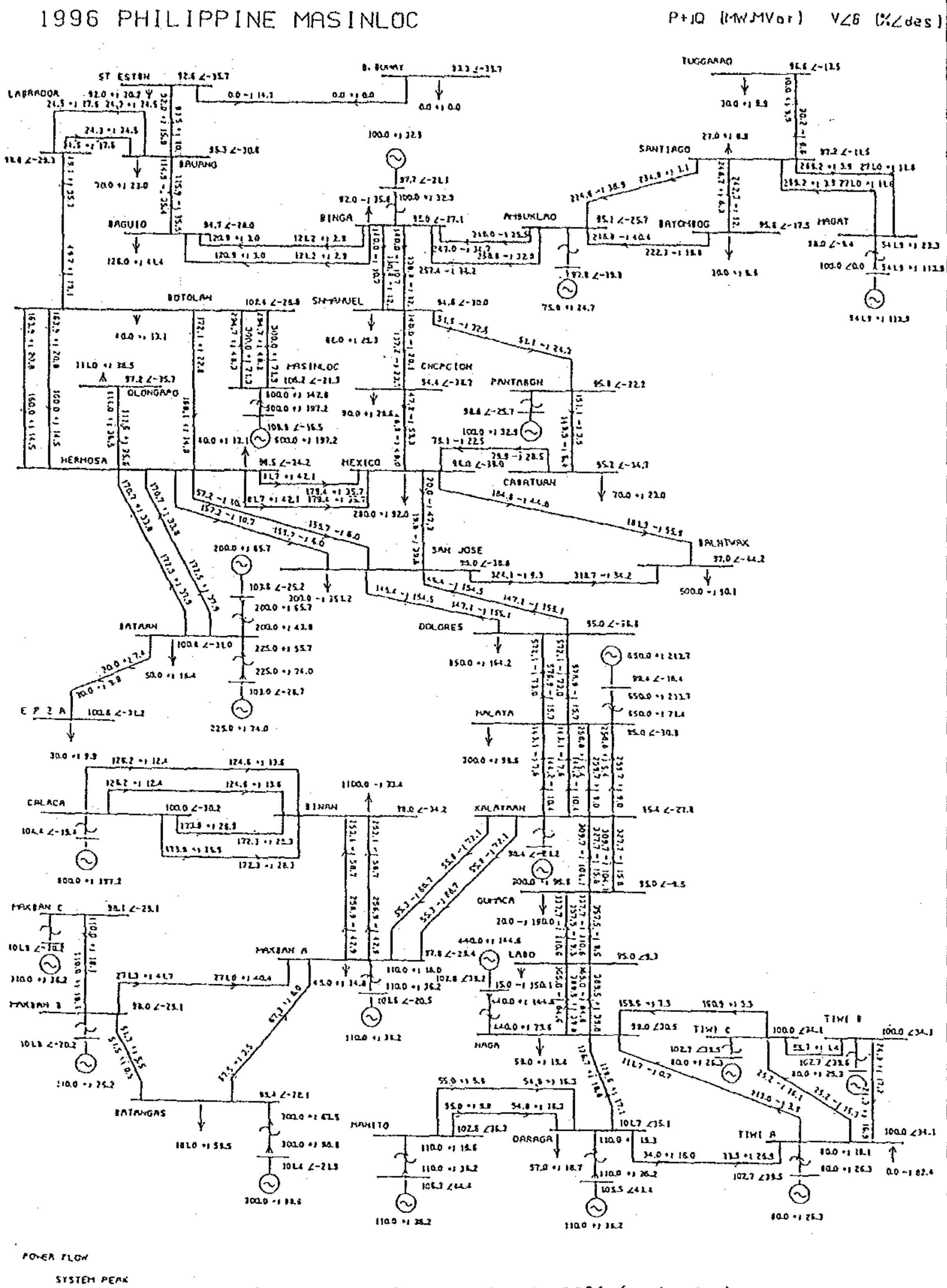


Fig. 2.2 Luzon Grid Power Flow in 1996 (peak time)

3. Site Selection

Many points must be considered in evaluating the suitability of each site for a coal-fired power plant. The main items are

- A sufficient area should be available.
- A good harbor is required for safe accommodation of coal vessels and ease in unloading coal.
- An area must be available for large-scale ash disposal.
- Fresh water must be available.
- The area must have no more than minimum environmental problems.
- A power-consuming area mut be as near as possible.

These items were examined in the first stage of evaluation of listed sites, which led to a general conclusion with regard to the three sites, such as Masinloc Zambales, San Juan Batangas and Limay Bataan. After this evaluation, Masinloc site is recommended for the study of the second stage.

(1) Recommendation of the Masinloc Site

The result of rough cost estimation of three candidated sites are shown in the following table with the form of comparison to Masinloc site with in-land ash disposal system. Based on the layout of each sites, the calculatioin carried out only the difference in characteristics and conditions of site.

(Unit: 1,000$)

Site	Masinloc	San Juan	Limay
In-land ash disposal system	Base	Base +23,200	—
Off-shore ash disposal system	Base +36,900	Base +78,400	Base +41,000

The present study dealt with the feasibility of 2 x 300 MW coal-fired power plants. Though not satisfactory in every aspect, the Masinloc site is the best place from the economic point of view.

The main reasons the other proposed sites and development plans are inferior to the Masinloc site with in-land ash disposal are as follows:

(a) Off-shore ash disposal entails high construction cost of revetment of ash disposal area.

(b) At San Juan site a long break water in around twenty meters deep water must be constructed.

However, the other two sites are also suited for power plant construction. Further studies on fuel, harbor, and environmental problems are necessary for establishing power development plans suited for the sites.

(2) Feature of the Masinloc Site

(a) The advantages of the Masinloc site is the availability of adequate power plant area, good geologic condition, and calmness of the harbor area. The major problem is an extensive coral reef, which might be an obstacle to the port plan. Other problems include the availability of fresh water and the length of transmission line; these are not, however, critical to influence the feasibility of the project.

(b) The major problem in the port plan is that a winding sea channel will need to be planned. This raises such issues as the following:

- Ensure safe navigation of vessels.
- Sea casualty would, until its complete settlement, interrupt coal delivery.

The following measures must be taken to overcome these problems:

- Deployment of tugboats
- Providing sufficient navigation signals
- Preparing good sea channel
- Assuring sufficient coal-storage capacity

4. Selection and Procurement of Coal

The energy policy of the Republic of the Philippines emphasizes the diversification of energy and the efficient utilization of domestic resources. According to this policy, the coal-fired thermal power project for the Masinloc site has been formulated with the object of using indigenous coal as much as possible. This fuel issue is one of the major themes in this study. In general, the fuel condition should be decided at the beginning of a coal-fired thermal power project plan. These include the source and the properties of the coal. However, the present study had only the policy set forth, and the specific contents remain to be examined at the study stage. This had considerable influence on the study of the plant layout and the preliminary design of the facilities.

The fuel issues will be discussed in following three categories.

(1) Demand and Supply of Indigenous Coal

The first issue is to obtain the supply and demand forecast for indigenous coal. In 1987, JICA conducted a series of studies to prepare a master plan on the future of coal mining in the Philippines. Therefore, the study of indigenous coal issue can be based on this JICA report.

There are about 40 coal mines in the Philippines. These coal mines now operating or will start operating in the near future. These mines were screened from two standpoints.

- Production capability
- Demand source

Summary of Coal Mines

(Unit: tons)

Sel No.	Coal Mine	Area	Production (as 1988)	Main Consumer
1.	Semirara	Simirara	670,181	NAPOCOR
2.	Maoangas	Mindanao	210,932	Cement Industry
3.	Uling	Cebu	18,836	Atlas, Ludo & Luym
4.	DMC-CERI (Bislig)	Mindanao	77,807	NAPOCOR (Naga)
5.	Piedra Negra	Mindanao	2,384	
6.	ZAMBOCO	Mindanao	4,558	
7.	FF CRUZ	Mindanao	7,563	
8.	ACRI-BATAN	Batan	6,710	Surigao Cement
9.	BICOL	Batan	19,879	MMIC etc.
10.	PMI	Batan	15,655	LUDO, MMIC, etc.
11.	CARBEX	Batan	27,432	Atlas, Rizal, NPC
12.	Pilipino Cathay	Pilillo	9,888	Cement Industry
13.	Hercules	Masbate	11,802	Atlas
14.	Aznar	Cebu	9,393	APOCEMCO
15.	J.D. Almendras	Cebu	47,854	NAPOCOR (Naga), Atlas, etc.
16.	R.M. Durano	Cebu	8,997	Cement in Cebu
17.	Adlaon	Cebu	17,183	Atlas etc.
18.	Cebu Coal	Cebu	26,291	NAPOCOR (Naga), APOCEMCO

The Semirara Coal Mine is assessed to have the largest supply capacity of all the mines that can be tapped for this project. The supply capability of other coal mines are not adequate. Therefore, when examining supply and demand, the result will not be greatly affected even if attention is directed to Semirara Mine only.

The Semirara Coal Mine has three pits. The Unon pit presently supplies coal to Calaca No.1 but the possibility of increased production is small. This means that a new pit at Himalian or Panian must become the coal source for the Zambales power project. As a result, production from the new pit is predicted to be feasible by the time this project is commissioned.

The quantitative balance of indigenousd coal available to the Zambales project was estimated and the results are shown in the following tables.

Total Demand & Supply Balance in the Philippines

(unit, 10,000 Btu/b, 1,000 t)

	1989	1990	1991	1992	1993	1994
Demand	2,597	2,631	2,688	3,642	3,659	3,939
Supply	1,342	1,415	1,495	2,232	2,651	2,811
Shortage	1,255	1,216	1,173	1,410	1,006	928
Self sufficiency Ratio (%)	51.7	53.8	56.0	61.3	72.5	75.2
	1995	1996	1997	1998	1999	2000
Demand	3,839	4,882	6,863	8,853	10,852	12,862
Supply	2,981	3,111	3,253	3,410	3,714	3,991
Shortage	858	1,771	3,610	5,443	7,138	8,871
Self sufficiency Ratio (%)	77.7	63.7	47.4	38.5	34.2	31.0

Demand & Supply Balance of Coal in Luzon Grid

(unit, 10,000 Btu/b, 1,000 t)

	1989	1990	1991	1992	1993	1994
Demand in Luzon Grid	930	930	930	1,860	1,860	1,860
Supply	609	609	609	609	1,257	1,473
Shortage	321	321	321	1,251	603	387
Self sufficiency Ratio(%)	65.5	65.5	65.5	32.7	67.6	79.2
	1995	1996	1997	1998	1999	2000
Demand in Luzon Grid	1,860	2,790	4,650	6,510	8,370	10,230
Supply	1,473	1,473	1,473	1,473	1,473	1,473
Shortage	387	1317	3,177	5,037	6,897	8,757
Self sufficiency Ratio(%)	79.2	52.8	31.7	22.6	17.6	14.4

As seen in this Table, it is difficult to depend 100% on indigenous coal sources to supply the new coal-fired thermal power plant. Indigenous coal cannot supply more than half of the plant's demand.

The shortage must be procured from overseas sources. This is the essence of the first issue.

(2) Decision on Design Coal

The second issue is the selection of an overseas coal source to compensate the domestic shortfall.

This overseas coal selection is closely related to selection of the design coal, or the decision on the fuel properties that are applied to the boiler design.

There are many overseas coal sources. To screen them as a supply source for this project, it is first necessary to decide on the standard properties of coal for the plant design.

When EPDC, one of the utilities in Japan, planned and built the first power plant using imported coal in Japan, various kind of overseas steaming coals were used for about ten years, and data concerning these coals were accumulated. They have established their coal property criteria to apply to coal they purchase from abroad. Detailed property of the criteria is described in the Report.

According to this standard, Lemington (Australia) coal was selected from the seven types indicated by NAPOCOR, mainly to make up for the shortcomings of Semirara coal. Lemington and Himalian of the Semirara Mine are included in the preliminary design. In the future, when NAPOCOR set up its procurement strategy of overseas coal, it is important to select types with properties are equal or superior to the design properties.

Design Coal Property

Item		Semirara Himalian Clean Coal	Lemington Coal	50/50 Blended COAL
Proximate Analyisis	(A/R Basis)			
Heating Value	Kcal/kg	4,000	6,524	5,262
Total Moisture	%	29.00	9.77	19.39
Fixed Carbon	%	28.80	49.80	39.30
Volatile Matter	%	30.20	30.05	30.13
Ash	%	12.00	10.39	11.20
Total Sulfur	%	0.60	0.49	0.55
Fuel Ratio		0.95	1.66	1.31
Grindability	HGI	35	50	41.94
Ultimate Analysis	(Dry Basis)			
Carbon	C %	59.15	69.30	64.82
Hydrogen	H %	1.92	4.50	3.36
Oxygen	O %	19.62	12.60	15.72
Nitrogen	N %	1.02	1.60	1.34
Sulfur	S %	1.32	0.50	0.86
Fluorine	F %	-	-	-
Chlorine	Cl %	-	-	-
Ash	A %	16.90	11.50	13.87
Ash Composition	(Dry Basis)			
	SiO_2 %	45.53	72.80	58.17
	Al_2O_3 %	20.01	11.60	16.11
	Fe_2O_3 %	7.49	4.20	5.96
	CaO %	7.49	2.20	5.03
	TiO_2 %	0.87	0.20	0.55
	MgO %	4.16	0.20	2.32
	SO_3 %	6.68	1.40	4.23
	P_2O_5 %	0.25	5.60	2.73
	Na_2O %	5.45	0.20	3.01
	K_2O %	1.34	0.60	0.99
	BaO %	0.15	-	-
	SrO %	0.18	-	-
Ash Fusion Temperature				
	IDT ℃	1070-1560+	1240	1148-1411
	ST ℃	1100-1560+	1340	1211-1457
	HT ℃	1110-1560+	1400	1244-1485
	FT ℃	1110-1560+	1480	1281-1522

(3) Overseas Coal Procurement Strategy

The third issue is the strategic aspect for overseas coal procurement in NAPOCOR.

The west coasts of Canada and the United States, and Colombia, Australia, Indonesia and China -- these countries forming the Pacific rim countries with the Philippines in the center -- are known for their production of superior steaming coal in terms of both quality and quantity.

From this consideration, the Philippines is in an advantageous position for the importation of the coals.

The following Table shows same sources which are available for procurement of coal.

Information of Overseas Coal

Source	Total Moisture (%)	Ash (%)	VM (%)	Heating Value (kcal/kg)	Sulfur (%)	Production (million ton
(Australia)						
Work Worth	8	15 max	29.0	6,850	0.6	3.2
Lemington	8	14	31	6,700	0.8	3.0
Ulan	9 - 10	17	31.5	6,950	0.8	6.3
R.W. Miller	8	20 max	30 - 35	6,350	1.0	5.5
Lithgow	8	10	32.5	7,260	0.6	8.2
Blair Athol	16.0	8.0	27.2	6,520	0.3	5.5
(China)						
Datong	8 max	10 - 20	25 min	6,800	1	12.9
Ping Shou	8	13.3	32.3	6,586	1.13	-
(Indonesia)						
Kaltim Prima	9.5	4	39	7,100	0.5	up to 6
Belau	23.9	1.8	38.6	5,790	1.28	
(U.S.A.)						
Sky Line	9.5	8.5	40	6,950	1.0	2.0
Pinnacle	7.01	10.69	36.77	6,789	0.56	1.5
Bull Mountain	13.24	6.64	35.02	6,358	0.57	0.5
(Canada)						
Coal Vallet	10.0	10	35	6,350	0.25	2.0
Quinsam	10	12	38.5	6,800	1.0	0.1
(Colombia)						
El Cerrejon	11	8.25	33.8	6,500	0.7	9.4

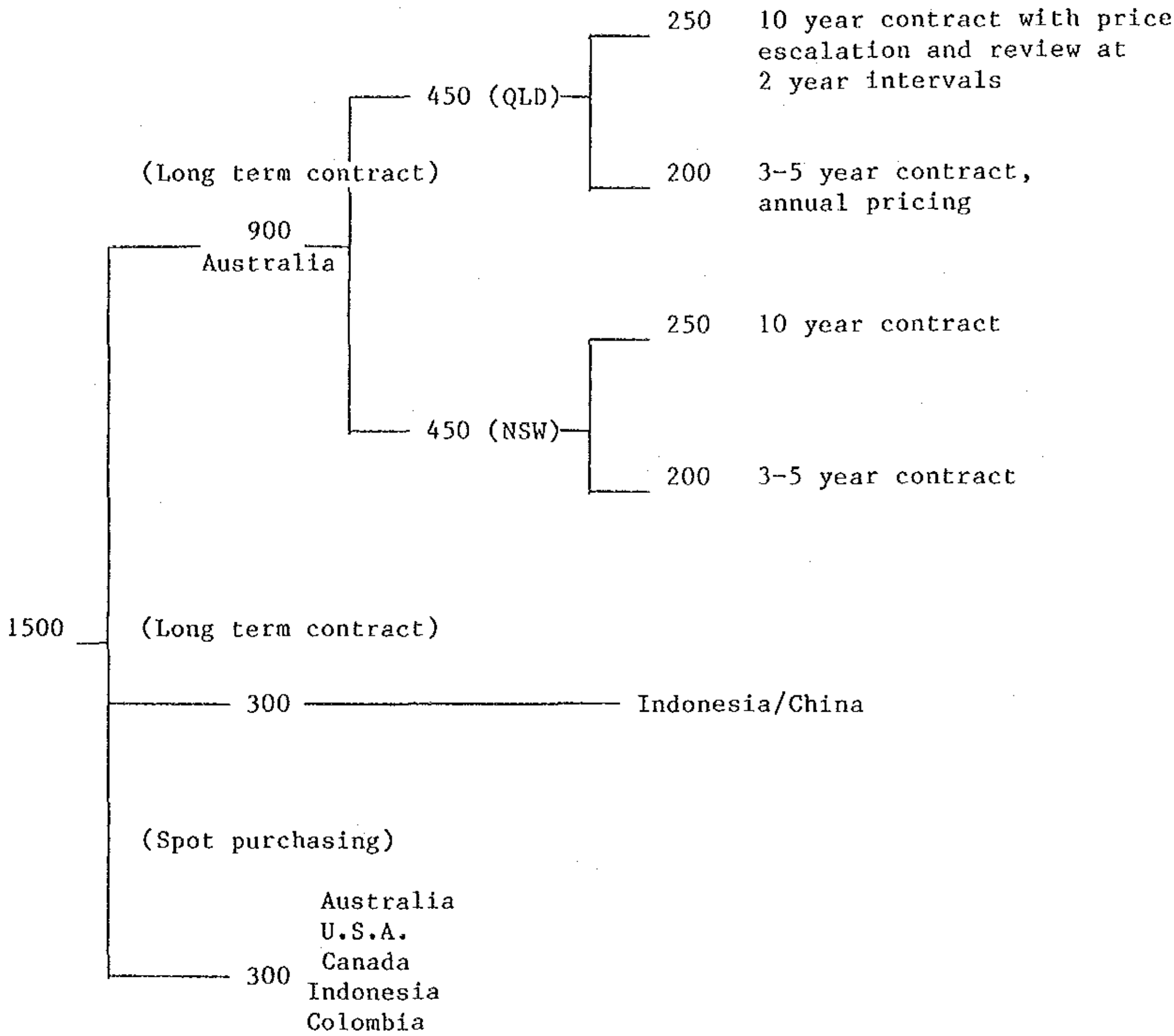
What strategy should be adopted for selection from these coal source fit for the project? This question is considered based on our experience. NAPOCOR plans to install 3,200 MW coal-fired thermal power project up to the year 2000. The required amount of overseas coal will reach to about 7 million tons. To import coal of such a volume, it is necessary to establish a procurement strategy, map out a procurement plan based on this strategy, and import according to the plan.

It is desirable that the electricity cost should be of a stable structure over a long period. This means that the generation cost will remain unchanged as much as possible. In other words, the fuel charge should remain stable. Fuel procurement for power plant extends over a period of 20 to 30 years. On the other hand, coal market conditions flactuates by many factors. This is easily understandable by the situation caused by the oil crisis of 1978. Although not so violently as in those days, coal prices changed incessantly according to the rule of supply and demand. To minimize the adverse effect of changing prices, it is necessary to seek price stability under long-term purchase contract. Another point of note is that electric power demand is also unstable. To provide favorable flexibility in accommodating fluctuations in demand, it is necessary to prepare for procurement of a certain portion (10% - 15%) of the total on a spot purchase contract basis.

The long-term vs spot contract ratio is shown in relation to total procurement in tons as an example.

An Idea of Combination of Coal Purchasing

(unit 1,000 t)



(Note) QLD: State of Queensland
NSW: State of New South Wales

Marine transportation is another important issue in overseas coal procurement along with procurement of coal. Shipping contracts are also divided into long-term and spot contracts. The long-term contract will have a certain vessel or type of vessel exclusively available for transport over several years. The distinctive feature of this type of contract is that it enables setting a stable freight rate unaffected by market conditions. A spot contract is based on the quantity of coal to be transported, leaving the freight rate to prevailing conditions. In order to maintain stable electricity cost, a procurement system should be adopted that mainly depends on long-term contract but leaves room for spot contract to flexibly cope with changes in power demand.

It is thus necessary to establish the most favorable coal procurement strategy for NAPOCOR by paying constant attention not only to coal market conditions but also to maritime market. To attain this objective, it is essential to train experts and set up a procurement organization as early as possible.

5. Outline of Generating Facilities

(1) Present Status of the Site

1) Topography

The project site is located at Bani Point. The vicinity of Bani Point, Oyon Bay east of the site, is surrounded by land and forms a small semi-enclosed shore-area. The southern off-shore area of the site is dominated by well developed reef-shoal and Salbadole island. The western part of the site is South China sea.

The topography of the site consists of gently sloping hills which are 15 to 25 m above sea level along Oyon Bay. The Lawis river and the Masinloc river flow in the vicinity of the site.

A national road runs approximately 2.6 km east of the site.

There are two harbors, Port Masinloc and Masinloc Harbor, in Oyon Bay. At the present, smaller than 40,000 DWT bulk carriers are entering Port Masinloc.

2) Climate and Maritime Weather

The main data of climate and maritime weather of this site are as follows: (average values)

Temperature	:	27°C
Annual average rainfall	:	3,700 mm
Prevailing wind	:	Speed 2 m/s
		Direction NE to E and NW
Wave height at South China Sea	:	Approx. 85% of wave have a wave height of 2 m or less
Tidal difference	:	1.3 m

(2) Layout

Regarding the layout of equipment in the power station, it is desirable that a series of flow from the acceptance of fuel up to the transmission line should be laid out rationally. However, it is common that they cannot be laid out ideally due to the influence of the characteristics of the site, topographic condition, etc. Thus, the characteristics of the site and geological condition should normally be considered first and studies should be made to obtain a rational layout.

Also, several systems are considered for the layout of equipment within the power station bearing in mind reduction in construction cost as well as ease of maintenance .

1) Power plant and coal storage yard

The power plant and the coal storage yard is placed on the eastern side of Bani Point in order to lessen effects of waves and winds. The power house is located on sound ground to the south of the coal storage yard, and to shorten the length of cooling water pipes.

2) Cooling water facilities

The condenser cooling water (25 m^3/s) is taken in and discharged into the same bay area.

In order to prevent recirculation of thermal effluents, sufficient distance (800 m) is maintained between the intake and the outlet.

The intake is located at the entrance of Oyon Bay, where influences of waves are small.

The outlet is extended to about 300 m off the shore line, where the water depth is deep.

3) Port facilities

The coal unloading jetty is arranged at the entrance of Oyon Bay to maintain required calmness at the harbor using damp-effect of the shoal to the waves.

The approach channel for coal vessels is the existing approach channel from the open sea to Port Masinloc and then to take a course along the deepest water from Port Masinloc to the jetty.

4) Other facilities

The ash disposal area is placed at the low-lands on the western side of the power plant from an economic view point.

Fresh water required for the power plant can be taken from the Masinloc River.

(3) Main Items of Generating Facilities

1) Coal handling facility

It is necessary to incorporate in the plan, in consideration of receiving overseas coal, the capacity of coal handling facilities (e.g., unloader, coal yard, conveyor, stacker, reclaimer). For this purpose, the plan for facilities has been optimized by simulation. The coal yard is designed to receive and discharge coal by stacker and reclaimer. It is thought that this system is advantageous compared to using bulldozer in order to mitigate dispersion of dust and generation of noise.

2) Selection of design coal

By selecting the blending ratio between indigenous coal and overseas coal to be 50/50 weight percent, it will improve the degree of utilization of indigenous coal as well as improve the economy of boiler design, coal storage capacity, and ash disposal area.

3) Advantageous steam condition

Regarding steam conditions, 169 kg/cm^2 and 538/538 degrees have been selected considering economic life (30 years) of the power station and ease of maintenance.

4) Steam-turbine composition

It is a recent tendency to adopt 1 casing for low-pressure casing of turbine of 300 MW class. It allows total economy to be improved.

5) Pre-boiler arrangement

As a result of studies for improving efficiency, the number of extraction stages of the turbine is 8.

6) Electric facility

Based on the results of the system analysis, short-circuit ratio and power factor of the generator are selected as 0.58 and 0.9 respectively.

6.9 kV motors for the power station are recommended. This will enable the motors to be compact and reduce the cost of cables.

Outline Description of Generating Facilities

1. Basic Factor of Design

(1)	Installed Capacity	600 MW (2 x 300 MW)	
(2)	Annual Utilization Factor	70%	
(3)	Thermal Efficiency	36.0% (annual average)	
(4)	Station Service Factor	7.5%	
(5)	Main Fuel (coal)		
		(Semirara coal)	(Lemington coal)
	Heating value (as received basis)	4,000 kcal/kg	6,524 kcal/kg
	Ash contents	12%	10.39%
	Blending ratio	50%	50%
(6)	Annual Coal Consumption	1,680,000 ton (840,000 ton x 2)	
(7)	*Coal Storage Capacity*	*300,000 ton (maximum)*	
(8)	Vessel Size	60,000 DWT (for overseas coal) 5,000 DWT (for indigenous coal)	

2. Land Reclamation

(1)	Site Area	Total	106 ha
		Power station	18 ha
		Coal yard	15 ha
		Ash disposal area	31 ha (for 10 years)
(2)	Site Formation Level	DL + 3.5 m	

3. Port Facilities

(1)	Coal Unloading Jetty	Length	240 m
		Width	25 m
		Depth	15 m
(2)	Approach Channel	Length	5,500 m
		Width	350 m
		Depth	16.5 m

4. Coal Handling and Storage Facilities

(1)	Coal Unloader	Bucket-chain type continuous unloader
	Capacity	2 x 700 t/h
(2)	Stacker	1 x 1,600 t/h

(3) Reclaimer	2 x 800 t/h
(4) Coal Storage Capacity	300,000 ton 150,000 ton (indigenous) 150,000 ton (overseas)

5. Fuel Oil Storage Tank

(1) Heavy Oil Tank	2 x 4,000 kL
(2) Light Oil Tank	1 x 1,000 kL

6. Fresh Water Supply System

(1) Quantity	2,600 m^3/day (max)
(2) Fresh Water Tank	1 x 10,000 m^3

7. Boiler System (per unit)

(1) Boiler	Single drum, outdoor type
Evaporation	(MCR) 990 t/h (ECR) 930 t/h
(2) Induced Draft Fan	2 x 16,000 m^3N/min
(3) Forced Draft Fan	2 x 6,390 m^3N/min
(4) Coal Pulverizer	5 x 41 t/h

8. Turbine System (per unit)

(1) Turbine	Tandem compound, reheat, regenerative condensing turbine	
Rated output (at generator end)		300 MW
Steam condition (at MSV)	Pressure	169 kg/cm^2g
Steam temperature	Temp. (MSV)	538°C
	(RSV)	538°C
Rotating speed		3,600 rpm
(2) Condenser		
Cooling seawater temperature (design)	Inlet 31°C Outlet 39°C	
Cooling seawater quantity	41,500 m^3/h	

(3) Condensate Pump — 3 x 390 t/h

(4) Boiler Feed Water Pump — (Motor driven) 3 x 520 t/h

9. Condenser Cooling Water Facilities

(1) Intake

Type	Deep Water Intake
Dimension	2 sets x 9.0 m

(2) Intake Pipe Line

Type	Embedded steel pipe
Dimension	Inner diameter 3 m Length (mean) 2 lines x 530 m

(3) Intake Pump Pit

Type	Reinforced concrete structure
Dimension	Width 24.6 m Height 12.7 m Length 35.0 m

(4) Outlet Pit

Type	Reinforced concrete structure
Dimension	Width 12 m Height 10.5 m Length 25 m

(5) Outlet

Type	Rubble stone revetment
Dimension	Width 12.0 m Height DL + 3.0 m Length 500 m

10. Electrical Facilities (per unit)

(1) Generator

i) Type — Indoor type, horizontal shaft, 3 phase, hydrogen-cooled

ii) Rating

Generator output	334,000 kVA
Voltage (according to manufacturer's standard)	18 to 24 kV
Power factor	90%
Short circuit ratio	0.58

iii) Exitation — Thyrister (Brushless)

(2) Main Transformer	
i) Type	Outdoor type, 3 phase, forced oil circulating, forced air-cooled
ii) Rating	
Capacity	300,000 kVA
Voltage	18 to 24/230 kV
(3) House Transformer	
Capacity	30,000 kVA
Voltage	18 to 24 kV/6.9 kV
(4) General Service Transformer	
Capacity	40,000 kVA
Voltage	230/6.9 kV
(5) Switchyard	
i) System	Outdoor double bus bar
ii) Circuit breaker	
Type	Porcelain type
Rating	242 kV, 2,000 A
(6) 6.9 kV Metal Clad Switchgear	
i) Cubicle type	Indoor, single bus, metal enclosed type
ii) Circuit breaker	SF_6 or vacuum type 6.9 kV
11. Ash Handling system (per unit)	
i) Chain conveyor	11.7 t/h
ii) Clinker crusher	11.7 t/h
iii) Fly ash silo	1 x 1,000 m^3
12. Powerhouse	Steel structure Ground floor area 5,800 m^2
13. Stack	Height 120 m

14. Environmental Protection Facilities

(1) Electrostatic Precipitator — Dry type

Flue gas capacity — $1,034 \times 10^3$ m^3N/h

(2) Waste Water Treatment

(3) Coal Yard Water Treatment

(4) Waste Water Treatment for Ash Disposal Area

6. Environmental Issues

The Philippines have already established statutory regulations on environmental control. The JICA study mission has evaluated the existing environment in Masinloc area and studied the environmental control facilities in accordance with the statutory regulations.

Based on the above basic study of the environmental control facilities and the basic factors of the power plant, a preliminary evaluation of environmental impacts to the surroundings by installing a power plant was made, and as a results of the above evaluation, it is expected that there will be very little influence to the environment of the surrounding area.

(1) Effects of Air Pollution

The power station will be equipped with a high-performance electrostatic precipitator (ESP) (dust-collecting efficiency is 99% min) as well as a 120 m height stack will be installed to diffuse flue gas and reduce ground-level concentration of pollutant matter. The calculation results of the short-term diffusion prediction using Bosanquet's and Sutton's formura are as follows:

Max. Ground-Level Concentration and Distance
(Stability of Atmosphere: Neutral, Wind velocity: 5 m/s)

	Ambient Air Quality Standard	1 unit Operation	2 units Operation
SOx	0.30 ppm (H)	0.024 ppm	0.028 ppm
	0.14 ppm (D)	0.014 ppm	0.016 ppm
NOx	0.10 ppm (H)	0.015 ppm	0.017 ppm
Dust	0.25 mg/scm (H)	0.004 mg/scm	0.005 mg/scm
	0.18 mg/scm (D)	0.002 mg/scm	0.003 mg/scm
Max. Ground-Level Concentration Distance		12.5 km	17.1 km

Remarks (H): Hourly value
(D): Daily average value
scm: Standard cubic meter

(2) Influence of Thermal Effluent

To prevent recirculation of thermal effluent and minimize the effect to the environment of the surrounding area, the following were considered in determining the location and type of intake and outlet.

- Deep water intake
- Enough distance between intake and outlet (approx. 800 m)
- Enough distance between shoreline and portal of outlet (approx. 300 m)

The thermal effluent diffusion predictive calculation was conducted using "Mostafa A. Shirazi and Larin R. Davis' formula" developed by the U.S. Environmental Protection Agency (EPA).

The conditions and the results are as follows:

(Conditions)

- Discharge volume ---------- 25.0 m^3/s (at two units operation)
- Discharge speed ---------- 0.7 m/s
- Water temperature at Intake ---------- 31°C
- Water temperature at Outlet ---------- 39°C

(Results)

. 1°C increase area ----------	Diffusion area	0.67 km^2
	Reaching distance	1.7 km
. 3°C increase area ----------	Diffusion area	0.01 km^2
	Reaching distance	0.3 km

7. Project Schedule

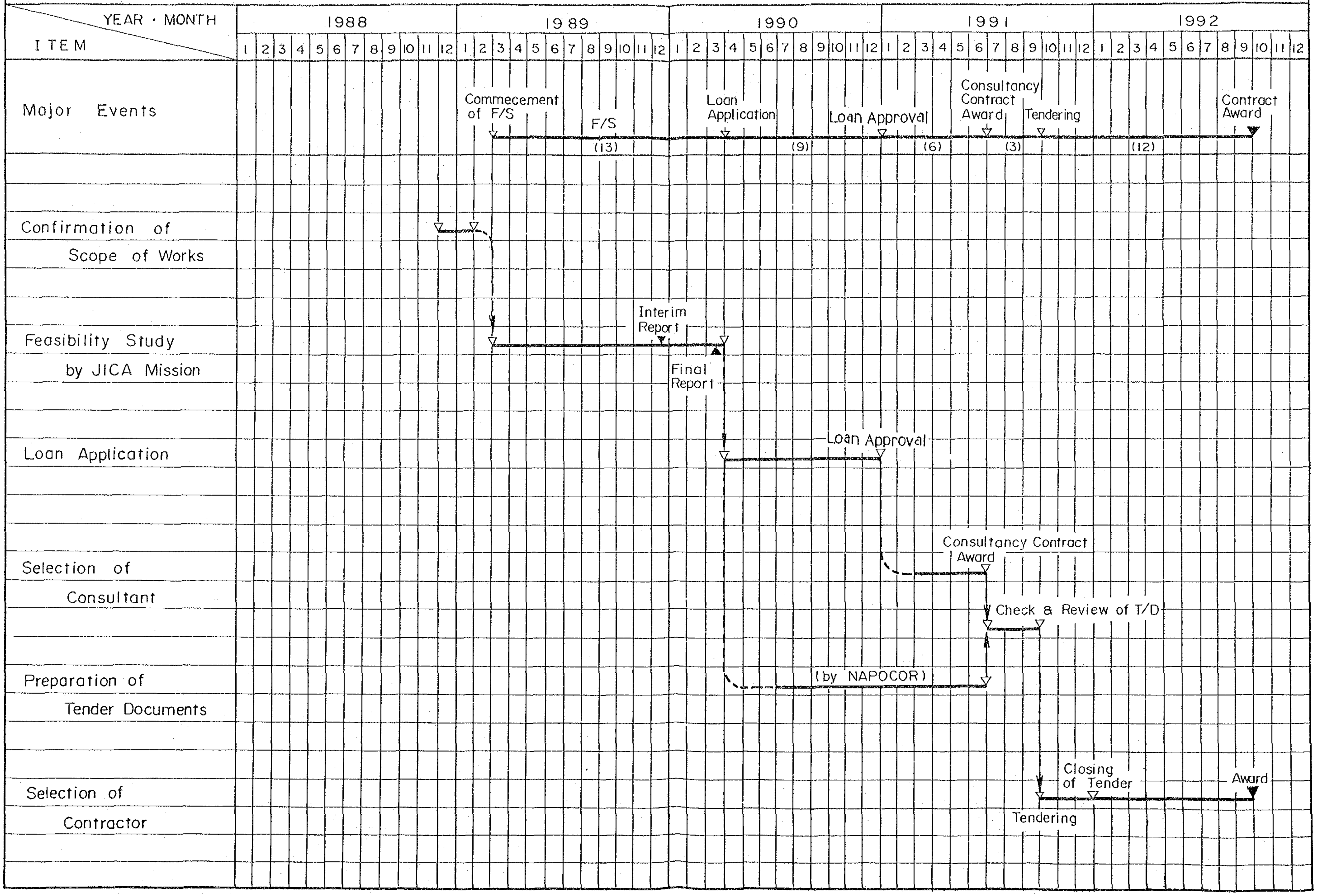
The schedule for planning and construction of a coal fired power plant of 2 x 300 MW at the Masinloc site can be roughly divided into two (2) stages. The schedule prior to commencing construction, after submitting of feasibility study report in March, 1990, will be selection of contractor, and finally award of contract. 30 months will be needed for the preparatory stage. The schedule for performing construction will be 43 months from the award of the contract until taking over of No.1 unit. According to this time schedule, the award of the contract will be October, 1992, and taking over of No.1 unit will be May, 1996.

The main mile-stones of the schedule are planned as follows:

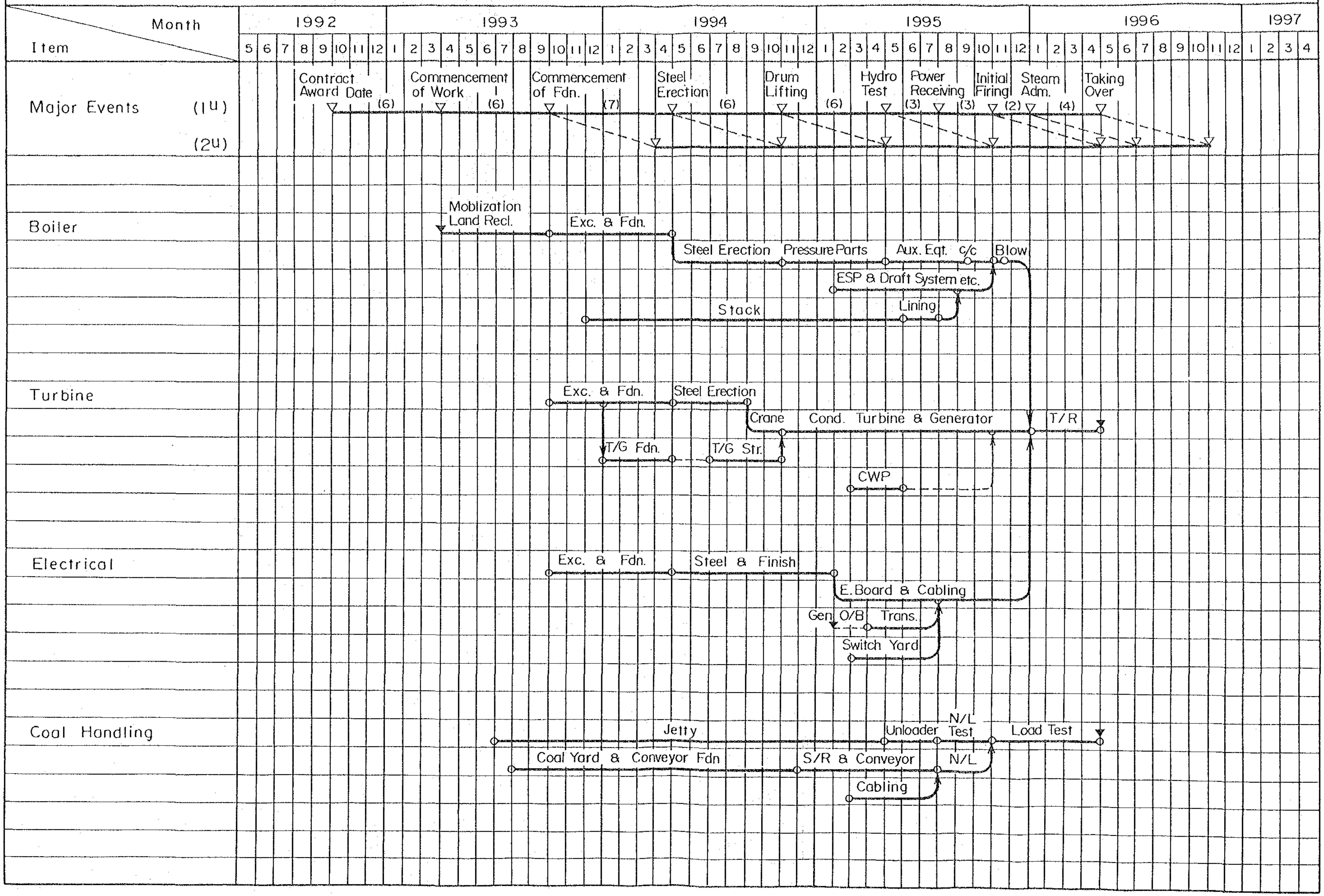
Loan Approval	January, 1991
Consultancy Contract	July, 1991
Tendering	October, 1991
Award of Contract	October, 1992
Commencement of Work	April, 1993
Steel Erection	May, 1994
Initial Firing	November, 1995
Taking Over of No.1 unit	May, 1996

No.2 unit will be scheduled to start operation 6 months after taking over No.1 unit.

Zambales Coal-Fired Power Project Schedule



Zambales Coal-Fired Power Project Construction Schedule



8. Estimated Construction Cost

The construction cost of the Zambales Power Project is estimated for a standard construction cost of 2 x 300 MW coal-fired power plant. The overall construction cost including in-direct cost and I.D.C. is approximately US$750 million. The main items of construction cost and estimated cost are shown as follows:

(US$ x 1,000)

	1U		2U		Total		
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C+L.C
Direct cost	288,642	100,333	177,359	30,722	466,001	131,055	597,056
In-direct cost	24,156	15,868	14,070	6,193	38,226	22,061	60,287
I.D.C.	22,228	49,471	11,148	11,973	33,376	61,444	94,820
Total	335,026	165,672	202,577	48,888	537,603	214,560	752,163

(note) I.D.C.: Interest Dur ng Const uction
F.C. : Foreign Currency
L.C. : Local Currency

9. Economic Evaluation

The economic performance of the proposed coal-fired power plant project was analyzed by using three methods of analysis:

1) "Benefit/cost" analysis

2) "Equalizing discount rate (so-called "Economic internal rate of return - EIRR) analysis

3) "Screening curves" (Time-cost curves) analysis

The most important factor which influences economic analysis of thermal power development project is fuel prices. The proposed project is designed to use Semirara coal and overseas coal on a 50/50 basis, and the average cost of those coals is estimated at US$55.15/ton based on prices in 1989. On the other hand, price of heavy oil which has 1.0% sulfur content equivalent to average sulfur content (0.55%) of coal (Bunker C) is estimated at US$137/kl in 1989.

However, range of fluctuation of heavy oil price has been around 60% in the last 4 years, for example heavy oil price which has 1.0% sulfur content was US$207/kl.

Heavy oil price, which has wider range of fluctuation than coal price, is expected to steadily rise. Considering the above situation, the following two kinds of heavy oil prices are adopted for the economic analysis.

	Base Analysis	Sensitivity Analysis
Coal Price (US$/t)	55.15	10% up
Heavy Oil Price (US$/kl)	137	207

Based on this evaluation, the following conclusion was obtained.

(1) The equalizing discount rate between the proposed project and the alternative thermal power plant is 4.0% in the case of the Base Analysis and is from 20.2% to 22.3% in the case of the Sensitivity Analysis.

(2) From the viewpoint of optimum power source structure for Luzon grid, the proposed project does not have advantage over oil-fired

thermal power plants until 1997, that is after commissioning, on the assumption that market rate (assumption rate: 9%) is adopted as an interest rate to finance all construction costs of both the proposed project and the oil-fired thermal power plant and heavy oil price is US$137/kl.

However, it is profitable to construct coal-fired thermal power plants which has from 1,600 MW to 1,700 MW capacity on the assumption that heavy oil price is US$207/kl.

(3) It is profitable to construct coal-fired thermal power plants which has around 710 MW capacity on the assumption that interest rate of some soft loan (assumption rate: 3.9%) is adopted to finance the construction cost even if heavy oil price is US$137/kl.

10. Financial Analysis

The results of financial analysis for the project are as follows:

a) The Rate of Return (ratio of operating income to average net fixed assets in operation) will be 0.96% in average for the first 10 years from commissioning and 3.72% in average for the whole service life of 30 years.

b) The yearly cash balance will be influenced by amortization of principal and operating & maintenance costs, therefore, red figures and black figures are presented mutually with the yearly cash balance.

c) The financial internal rate of return will be about 3.37%.

11. Considerations for Future Extension

If NAPOCOR has an intention of installing units No. 3 and 4 at the Masinloc site in the future, the following issues should be taken carefully into consideration at the time of actual design stage of this project.

1) Regarding the coal unloading facility, about 5,000 DWT new coal unloading jetty and off-shore conveyor shall be constructed besides the 60,000 DWT facility. It is difficult to extend the 60,000 DWT facility because it would interfere with the operation of No. 1 and No. 2 units.

2) Regarding the condenser cooling facility, all relevant facilities for No. 3 and No. 4 units shall be planned as new one. In this connection, the location and layout shall be considered carefully to avoid interference of circulating water pipes and diffusion of thermal effluent of sea water with No. 1 and No. 2 units.

3) Regarding the volume of fresh water, the total amount of fresh water from the Masinloc river might not be enough for the project after completion of the additional units. Therefore, a new water source shall be secured separately.

4) Regarding the ash disposal area, off-shore ash disposal should be studied since the capacity of inland ash disposal area is not sufficient for No. 3 and No. 4 units.

5) Regarding the environmental facility, DeSOx facility would not be required if industrialization adjacent to the project site remains in the present condition.

12. Recommendations

Some items necessary for the smooth and swift completion of the project has been summarized in the form of recommendations.

(1) The range of overseas coal for possible procurement is extremely extensive. In procurement, attention should be paid to economy, as well as reliability and security, and to diversification of procurement sources. The establishment of an organization to study procurement strategies and implement them within NAPOCOR is desirable for a systematic procurement of imported coal.

(2) The preliminary design of the power plant facilities has assumed 50/50 basis use of indigenous and imported coals. Australia's Lemington coal (6,524 kcal/kg) has been employed for the design. Sources of procurement are extensive and in variety, and policy of procuring party can be reflected strongly in the contract. When procuring overseas coal in the future, it is desirable that coal of quality comparable to or better than Lemington coal be studied based on the standards of coal quality evaluation.

(3) Taking into consideration the energy policy of the Philippine Government, the plant has been designed to use indigenous coal and overseas coal on a 50/50 basis. However, the result of study has revealed that potential supply capacity of indigenous coal, at the starting time of this project, might be less than 50% of the demand. Therefore, from an economic view point, all boilers should not be designed for mixed burning of indigenous and overseas coal.

(4) The construction schedule is set at 43-months from contract award to taking over of the first unit. It is a standard schedule based on similar existing projects. It is important that all possible measures be taken to start operation as early as possible. Hence, efforts for smooth contract award procedure are necessary. The following are possible to achieve for this end:

   1) NAPOCOR must start negotiations for financing as quickly as possible following receipt of this report.

2) The tender document shall be prepared by NAPOCOR. The reason is that NAPOCOR has experience with Calaca in preparing standard tender documents for coal-fired thermal power plant. It is believed that necessary information for the preparation of the tender documents can be obtained from the report and past exchanges of views. Hence, NAPOCOR must start preparation of tender specifications after receipt of this report.

The period until the contract is awarded should be reduced to the shortest possible period.

(5) There are many problems that require understanding and cooperation of the local community, such as acquisition of land, construction of large-scale port, adjustment with existing navigation routes, and acquisition of ash disposal area. For this reason, discussions with the local community on the project should start immediately.

(6) It is important to precisely understand the natural conditions at the planned site in order to smoothly carry forward the detailed design and the project construction. It is necessary to carry out observation of wind, sea water temperature, runoff of Masinloc river, etc. as well as topographic survey of sea-bottom and land configuration, and additional geological survey should be required systematically around the planned site.

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