5.2.2 Demand Forecast

(1) Current Status of Demand for Indigenous Coal

i) Current status of demand and supply

The demand in 1988 was about 2.48 million tons and the supply was about 1.34 million tons. The breakdown of these figures follows:

Demand and Supply Results of Coal in 1988

(Unit: 10^3 ton)

Demand	Power Utility	Cement	Others	Total
	1,446	1,014	19	2,479

Supply	Semirara	PNOC-CC	Cebu Is.	Batan Is.	Others	Total
	670	230	243	70	123	1,336

(1,143 tons short of the supply)

The deficiency is supplemented by importing overseas coals.

ii) Demand by NAPOCOR

NAPOCOR owns two coal-fired thermal plants; Calaca I (300 MW) in southern Luzon and Naga I (50 MW) and II (55 MW) in middle Cebu. Though the Calaca I plant was originally planned to use only Unong coal from Semirara Island, the coal turned out to be lacking specification of purchase conditions because of poor mining conditions, besides its poor quality. Because the use of the coal resulted in frequent boiler troubles through deposition of alkaline components in ash, the exclusive use of Seminara coal was eventually abandoned. Subsequent improvement in the heating value of raw coal through improvement in mining conditions enabled its blended use with overseas coal in a blending ratio of six to four. The overseas coal to be mixed is mainly Ulan coal from Australia, which has a low level of alkaline components in ash. On the other hand, the Naga I boiler is designed to use high rank coal from Cebu Island, and the Naga II boiler is designed for low rank coals. Both classes of coal are available in Cebu Island. The following table lists the characteristics of coal for these three plants.

Characteristics of Coal Used by NAPOCOR Power Plants

	T.M (%)	Ash (%)	F.C (%)	V.M (%)	S (%)	H.V (Btu/lb)
Calaca I	24.0 Max	18.0 Max	33.0 Min	35.0 Min	1.0 Max	8,700 Min
Naga I	16.5 Max	15.0 Max	31.0 Min	44.0 Min	3.8 Max	9,180 - 9,720
Naga II	22.0 Max	22.0 Max	26.0 Min	30.0 Min	4.0 Max	7,020 - 7,500

Note : All figures are on an air-dried basis, except for total moisture.

iii) Demand by cement industry

The cement industry uses high-grade coals of about 10,000 Btu/lb. The Cement Association made a coal supply contract with PNOC-CC, which established two coal-centers in Luzon Island (Poro point and Batangas) and one in Mindanao Island (Iligan); these facilities control the coal characteristics by blending for use in the cement industry. Besides this route, cement plants such as Apo cement in Cebu Island, Pacific Cement in Surigao on Mindanao Island and Davao Cement in Davao directly receive coal from various mines including those of PNOC-CC. The coal centers supplement the deficiency of indigenous coal with imported coals, which also serve in upgrading the heating value. The standard blending ratio of indigenous coal to imported coal is 55 : 45, which partly is a result of the protection policy for indigenous coal recommended by the Coal Council of Advisers in the Energy Regulatory Board. The following table shows the actual operation of coal centers for delivery to the cement industry.

Coal Supply to Cement Industry from PNOC-CC's Coal Centers

Coal Center	Cement Industry	Distance	1987 (10^3t)	1988 (10^3t)
Poro Point	Bacnotan Consol I.	30 km	72.1	77.3
	Northern Cement	71 km	86.3	85.2
Batangas	Central Luzon	202 km	37.6	37.8
	Continental Corp.	175 km	12.1	31.7
	HI-Cement Corp.	174 km	72.3	61.8
	Republic Cement	171 km	71.2	71.9
	Island Cement	124 km	0	161.9
	Filipinas Cement	130 km	0	111.7
	Rizal Cement	146 km	81.2	92.7
	Fortune Cement	30 km	57.1	55.6
Cebu Is. Mines	Apo Cement	-	43.3	50.9
Iligan	Iligan Cement	-	61.8	57.6
Mindanao Is. Mines	Pacific Cement	-	26.1	25.5
	Davao Cement	-	89.6	92.2
	Total		713.8	1,013.9

Furthermore, the coal specifications between the Cement Association and the PNOC-CC are as follows:

Size	T.M*1	Moisture	Ash*2	V.M*2	S*2	H.V (Btu/lb)*2
25 mm Max.	18% Max.	10% Max.	15% ±2%	20% Min.	3% Max.	9,500 Ave. 8,500 Min.

Note : *1 As Received Basis
*2 Air Dried Basis

iv) Other industries

Atlas Copper Mine: 2 x 35 MW (fluidized bed combustion boiler) and 30 MW (conventional boiler); Coal consumption is about 340,000 t.

Ludo & Luym Corp.: 150,000 lb/hr boiler; coal consumption is 200 t/d.

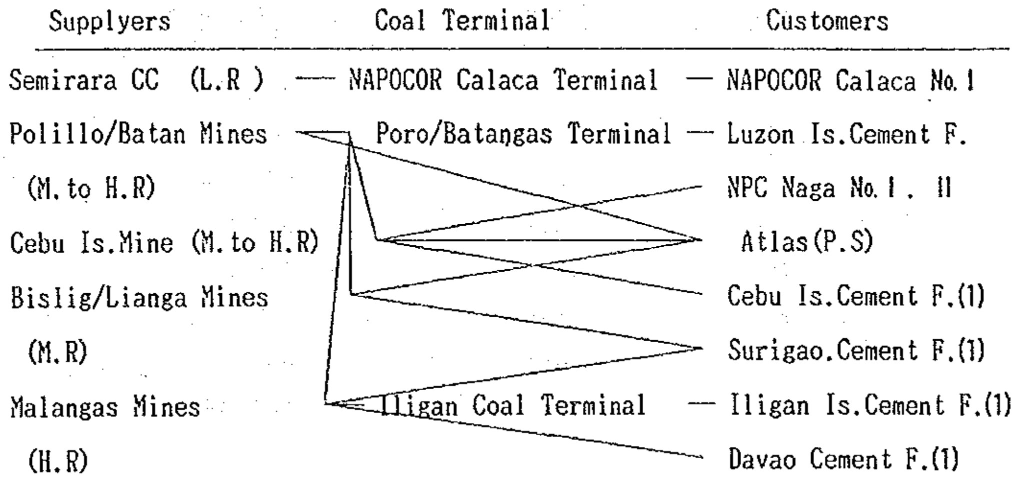
Semirara inhouse : Presently 2 x 7.5 MW; power plant coal consumption is about 40,000 t. The addition of 31 MW is planned for the future, making coal consumption 120,000 t.

MMIC, Nonoc Island: Presently out of operation; should its operation be resumed in 1989, it would consume 860,000 t at maximum. (A 60,000 DWT class quay and a 250,000 t coal storage yard. Imported coal acceptable.)

v) Flow of indigenous coal

The following diagram shows the flow of indigenous coal.

Indigenous Coal Flow



(Note L.R:low rank, M.R:medium rank, H.R:high rank)

Note: The low rank coal has a heating value of less than 8,700 Btu/lb. The medium rank coal has a heating value of 8,700 to 10,000 Btu/lb. The high rank coal has a heating value of more than 10,000 Btu/lb.

This diagram illustrates coal flows from major mines to consumers.

(2) Coal-fired Thermal Power Development Plan

The development plan published in June 1988 presented the following plans up to 2000 for the development of coal-fired thermal power plants.

Commissioning	Power Plant	Plant Capacity
1992	Calaca II	300 MW
1993	Coal III	300 MW
1997	Coal A	600 MW
1998	Coal B	600 MW
1999	Coal C	600 MW
1999	Mindanao A	100 MW
2000	Coal D	600 MW
2000	Mindanao B	100 MW

Eight new plants up to year 2000 will be lined to NAPOCOR's coal-fired power plants, making its total production 3,200 MW, which would be a remarkable growth from the present level of three plants producing 405 MW. Coal demand for this plan is about ten million tons, which is remarkably greater than the planned production of indigenous coal (3.99 million tons in the year 2000).

Note: $$\frac{3{,}200 \text{ MW} \times 8{,}760 \text{ hr} \times 0.7 \times 860 \text{ kcal/kWh}}{5{,}560 \text{ kcal/kg} \times 0.36 \times 0.85} = 9{,}920{,}000 \text{ tons}$$

Heat rate : 9,500 Btu/kWh

Total moisture: 15%

The general coal demand forecast cited below presented figures as follows on the basis of suppositions in the NAPOCOR's plan in January 1988 (10,000 Btu/lb as standard).

Calaca I	:	300 MW	930×10^3 t/year	
Calaca II	:	300 MW	930×10^3 t/year	
Coal III	:	300 MW	930×10^3 t/year	
Coal A, B, C & D	:	600 MW each	$1,860 \times 10^3$ t/year	
Mindanao I, II	:	100 MW each	282×10^3 t/year	

Naga I, II :

Year	1989	1990	1991	1992	1993	1995	2000
(10^3t)	209	217	226	241	225	225	236

(3) Cement Industry

In 1988, OEA forecasted demand in 1988 as 774×10^2 with an average annual growth of 5%. The coal demand, however, suddenly rose to a million tons in 1988. The present forecast does not change the forecast level of 1.09 million tons for 1995 and assumed 1.0 million t/y until 1993.

(4) Other Industries

Consumption by Atlas, Philphos and other plants is assumed to follow the OEA forecast in 1988, which means:

Annual growth of consumption by Atlas is assumed to be

1988 - 93	5.5%
1993 - 95	7.3%
1995 - 2000	9.0%

A constant level of 40,000 t/y is assumed for Philphos.

Annual growth for other plants is assumed to be

1988 - 93	7.8%
1993 - 95	10.4%
1995 - 2000	10.0%

(5) General Forecast for Coal Demand (Based on Coal of 10,000 Btu/lb)

The discussion above is summarized in the following table.

(Unit: 10^3 ton)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
NAPOCOR Demand												
Calaca I	930	930	930	930	930	930	930	930	930	930	930	930
Naga I & II	209	217	226	241	225	225	225	225	225	225	225	236
Calaca II				930	930	930	930	930	930	930	930	930
Coal III					930	930	930	930	930	930	930	930
Coal A									1860	1860	1860	1860
Coal B										1860	1860	1860
Coal C											1860	1860
Coal D												1860
Mindanao A											282	282
Mindanao B												282
Sub Total	1139	1147	1156	2101	3015	3015	3015	3015	4875	6735	8877	11030
Cement	1000	1000	1000	1000	1000	1038	1090	1145	1202	1262	1325	1392
Atlas	290	306	323	340	359	385	413	450	491	535	583	635
Philphos	40	40	40	40	40	40	40	40	40	40	40	40
Others	128	138	149	161	173	191	211	232	255	281	309	340
Total	2597	2631	2668	3642	4587	4669	4769	4882	6863	8853	11134	13437

(6) General Supply and Demand Plan of Coal

The demand in (5) and supply in (3) are summarized as follows:

(Unit: 10,000 Btu/lb 10^3 ton)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Demand	2597	2631	2668	3642	4587	4669	4769	4882	6863	8853	11134	13437
Supply	1342	1415	1495	2232	2651	2811	2981	3111	3253	3410	3714	3991
Shortage	1255	1216	1173	1410	1936	1858	1788	1771	3610	5443	7420	9446
Sufficiency (%)	51.7	53.8	56.0	61.3	57.8	60.2	62.5	63.7	47.4	38.5	33.4	29.7

From the total balance of demand and supply in the Philippines, the self sufficiency of coal is predicted to become less than 50% after 1997, getting as low as 30% in 2000. However, indigenous coal for thermal power plants in Luzon comes mainly from Semirara, and other sources are not available at the moment. The matter will be discussed below.

(7) Demand by Luzon Power Plant and Supply from Semirara

(Unit: 10,000 Btu/lb 10^3 ton)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Demand of Luzon Grid	930	930	930	1860	2790	2790	2790	2790	4650	6510	8370	10230
Semirara Coal Supply	609	609	609	609	1257	1473	1473	1473	1473	1473	1473	1473
Shortage	321	321	321	1251	1533	1317	1317	1317	1317	5037	6898	8757
Sufficiency	65.5	65.5	65.5	32.7	45.1	52.8	52.8	52.8	31.7	22.6	17.6	14.4

As for Calaca I, Calaca II, and Coal III, according to the above table, about 50% of Semirara coal can be used, but almost nothing can be expected from facilities to be taken over after 1997.

On the other hand, coal III project is planned as BOT/BOO scheme and it may consume only overseas coal. In this case, indigenous coal demand by Luzon power grid should be varied as follows:

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Demand of Luzon Grid	1860	1860	1860	1860	1860	3270	5580	7440	9300
Semirara Coal Supply	609	1257	1473	1473	1473	1473	1473	1473	1473
Shortage	1251	603	387	387	387	2447	4107	5967	7827
Sufficiency	32.7	67.6	79.2	79.2	79.2	39.6	26.4	19.8	15.8

Therefore, the demand ratios of the Semirara coal at Calaca I, Calaca II, and Coal A project only are shown below.

(Unit: 10,000 Btu/lb 10^3 ton)

	1989 to 1991	1992	1997 to 2000
Calaca I	465	465	465
Calaca II		465	465
Coal A			930
Total	465	930	1,860
Supply	609	1,257	1,473
Balance	+144	+327	-387

Where: Rate of self sufficiency is to be considered as 50%

Thus, some 60% supply is possible up to 1996, thereafter, however, the figure inevitably falls below 40%. Under these circumstances, it seems adequate to have a ceiling of indigenous coal of 50% for the Zambales Coal-fired Project.

The above calculation assumes a sustained production at Unong mine at the present level and the start of operation of a new mine in 1993 at a level of 1.2 million t/y, as forecast by OEA.

5.3 Selection of Design Coal

In designing a coal-fired thermal power plant, the most important task is to select the coal to be used and know the coal characteristics and ash composition.

Important coal characteristics are those controlling combustion, ash fusion and deposit and generation of air pollutants. There are, therefore, broad guidelines for decisions on the specifications of the furnace, the pulverized coal firing system, the coal handling facility and other equipment.

Important characteristics of coal ash are not only those affecting the performance, structure and dimensions of boiler, but also those that influence the reliability, operability and economics of the plant.

Generally speaking, effects of coal characteristics on boiler and related facilities are as shown below:

5.3.1 Coal Handling Property

(1) Surface Moisture

i) If there is little surface moisture, coal dust is prone to disperse in outdoor coal stockyard.

ii) If surface moisture is approximately between 8% to 15%, coal fluidity will weaken considerably, causing clogging in the hopper, shoot, bunker, etc.

iii) If there is little surface moisture, the temperature increase of coal due to natural oxidation will be enhanced and spontaneous combustion is liable to occur.

(2) Distribution of Size

i) Coal with a high percentage of size less than 2 mm has low fluidity which often causes clogging in the hopper, shoot, bunker, etc. Generally speaking, coal with extremely high grindability (HGI) has a high proportion of particles with very small size.

ii) Coal with high proportion of particles with very small size causes dust dispersion in handling equipment and the outdoor coal stockyard.

iii) If coal with the size bigger than that for which the handling equipment is designed is mixed in, clogging is liable to occur.

(3) Ash and Clay Contents

i) Coal with high percentages of ash and clay shows strong coking property, which often causes clogging.

(4) Volatile Matter

Coal with much volatile matter is prone to spontaneous combustion.

(5) Pyrite (FeS_2)

Coal with much pyrite content is liable to be oxidized at low temperature, causing spontaneous combustion.

5.3.2 Combustibility

(1) Fuel Ratio

i) The lower the fuel ratio the more combustibility of the coal is enhanced because of higher volatile matter percentage.

ii) Generally speaking, coal with a high fuel ratio is characterized by high ignition temperature, low burning velocity and inferior combustibility.

(2) Ash Content

In the case of coals with the same volatile matter, the more ash content included, the less the combustibility of the coal.

(3) Coal Rank

The factors that greatly affect combustibility include fuel ratio, volatile matter and oxygen contents. Since these factors are related to coal rank, the latter can be a convenient combustibility indicator. The more the coal carbonization degree is enhanced, the more the proportion of fixed carbon increases, and the less the percentage of volatile matter becomes, lessening combustibility.

5.3.3 Slagging and Fouling Property

The most serious problems for a coal-fired boiler are slagging and fouling. The phenomenon of melted coal ash deposit on the furnace water walls is called slagging, while that of coal ash deposit on the heating surface in the gas temperature range below the ash softening temperature (ST) is referred to as fouling.

Phenomena due to Slagging and Fouling and their Effects

Principal phenomena due to slagging and fouling and their main effects are as follows:

Slagging

i) Slag Deposit

Increased temperature difference in water wall tubes due to unbalanced heat absorption.

ii) Increase in Furnace Outlet Flue Gas Temperature

Reduction of efficiency through injection of reheater spray water.

Reduction of efficiency due to increase in furnace outlet flue gas temperature.

iii) Dropping of Big Clinker Mass

Breakdown of the furnace bottom tube.

iv) Clogging in the Burner Throat

Formation of melted slag owing to generation of partial reducible atmosphere.

Fouling

→ 1) Limitation of the plant load
2) Limitation of adaptable coal characteristics

i) Clogging in the Gas Path

Increase in the furnace outlet gas temperature due to reduction of heat absorption at the furnace water wall.

ii) Reduction of Efficiency

Reduction of efficiency through injection of reheater spray water.

Reduction of efficiency due to increase in furnace outlet flue gas temperature.

To assess slagging and fouling trends, many of the parameters shown below are employed. Details of each of these items are explained below:

(1) Slagging Characteristics

i) Ash-Fusion Temperature (AFT) Characteristics

Generally speaking, coal ash with a low AFT has a strong slagging characteristic while coal ash with a high AFT has a weak slagging nature.

When the furnace water wall temperature is close to the coal ash softening temperature, deposits on the furnace water wall are liable to become porous. When ash cohesion is weak, ash is prone to drop off the furnace water wall by weight itself and is easily removed with a sootblower.

When coal ash aggregates on a high temperature gas part having a temperature higher than its softening temperature, the aggregated ash surface becomes fused and flows down.

When coal ash arrives at the heating surface with temperature lower than its softening temperature, its condition is that of simple dust and it is easily removed.

On the other hand, if ash particles are exposed to a temperature higher than their softening temperature for a long period, ash turns into plastic or liquid state, with the slag generated fixed on the wall and so strongly stuck that it is difficult to remove it. Since slag and deposits continue to accumulate on themselves in piles and since they act as insulators, they grow until their surface temperature reaches the fusing temperature, beginning to flow down.

The difference between the initial deformation temperature (IDT) and the fluid temperature (FT) is one index of the shape of the slag growing on the surface of the furnace water wall.

When the temperature difference is small, the deposited slag is thin and it is in the fluid state and difficult to remove with a sootblower. The bigger the temperature difference, the thicker the slag deposit grows on the furnace water wall: its growth continues until its surface becomes fluid. The cohesion between the furnace water wall and slag is not strong and the slag is easily removed with a sootblower.

ii) Base/Acid (B/A) ratio

The Base/Acid ratio is defined by the following formula. SiO_2, Al_2O_3 and TiO_2, which belong to acid oxides, have a tendency of higher fusion temperature. On the other hand, increasing of Fe_2O_3, CaO, MgO and K_2O, which belong to alkali oxides, have a tendency to reduce the ash fusion temperature.

$$\frac{B}{A} = \frac{Fe_2O_3 + CaO + MgO + Na_2O\ K_2O}{SiO_2 + Al_2O_3 + TiO_2}$$

The B/A ratio indicates the proportion of ash content which has the tendency of production of low melting point salt in the process of combustion. When the B/A ratio of ash shows extremely low or extremely high, the ash has the tendency of difficulty of production of low melting point salt.

Since the B/A ratio does not include assessment of the fusing characteristic of an alkaline compound or reaction of an alkaline compound with an acid compound, it is used only as a rough, auxiliary index.

In the case where coal contains iron as a pyrite (FeS_2), the low melting point salt is produced in the combustion process, which causes slagging.

Accordingly, in the case of bituminous type coal ash ($Fe_2O_3 > MgO + CaO$), which contains some sulfur and also pyrite (FeS_2) in proportion to the sulfur content, the following equation and assessment method based on B/A ratio are used.

$Rs = B/A \times S$

S: Sulfur content, wt% moisture free.

Slagging Characteristic Assessment (1)

Slagging potential	Slagging index (Rs)
Low	Less than 0.6
Medium	0.6 - 2.0
High	2.0 - 2.6
Severe	More than 2.6

In the case of lignitic type coal ash, which have little sulfur content and relatively small ferric content ($Fe_2O_3 < MgO + CaO$), the following equation and assessment method using ash fusion temperature as the index are employed since good correlation can be found between the ash fusion temperature and ash viscosity:

$$Rs' = \frac{\text{Max. HT} + 4 \times \text{Min. IDT}}{5}$$

HT : Maximum Hemispherical Temperature

IDT: Minimum Initial Deformation Temperature

Slagging Characteristic Assessment (2)

Slagging potential	Slagging index (Rs)
Medium	Over 1,230
High	1,230 - 1,150
Severe	Less than 1,150

(2) Fouling Property

1) Alkaline Contents ($Na_2O + K_2O$)

Na and K, alkaline metals, are exceptional substances generating low melting point salt despite their B/A ratio; their fouling characteristic within a convective surface is in proportion to the alkali volume within coal ash.

Fouling Property Assessment (1)

Fouling potential	$Na_2O + K_2O$
Low	Less than 3.5
Medium	3.5 - 5.0
High	Over 5.0

Active alkaline contents are gasified in the combustion gas and they react with other contents or aggregates on the heating surface, playing the role of paste on which other contents are deposited. In particular, Na_2O has much to do with the fouling of convective heating surface. In the case of bituminous type coal ash, Na is related to its B/A ratio or sintering strength of coal ash.

In the case of lignitic type coal ash, sufficient assessment is possible on the basis of correlation with the proportion of Na_2O.

ii) Bituminous Type Coal Ash ($Fe_2O_3 > MgO + CaO$)

$$Rf = B/A \times Na_2O$$

Fouling Property Assessment (2)

Fouling potential	Fouling index (Rf)
Low	Less than 0.2
Medium	0.2 - 0.5
High	0.5 - 1.0
Severe	More than 1.0

iii) Lignitic Type Coal Ash ($Fe_2O_3 < MgO + CaO$)

$$Rf' = Na_2O$$

Fouling Property Assessment (3)

Fouling potential	Fouling index (Na_2O)	
	Case 1	Case 2
Medium High Severe	Less than 1.2 1.2 - 3.0 More than 3.0	Less than 3.0 3.0 - 3.6 More than 6.0

Case 1: $(CaO + MgO + Fe_2O_3) > 20\%$

Case 2: $(CaO + MgO + Fe_2O_3) < 20\%$

(3) Ash Erosion Property

Erosion of coal ash is caused by the ramming of ash particles in the combustion gas onto the tube surface. The erosion velocity of ash can be approximated by the following equation:

$$R = K \times V^{3-3.5} \times A^{0.64-1.0}$$

K: Erosion constant

V: Gas flow velocity (m/s)

A: Ash density in the flue gas (g/Nm^3)

The erosion constant (K) derives from coal ash characteristics while ash density in the flue gas (A) stems from the proportion of coal ash.

Factors controlling erosion constant (K) include hardness, shape and fracturing characteristic of ash particles. As far as ash particles in the coal-fired boiler are concerned, however, fracture characteristic has little effect.

Quartz (α-Quartz), pyrite (FeS_2) and mullite ($3Al_2O_3 \cdot 2SiO_2$) are included within coal and coal ash in relatively large quantities, with their hardness being substantial and their erosion potential high. Of these, pyrite poses little problem since it disappears in combustion.

To estimate the content of quartz with high erosion potential through ash content analysis, it is suggested that the

SiO_2/Al_2O_3 ratio should be used as an index. Since clay substance, which is included in coal ash in large quantities and has little to do with erosion potential, has a small SiO_2/Al_2O ratio, it is possible to surmise that the proportion of quartz is high if the ratio proves to be high. To assess the ash erosion property, it is possible to use the following table as schematic indexes. It is clear from the erosion velocity equation shown above, that the ash density content in the flue gas is an important factor. This must be considered in the study.

Ash erosion potential	SiO_2/Al_2O_3 ratio
Low	Less than 2.0
Medium	2.0 - 3.0
High	More than 3.0

5.3.4 Criteria for Overseas Coal Selection

Coal from different foreign countries has different properties. Even coal produced from the same coal field may have widely different characteristics depending on the coal pit or layer from which it is obtained. In boilers and related facilities, it is important, from the standpoint of reducing equipment cost and ensuring wider operability of the planned power plant, to set criteria based on coal characteristics and ash composition features as stated above and select coal that satisfies the criteria.

The main considerations in fixing the criteria for overseas coal selection from the above-stated viewpoint are as follows:

(1) Relation to Indigenous Coal

When overseas coal is blended with indigenous coal, the overseas coal should be such that various expected characteristics after its blending with indigenous coal will supplement the shortcomings of indigenous coal, contributing to improvement of reliability, operability and economics of the power plant.

(2) Ease in Procurement

With the above condition, the coal should be available from as extensive an area as possible.

(3) Understanding Coal Characteristics

Coal characteristics should be understood through practical use and analysis. Otherwise, they should be such as to be regarded as similar to experienced coal, under the prediction evaluation method established on the basis of achievements.

Indigenous coal (Semirara coal) suggested by NAPOCOR is low-grade lignitic coal having the following characteristics, judging from the properties of its contents:

1) Low heating value.
2) High alkali content.
3) High ash loading per unit heating value.
4) low ash fusion temperature.
5) Low grindability (HGI)
6) High quartz loading (SiO_2-Al_2O_3) per unit heating value.

High-grade bituminous coal is suitable for blending with such low-grade coal. In terms of ease in procurement there is no problem whatsoever.

Various characteristics of bituminous coal have been sufficiently learned through extensive combustion experience with imported coal at the Matsushima Thermal Power Plant of EPDC, and its assessment method has been established.

In consideration of the above facts, the normal values for overseas coal selection have been set as follows:

Normal Values for Overseas Coal Selection

(1) From the Viewpoint of Combustibility

i)	Coal rank	Bituminous coal
ii)	Heating value (A/R basis)	More than 5,500 kcal/kg
iii)	Volatile matter (A/R basis)	More than 20%
iv)	Fuel ratio	Less than 2.5

(2) From the Viewpoint of Slagging and Fouling Property

i)	Ash loading per unit heating value	
	Ash ST about 1,200°C	Less than 25 kg/10^6 kcal
	Ash ST about 1,300°C	Less than 35 kg/10^6 kcal
ii)	Ash ST	More than 1,200°C
iii)	Slag length (FT - ST)	More than 100°C
iv)	Ash property	
	Base/Acid ratio	Less than 0.5
	Fe_2O_3 contents (SO_3 free)	Less than 15%
	Na_2O contents (SO_3 free)	Less than 3%
	Na_2O + K_2O (SO_3 free)	Less than 4%
	CaO content (SO_3 free)	Less than 10%
v)	Total sulfur contents (A/R basis)	Less than 1.8%
vi)	Chlorine content (A/R basis)	Less than 0.18%

(3) From the Viewpoint of Pulverized Coal Firing System

i)	Grindability (HGI)	More than 40
ii)	Total moisture	Less than 16%

(4) From the Viewpoint of Erosion

i) Ash loading per unit heating value — Less than 30 kg/10^6 kcal

ii) Quartz loading (SiO_2-Al_2O_3) per unit heating value — Less than 10 kg/10^6 kcal

The assessment results of representative overseas coal based on the above-indicated normal value for overseas coal are shown in Table 5.3-1.

5.3.5 Assessment of Indigenous and Overseas Coal

Results of the analysis of the effect of the above-stated coal characteristics on a boiler and related equipment in the case of indigenous and overseas coal are set forth below.

The assessment was made concerning the following five kinds of coal:

- Semirara coal (ROM average) 100%
- Semirara coal (Selected average) 100%
- Overseas bituminous coal 100%
- Blended coal comprising Semirara (ROM average) coal 50% and overseas bituminous coal 50%
- Blended coal comprising Semirara (Selected average) coal 50% and overseas bituminous coal 50%

For overseas bituminous coal, the analysis data of Lemington coal was used for the following reasons.

a) Since the above-stated "normal values for overseas coal selection" are nothing but standard values for choosing overseas coal, it is impossible to assess various characteristics of blended coal by means of them. It is required, therefore, to temporarily employ real coal that can provide actual analysis data.

b) Of the seven kinds of overseas coal suggested by NAPOCOR, Lemington coal, which meet requirements of all items in the "Normal Value for Overseas Coal Selection", was chosen.

Assessment results based on property index study are indicated in Table 5.3-2.

(1) Semirara (ROM average) Coal 100%

i) Handling Property

Since this coal abounds in moisture, ash content and clay content and is of low carbonization degree, has much volatile matter and is easily broken, the proportion of particles with very small size is quite high. As verified in experience involving the Calaca coal-fired thermal power plant unit No. 1, the following troubles are liable to occur, with danger of load restraint in extreme cases.

a) Clogging in various units of the handling equipment, hopper, shoot and bunker.

b) Coal dust dispersion during handling and coal storage.

c) Spontaneous combustion during coal storage.

ii) Combustibility

Compared with Semirara (Selected average) coal, combustibility is lower in proportion to ash and clay content increments. However, the overall combustibility is unlikely to pose any problem because of high volatile matter content.

iii) Slagging and Fouling Property

Since the ash fusion temperature is extremely low and also the proportion of alkaline content (Na_2O + K_2O), particularly Na_2O content, is high, these properties are as follows:

Slagging property: "High" which is close to "severe".
Fouling property : "High"

And since the ash loading per unit heating value is high, the operational trouble due to slagging and fouling is liable to be serious, which would put constraints on operation of the power plant. Owing to reduction of heat absorption due to uncleanness of the furnace water wall and convective heating surface, the boiler outlet gas temperature rises, supposedly diminishing boiler efficiency.

iv) Erosion Property

Since both of the ash loading per unit heating value and the erosion index (SiO_2/Al_2O_3) are high, ash erosion property is strong. Accordingly, countermeasures against erosion on the convective heating surface are necessary.

(2) Semirara (Selected average) Coal 100%

Assessment results show exactly the same tendency as those of Semirara (ROM average) coal. In view of the experience at the Calaca coal-fired thermal power plant, the handling property with regard to clogging appears to have improved.

However, the problems of spontaneous combustion and coal dust dispersion in a coal stockyard are yet to be solved.

(3) Overseas Bituminous Coal 100%

Lemington coal, which was used this time, showed the highest evaluation results in all index items except erosion property.

Its erosion property assessment result was "severe" partly because it is rated only in terms of erosion index (SiO_2/Al_2O_3). Since its ash loading per unit heating value is low at 15.92 $kg/10^6$ kcal compared with the normal value of 30 $kg/10^6$ kcal, its overall erosion rating is considered to be without any problem.

(4) Blended Coal Comprising Semirara (ROM average) Coal 50% and Overseas Bituminous Coal 50%

i) Handling Property

Since Lemington coal has little ash content at 11.1% and also since the proportion of ash particles with size less than 2 mm is so small as 26%, handling property is believed to improve by blending 50% of Lemington coal.

ii) Combustibility Property

As its combustibility rating is "Good" and its ash loading per unit heating value becomes lower, it is assumed to be without any problem.

iii) Slagging and Fouling Property

On the strength of the blending of Lemington coal, alkaline content, slagging property and fouling potentials are all "Medium", this represents improvement from the case of Semirara (ROM average) coal only.

iv) Erosion Property

The erosion potential of the blended coal including Lemington coal is still "Severe". However, heating value rises because of blending and ash loading per unit heating value drastically falls to 24.2 kg/10^6 kcal compared with the corresponding single Semirara (ROM average) coal figure of 39.6 kg/10^6 kcal.

(5) Blended Coal of Semirara (Selected average) Coal 50% and Overseas Bituminous Coal 50%

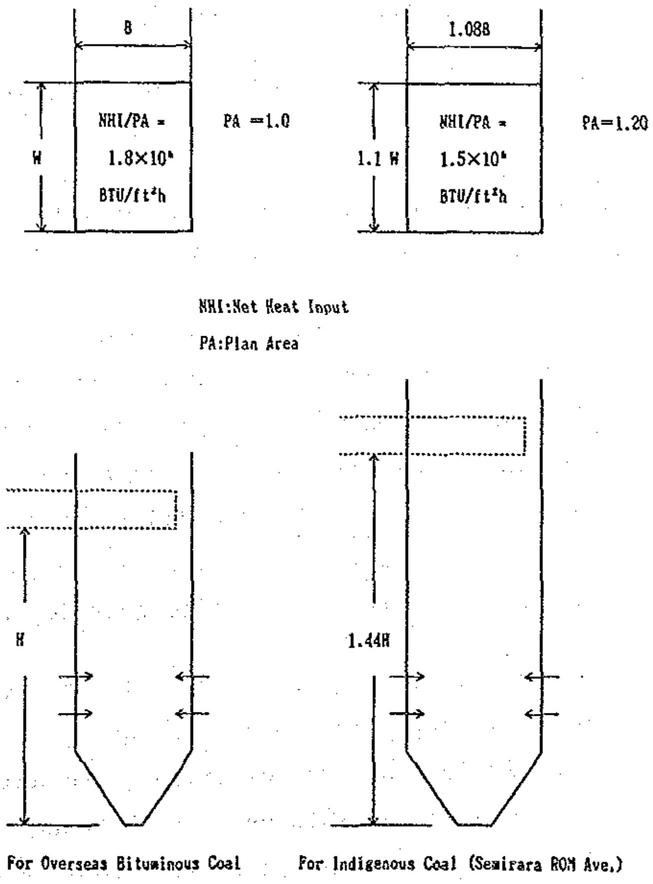
Evaluation results show the same tendency as that of Semirara (ROM average) coal 50% and overseas bituminous coal 50%. Potential has the same rank but some improvement can be noticed in all cases.

5.3.6 Designing Policy for Boiler

From the viewpoint of fuel procurement, it is desirable to design a boiler that can fire both indigenous coal 100% and overseas coal 100%, respectively. From the technological standpoint, however, this is impossible for the following reasons:

As shown in Fig. 5.3-1, dimensions of furnaces suitable for indigenous coal and overseas coal are greatly different.

Fig 5.3-1 COMPARISON OF FURNACE DIMENSIONS



The above figure depicts the furnace for Semirara (ROM average), and in the case of such low-grade coal as Semirara (90% worst coal), the furnace must be bigger. As the furnace dimensions are totally different, it is impossible to burn both overseas coal 100% and indigenous coal 100% respectively in the same boiler for the following reasons:

(1) In the case of burning of indigenous coal in a boiler which is designed for overseas coal only

i) Owing to furnace slagging and reduction of heat absorption at the furnace due to uncleanness of the water wall, the maximum plant output is limited to about 80%.

ii) Because capacity and inlet air temperature of the pulverizer are lower than required, the maximum plant output is limited to about 75%.

The maximum plant output will be the smaller of the two, about 75%.

(2) In the case of burning of overseas coal in a boiler which is designed for indigenous coal only

i) Since a boiler which is designed for indigenous coal only shall be designed with high slagging and uncleanness in furnace, the surface of water wall is not stained by overseas bituminous coal. Accordingly, excess heat absorption in the furnace and lowering of gas temperature at furnace outlet will occur causing mainsteam and reheat steam temperature to decline tens degrees.

ii) Since the heating value of coal rises greatly, the volume of coal supply decreases, and owing to the minimum load restrictions of the pulverizer, the number of pulverizers in operation diminishes. As the heat input into the burner increases greatly, it becomes necessary to restrain heat input into the burners.

iii) The required drying heat input to the pulverizer and heat exchange volume at the air preheater (AH) decreases. Accordingly, outlet gas temperature at the AH increases and boiler efficiency falls down.

5.3.7 Recommended Design Coal for this Project

Technologically, as clearly shown in the above study, it is not realistic to design a boiler for burning 100% of both indigenous coal and overseas coal, respectively.

In a separate study of the supply and demand of indigenous coal, the following conclusions are obtained:

(1) With regard to the supply-demand balance of coal in the entire Philippines, the self-sufficiency ratio of indigenous coal stands at 58% in 1993 and 63% in 1995, and is expected to be less than 40% after 1997.

(2) Furthermore, there is no indigenous coal source that can provide coal to this project other than Semirara coal at present.

(3) The self-sufficiency ratio of indigenous coal will maintained at approximately 50% until the commissioning of this project.

Meanwhile, NAPOCOR's requirements for fuel are as follows:

(4) Indigenous coal should be consumed as much as possible.

(5) It must be possible to effectively absorb the fluctuation in indigenous coal supply.

If the above points are considered in an overall manner, it is realistic and meets the purpose of this project most suitably to adopt a blended coal consisting of indigenous coal and overseas coal as split bases (50/50 wt%).

5.3.8 Selection of Indigenous Coal

As far as the coal characteristics evaluation is concerned, both Semirara (ROM average) coal and Semirara (Selected average) coal have similar properties. But this evaluation concerns only their combustion within a boiler and behavior of combustion ash, and does not take into account the effect on equipment costs and operating expenditures stemming from the difference in heating value and ash loading.

In selecting indigenous coal, principal items will be studied from the above-stated viewpoints:

(1) Coal Consumption and Ash Generation Volume

Study conditions

Plant output	2 x 300 MW
Plant efficiency	36%
Annual plant utilization factor	70%

Heating value	
Semirara (ROM average) coal	3,761 kcal/kg (A/R basis)
Semirara (Selected average) coal	4,055 kcal/kg (A/R basis)
Ash contents	
Semirara (ROM average) coal	14.9% (A/R basis)
Semirara (Selected average) coal	12.0% (A/R basis)

The trial calculation results that were based on the above-stated premises show the following:

i) Annual coal consumption

The annual consumption of Semirara (ROM average) coal is about 8% more than that of Semirara (Selected average) coal.

ii) Annual ash generation volume

The annual ash generation volume of Semirara (ROM average) is about 34% more than that of Semirara (Selected average) coal.

Therefore, in the case of Semirara (ROM average) coal, boiler capacity, boiler auxiliary equipment, other coal-related equipment, unloaders, conveyers, coal storage yard, bunkers, pulverizers and other facilities must be 8% more than in the case of Semirara (Selected average) coal. These necessitate increased equipment costs and operating expenditures.

Also, the capacity of ash disposal equipment, silos, ash disposal area and other facilities for ash disposal must be 34% bigger, necessitating increased equipment costs and operating expenditures.

(2) Coal Handling Problems

As explained above, Semirara (ROM average) coal has a serious problem concerning its handling and it is necessary to take special countermeasures against clogging in the hopper, shoot, bunker, etc. Additionally absolutely sure countermeasures cannot be found and it is probable that operation of the power plant will be somewhat affected.

Since Semirara (ROM average) coal has serious costs and operational problems as seen above, it should not be adopted as the design coal for this project. Instead, Semirara (Selected average) coal, which has fewer problems, should be selected.

(3) In this project study, analysis of the data on Himalian and Panian, provided by NAPOCOR, is employed. As for Unong coal, data contained in the final report of "The Study for Calaca Coal-fired Thermal Power Plant Upgrading Project" was adopted. Since the average values in this analysis data are quite close to the weighted average values of coal received in 1985 to 1986, if they are limited to proximate analysis items, they can be considered to represent Unong coal.

Relative evaluation results of Unong, Himalian and Panian coal are as follows:

i) Combustibility

It becomes better as the arrow moves rightward.

Himalian —> Panian —> Unong

ii) Ash Contents per Heating Value

Ash contents in Himalian and Panian area are almost the same and are least in the case of Unong.

iii) Alkaline Contents

They become lesser as the arrow moves rightward.

Himalian —> Panian —> Unong

iv) Slagging Property

It improves as the arrow moves rightward.

Himalian —> Panian —> Unong

v) Fouling Property

It becomes better as the arrow moves rightward.

Himalian —> Panian —> Unong

vi) Erosion Property

It becomes better as the arrow moves rightward.

Himalian —> Panian —> Unong

vii) Coal Consumption Volume

It becomes less as the arrow moves rightward.

Himalian —> Panian —>Unong

viii) Ash Generation Volume

The volume for Himalian and Panian is almost the same and it is least in the case of Unong.

The results indicate that the design coal to be employed in the preliminary designing shall be Himalian clean coal. The future design guideline will be obtained by adopting the source with bigger tolerance with regard to Himalian coal and Panian coal which are considered to be indigenous coal sources in the future.

Coal property which is used for preliminary design is shown in the Table 5.3-3.

Table 5.3-1 Assessment of Overseas Coals Based on Normal Values for Overseas Coal Selection (1/2)

Coal Name	Combustibility		Slagging and Fouling Property				Pulverized Coal Combustion Equipment		Erosion Property		Overall Assessment
	Heating Value More than 5500kcal/kg	Volatile matter More than 20 %	Ash Softening Temperature More than 1200℃	Fe_2O_3 Less than 15 %	CaO Less than 10 %	Na_2O Less than 3 %	Grinda-bility More than 40 HGI	Total Moisture Less than 16 %	Ash loading Less than 30kg/10^6kcal	Quartz Loading Less than 10kg/10^6kcal	
Lemington	○	○	○	○	○	○	○	○	○	○	○
Workworth	○	○	○	○	○	○	○	○	○	△	△
Blair athor	○	○	○	○	○	○	○	△	○	○	△
Miller Blend	○	○	○	○	○	○	○	△	○	△	△
Lithgow	○	○	○	○	○	○	○	○	○	△	△
Ulan	○	○	○	○	○	○	○	○	○	△	△
Datong	○	○	○	△	○	○	○	○	○	○	△

○ : Normal value is fulfilled   △ : It needs additional consideration at design stage

Table 5.3-1 Assessment of Overseas Coals Based on Normal Values for Overseas Coal Selection (2/2)

Coal Name	Combustibility		Slagging and Fouling Property				Pulverized Coal Combustion Equipment		Erosion Property		Overall Assessment
	Heating Value More than 5500kcal/kg	Volatile matter More than 20 %	Ash Softening Temperature More than 1200℃	Fe_2O_3 Less than 15 %	CaO Less than 10 %	Na_2O Less than 3 %	Grindability More than 40 HGI	Total Moisture Less than 16 %	Ash loading Less than 30kg/10^6kcal	Quartz Loading Less than 10kg/10^6kcal	
Berau	×	○	—	×	○	○	○	×	○	○	×
Kaltim Plima	○	○	—	○	○	○	○	○	○	○	○
Tanito Harum	○	○	—	○	○	○	○	○	○	○	○
Malti Harapan Utama	○	○	—	○	○	○	○	○	○	○	○
Utah Indonesia	○	○	—	○	○	○	×	○	×	○	×
Artmin Indonesia Senakin	○	○	—	○	○	○	×	○	×	○	×
Artmin Indonesia Satui	○	○	—	○	○	○	○	○	○	○	○
Kideco Jaya Agung Saramangan	×	○	—	×	△	○	○	×	○	○	×
Kideco Jaya Rato	○	○	—	○	○	○	○	△	○	○	△

○ : Normal value is fulfilled   △ : It needs additional consideration at design stage

Table 5.3-2 Assessment Based on Property Evaluation Index

PROPERTY	INDEX	Indigenous Coal		Overseas Coal	Blended Coal	
		Semirara ROM Average	Semirara Selected Average	Lemington	50 % Semirara ROM and 50 % Lemington	50%Semirara Selected and 50 % Lemington
Combustibility	Good		◎	◎	◎	◎
	Medium	○				
	Low					
Ash loading	Low			○	○	○
	High	△	△			
Alkali contents	Low			◎	◎	
	Medium					○
	High	△	△			
Slagging potential	Low			◎		
	Medium				○	○
	High	△	△			
	Severe					
Fouling potential	Low			◎		
	Medium				○	○
	High	△	△			
	Severe					
Erosion potential	Medium					
	High	△	△			
	Severe			×	×	×

Table 5.3-3 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

Table 5.3-4 Assessment Based on Property Evaluation Index for Indigenous Coal

Property	INDEX	Indigenous Coal			Overseas. C	Blended Coal		
		Semirara Unong Selected Average	Semirara Himalian Selected Average	Semirara Panian Selected Average	Lemington	50% Unong Selected and 50% Lemington	50% Himalian Selected and 50% Lemington	50% Panian Selected and 50% Lemington
Combustibility	Good	◎	◎	◎	◎	◎	◎	◎
	Medium							
	Low							
Ash loading	<30kg/10^6kcal	○			○	○	○	○
	>30kg/10^6kcal		△	△				
Alkali contents	Low	◎			◎	◎		◎
	Medium						○	
	High		△	△				
Slagging potential	Low				◎			
	Medium					○	○	○
	High	△	△	△				
	Severe							
Fouling potential	Low				◎			
	Medium	○				○	○	○
	High		△	△				
	Severe							
Erosion potential	Medium	○						
	High		△	△				
	Severe				×	×	×	×

Table 5.3-5 Coal Analysis Data (1/2)

ITEM		UNIT	INDIGENIOUS		AUSTRALIA						CHINA
			SEMIRARA ROM Arerage	SEMIRARA SELECTED Average	LEMINGTON	MILLER-BLEND	LITHGOW	WARKWORTH	BLAIR-ATHOL	ULAN	DATONG
Proximate Analysis(A/R basis)											
Heating value(HHV)	HV	kcal/kg	3761	4055	6524	6051	5956	6375	5903	6346	6568
Total Moisture	TM	%	30.00	29.00	9.77	10.16	9.31	8.53	18.16	9.00	11.17
Fixed Carbon	FC	%	26.00	29.00	49.80	45.66	46.19	47.81	50.66	48.53	54.15
Volatile Matter	VM	%	28.80	30.00	30.05	28.58	26.83	30.46	24.84	28.93	28.44
Ash	A	%	14.90	12.00	10.39	15.59	17.67	13.20	6.34	13.53	6.24
Total Sulfur	TS	%	0.50	0.60	0.49	0.65	0.47	0.47	0.18	0.75	0.47
Fuel Ratio	FR	%	0.91	0.96	1.65	1.59	1.72	1.56	2.03	1.67	1.90
Ultimate Analysis (Dry Basis)											
Carbon	C	%	57.37	61.61	69.30	68.70	58.00	71.30	75.90	71.59	77.80
Hydrogen	H	%	1.87	2.00	4.50	4.50	4.30	4.60	4.30	4.43	4.50
Oxygen	O	%	19.52	20.51	12.60	8.00	6.40	7.60	10.30	6.98	9.60
Nitrogen	N	%	0.98	1.06	1.60	1.60	1.40	1.60	1.70	1.53	0.90
Sulfur (Combustible)	Sc	%	1.32	1.38	0.50	0.70	0.50	0.50	0.10	0.60	0.40
Fluorine	F	%	NA	NA	0.006	0.00	0.00	0.00	0.00	NA	0.00
Chlorine	Cℓ	%	NA	NA	0.043	0.02	0.27	0.04	0.07	NA	0.80
Ash	A	%	18.90	13.40	11.50	16.50	19.50	14.40	7.70	14.87	6.80
Grindability		HGI	35	35	50	66.1	58	65	70	77	56
Particle Size under 2mm	PS	%	NA	NA	26.00	20.10	25.30	29.70	44.60	15.90	34.70
Ash Composion (Dry Basis)											
Silica Dioxide	SiO_2	%	51.17	45.53	72.80	66.10	65.90	75.60	61.10	77.00	48.20
Aluminum Trioxide	$A\ell_2O_3$	%	21.91	20.01	11.60	20.10	26.10	17.00	33.00	15.90	15.00
Iron Trioxide	Fe_2O_3	%	5.79	7.49	4.20	4.40	1.37	2.82	11.96	3.70	22.50
Calcium Oxide	CaO	%	4.48	7.49	2.20	2.59	0.46	0.62	0.30	0.75	4.42
Titanium Dioxide	TiO_2	%	0.96	0.87	0.20	0.86	1.15	0.82	1.64	0.70	1.48
Magnesium Oxide	MgO	%	3.37	4.16	0.20	1.05	0.11	0.52	0.46	0.20	1.84
Sulfur Trioxide	SO_3	%	4.61	6.68	1.40	1.31	0.10	0.37	0.13	1.15	2.78
Phosphate Pentoxide	P_2O_5	%	0.24	0.25	5.60	0.56	0.14	0.11	0.30	0.01	0.23
Sodium Oxide	Na_2O	%	4.23	5.45	0.20	0.54	0.09	0.29	0.49	0.10	0.37
Potassium Oxide	K_2O	%	1.51	1.34	0.60	1.41	2.01	0.71	0.29	0.35	1.37
Barium Oxide	BaO	%	0.12	0.15	NA	NA	NA	NA	NA	NA	NA
Strontium Oxide	SrO	%	0.15	0.18	NA	NA	NA	NA	NA	NA	NA
Ash Fusion Temperature											
Initial Deform. Temp.	IDT	℃	1050-1560	1050-1560	1240	1230	1340	1210	1410	NA	1260
Softening Temp.	ST	℃	1100-1560	1100-1560	1340	1320	>1450	1320	>1450	1400	1280
Hemispherical Temp.	HT	℃	1110-1560	1110-1560	1400	1340	>1450	1340	>1450	>1560	1320
Fluid Temp.	FT	℃	1110-1560	1110-1560	1480	1450	NA	1450	>1450	>1560	1390

Tabie 5.3-5 Coal Analysis Data (2/2)

ITEM		UNIT	INDONESIAN COAL								
			BERAU COAL	KALTIM	TANITO	MULTI HARAPAN	UTAH	ARUTMIN INDONESIA		KIDECO JAYA AGUNG	
				PRIMA	HARUM	UTAMA	INDONESIA	SENAKIIN	SATUI	SAMARANGAU	RATO
Proximate Analysis (A/R basis)											
Heating value (HHV)	HV	kcal/kg	5254	6774	6172	5946	5690	5924	6581	4790	5667
Total Moisture	TM	%	23.40	10.00	13.50	16.00	8.00	9.00	10.00	24.00	16.80
Fixed Carbon	FC	%	38.93	49.26	41.61	41.53	35.39	38.58	42.10	33.85	41.11
Volatile Matter	VM	%	34.61	36.00	37.41	37.75	36.74	37.25	40.16	40.10	40.92
Ash	A	%	3.33	4.74	7.48	4.72	19.87	15.17	7.74	2.05	1.17
Total Sulfur	TS	%	0.81	0.47	0.51	0.76	0.87	0.66	0.87	0.10	0.13
Fuel Ratio	FR	%	1.12	1.37	1.11	1.10	0.96	1.03	1.04	0.84	1.00
Ultimate Analysis (Dry Basis)											
Carbon	C	%	70.38	75.88	71.97	71.92	61.94	65.33	73.30	65.39	70.99
Hydrogen	H	%	4.88	5.49	5.24	5.19	4.86	5.25	5.58	4.67	5.23
Oxygen	O	%	1.44	11.37	12.31	15.10	9.88	11.08	10.60	23.55	19.92
Nitrogen	N	%	17.90	1.52	1.58	1.60	1.10	1.00	1.19	0.10	0.10
Sulfur (Combustible)	Sc	%	1.05	0.47	0.25	0.57	0.63	0.67	0.73	0.97	0.99
Fluorine	F	%	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chlorine	Cℓ	%	0.01	0.01	NA	0.11	0.02	0.01	0.01	2.63	1.38
Ash	A	%	4.34	5.26	8.64	5.61	21.59	16.67	8.60	2.69	1.40
Grindability		HGI	48.00	50.00	47.00	46.00	37.00	36.00	50.00	50.00	50.00
Particle Size (under 2mm)		%	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ash Composion (Dry Basis)											
Silica Dioxide	SiO_2	%	32.80	50.50	47.50	32.10	53.00	50.90	51.00	28.25	26.50
Aluminum Trioxide	$A\ell_2O_3$	%	21.40	31.50	19.25	31.30	29.60	34.90	36.60	6.80	31.00
Iron Trioxide	Fe_2O_3	%	20.00	10.00	10.50	8.90	6.50	3.50	4.20	42.38	17.70
Calcium Oxide	CaO	%	8.50	1.28	6.90	8.70	3.90	2.40	1.70	11.89	7.74
Titanium Dioxide	TiO_2	%	0.70	1.02	1.43	1.10	2.30	2.80	3.10	0.25	1.35
Magnesium Oxide	MgO	%	3.10	1.21	3.95	3.30	1.70	1.40	0.40	2.29	1.54
Sulfur Trioxide	SO_3	%	9.00	0.52	5.50	5.90	2.70	0.40	1.50	7.94	10.10
Phosphate Pentoxide	P_2O_5	%	NA	0.45	0.09	1.50	0.20	0.30	0.10	NA	NA
Sodium Oxide	Na_2O	%	0.90	1.48	0.33	0.40	0.80	0.20	0.30	0.04	0.77
Potassium Oxide	K_2O	%	0.80	1.80	1.00	1.00	0.20	0.30	0.20	0.04	0.96
Barium Oxide	BaO	%	NA	NA	NA	NA	NA	NA	NA	NA	NA
Strontium Oxide	SrO	%	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ash Fusion Temperature											
Initial Deform. Temp.	IDT	℃	1170	1130	1380	1260-1600	1380	1450	1600	1340	1310
Softening Temp.	ST	℃	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hemispherical Temp.	HT	℃	1260	1380	1450	1340-1600	1510	1570	1600	1380	1310
Fluid Temp.	FT	℃	1360	1480	1450	1360-1600	1570	1580	1600	1410	1330

5.4 Suggestions on Coal Procurement Strategy

For an effective and appropriate operation required for stable and economic procurement of coal from medium and long term perspective at Zambales Coal-Fired Power Project, it is imperative for persons in charge of planning for construction of coal thermal power station to have due and correct recognition of the series of actual business on coal procurement from the initial stage of the construction programme. JICA Study Team recognize that there can be no efficient operation without sufficient knowledge of the coal related business.

In this connection, suggestions have been prepared centering on the appropriate coal procurement strategy for NAPOCOR's guidance.

5.4.1 Present Supply/Demand Balance of Coal and its Future Forecast

First of all, an overview of the present supply/demand balance of coal and its future forecast are present to give a clearer view.

(1) Present Supply/Demand Balance

The amount of coal consumption in the country was about 2.48 million tons while the production of the domestic coal was about 1.34 million tons as shown in the following Table.

Table 5.4-1 Results of Coal Supply/Demand in 1988
(Run-of-mine, 1000 tons)

(Demand)

Electric Power	Cement	Others	Total
1,446 Calaca I (901) Naga I,II (214)	1.014 (14 plants)	19	2,479

(Supply)

Semirara	PNOC-CC	Cebu Isl.	Batan	Others	Total
670	230	243	70	123	1,336

The shortage of coal supply was compensated by imported coal. Imported coal was used at the Calaca power station in Luzon Island and in the Cement industry in 1988 as blending coal. The Calaca power station has one unit of 300 MW coal-fired thermal power plant and Calaca No. 1 was built to utilize the coal from the Unong pit in Semirara island. However, it was changed to utilize blended coal with low alkaline Australian coal instead of Unong coal alone because the actual quality of Unong coal supplied has shown too low heating value for the designed specifications of the boiler and also has slagging and fouling troubles caused by high alkaline contents in the ash and coal itself. After the application of selective mining to grade-up the coal quality, the blending ratio was tentatively set at 6:4 between the Unong coal and the imported coal. As an appropriate blending coal, Australia coal was selected.

On the other hand, the coal supply for cement factories is mostly carried out by PNOC-CC through its coal centers, i.e. Batangas and Poro Point in Luzon Island and Iligan in Mindanao Island, after blending indigenous coal with imported coal mainly from Australia and China.

(2) Future Forecast of Coal

Based on several information and assumptions, a preliminary future forecast of coal demand/supply balance in the country was made as shown in the following table.

Table 5.4-2 Coal Demand/Supply Balance for 1989-2000
(10,000 Btu/lb, 1,000t)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1) Demand in Luzon Island	930	930	930	1860	2790	2790	2790	2790	4650	6510	8370	10230
2) Supply from Semirara	609	609	609	609	1257	1473	1473	1473	1473	1473	1473	1473
3) Shortage	321	321	321	1251	1533	1317	1317	1317	1317	5037	6897	8757
4) Supply Ratio by domestic Coal (%)	65.5	65.5	65.5	32.7	45.1	52.8	52.8	52.8	31.7	22.6	17.6	14.4

According to the JICA team forecast, it is anticipated that coal shortage will arise after 1992 and will require a need by NAPOCOR to attend to this increased coal demand.

A projection of world trade volume of steaming coal published by B.P. Coal Ltd. shows steady growth of 3.9% per annum through the year 2000. The fastest growth area is the Far East. The power generation sector is the one that will provide most of the anticipated growth.

The forecast is based on a "bottom up" approach to the market. Each country was reviewed for its coal-fired electricity generating requirements and plans for increased industrial usage. Indigenous coal production potential was evaluated to determine requirements for net imports.

Two key assumptions were made including continued pressure to reduce domestic coal production subsidies in Europe and oil prices of $15-20 per barrel in constant dollars. The oil price assumption was especially important since it impacts heavily on economic growth which creates electricity demand, the largest source of coal demand.

Committed capacity includes production capacity currently operating and planned expansions from capacity additions and productivity related investment. In Colombia this includes expansion of El Cerrejon North and smaller new production projects for total of 28 million tons by 1995. China remains the biggest uncertainty but included in the forecast is a significant expansion. South African steaming coal exports are assumed to recover to 38 million tons per annum, which is about the recorded level in 1986. Poland and the USSR are forecast to slightly reduce their exports over the longer term due to domestic demand growth and production problems. The US remains the swing supplier and has substantial spare export capability although at prices higher than current market levels. Hence, the two-part breakdown for the US which includes capacity at "market" prices. Australia is expected to recover to reach the 1987 export levels and then experience moderate expansion of largely brownfield nature.

Supply and demand are expected to remain roughly balanced into the early 1990s. Several new projects will be required to meet forecast demand for the mid-late 1990s. The most certain of these are the Kaltim Prima (BP/CRA) project in Indonesia and the Zulia (ARCO/Agip) project in Venezuela.

Notwithstanding the above forecast, it is considered that the tight situation of availability is expected to continue into the coming years despite forecasts of increased export from Colombia, China and Venezuela. Price levels reflect the market's expectation for continued tight market conditions.

There is concern that present tendency of tightning in international coal market is likely to accelerate further tightning of the coal market especially in the Asian area. At present, availability of coal has not decreased greatly, but there are possibilities that rapid increased coal demand at world scale will easily lead stricter availability situation for coal in the Asian market.

For this reason, it is advisable for NAPOCOR to pay more attention to establishing a perspective on a long term strategy for appropriate coal procurement and set up NAPOCOR's fuel unit.

5.4.2 Appropriate Procurement Strategy

(1) Objectives of Diverisifation of Procurement Sources

The most important objectives which must be sought for by a coal buyer in establishing its procurement strategy are:

i) security and reliability
ii) flexibility
iii) economy

Security and flexibility are sometimes incompatible with each other. However, securing fuel for generation is the primary concern for electric utilities that have social responsibilities to ensure an uninterrupted supply of electric power for the public interest.

In terms of security, a certain overcommitment is a necessity in the planning stage in order to hedge risks of shortage of supply caused by discontinuation or closure of a mine or disruptions due to strikes and accidents at mines and transportation facilities.

On the other hand, there is always a possibility of fluctuation in demand due to unexpected situations in the construction and operation of power station, such as substantial delay in commissioning of the generating plant, actual load factor being different from that in planning stage, changes in plant efficiency, failure of power station operation, and so on.

It is therefore imperative that the utility buyer is well prepared for the aforementioned changes. In other words there must be sufficient flexibility in its procurement programme.

To this end, long-term contracts should be the basis of its procurement programme, supplemented by spot purchases for added flexibility.

While economy is also a crucial factor, it should be noted that most economical coal procurement mix at the present moment may not necessarily be the one which ensures future economy. For this reason, the coal procurement mix must be reviewed every several years for achieving maximum economy.

In terms of both security and economy, diversification of coal source is essential for the buyer. Diversification will not only serve to guard against supply disruption but also enhance the spirit of emulation both among coal exporting countries and even among suppliers within the same country but from different loading ports.

(2) Long-Term and Spot Purchasing

In order to examine security and flexibility of long-term and spot contract combinations, comparison was made between the two cases of quantity shares by contract as shown in the table below:

Table 5.4-3 Combination of Contracts and Quantity Shares

	Case (a)	Case (b)
Long-term contract with ± 10% option	80%	90%
Spot purchases without option	20%	10%
Total	100%	100%

Quantity adjustment which the buyer can make and which can affect the above combinations and as calculated is shown below:

Table 5.4-4 Quantity Adjustment

	Case (a)	Case (b)
Plus adjustment	+8%	+9%
Minus adjustment	-28%	-19%

It will be seen that Case (a) provides greater flexibility, and it would be appropriate for the initial combination of purchase contracts for Zambales Coal-Fired Power Project in Luzon (also includes Calaca 2). In case (b) certain measures have to be built in coal purchase contracts.

The combination of long-term contracts and spot purchasing should also take economics into consideration. Spot prices from a certain origin are normally lower than those of long term contracts from the same origin in both under and over-supply situations, and, vice versa, under a tight market situation. It exists for the next years, but in the long run supply and demand would tend to balance.

(3) Diversification and Number of Suppliers

These two captioned subjects are closely related to each other and it would be more appropriate to comment on these subjects together than to explain them separately.

Discussions on diversification are summarised below:

i) Purpose of diversification

Hedging risks of supply disruptions or cut-backs caused by the supplier and ensuring the security of supply, and

Stabilisation of prices by encouraging competition among the suppliers and keeping the bargaining power to the buyer's side by playing one supplier against another.

ii) Extent of diversification is determined on a case to case basis depending on:

- Reliability of a supplier
- Geographical distance betweeen producer and consumer
- Delivered prices of coal from various sources, and
- Trade relations between the exporting and importing countries

Determination of an optimum diversification scheme for the buyer is a discrete issue and there are no absolutes. Theoretically, the most effective diversification plan is determined through a cost benefit analysis. The benefit of a diversification policy, however, is virtually intangible in monetary terms. Additional costs required for diversification should be allowed at a reasonable extent like insurance premiums.

While we agree that Australia would be the most competitive source of coal for the Philippine import, we suggest that the allowable maximum share of Australian coal be about two-thirds of the total quantity.

Chinese coal would be almost as competitive as Australian coal in terms of CIF cost to the Philippines, and its supply capability and reliability are increasing tremendously based on the assistance from Japan and other nations.

The Japanese Government made a commitment in 1979 to extend a Yen credit equivalent to US$1.5 billion to the Chinese Government for the development of coal infrastructure facilities. Concurrently, the Export and Import Bank of Japan extended credit for the amount of US$940 million to fund the development of coal mines.

Thus the Chinese Government is proceeding with the extension of Qinhuangdao Port, the construction of Shijiusuo Port, the construction and extension of railways and the development of seven (7) coal mines including Sitaijou and Ziqu. The coal mines will eventually produce a total of 12 million tons, of which six (6) million tons will be steaming coal. Full scale operations are expected only after 1990. The new Qinhuangdao Port is scheduled to be completed next year.

Apart from these collaborations on a governmental basis, private enterprises in the United States and Japan agreed to carry out feasibility studies for the development of coal mines in joint ventures with the Chinese Government.

A major drawback of Chinese coal is the present state of poor quality control. The Japanese buyers are pushing very hard for effecting remedial measures at the supplier's cost and the Chinese supplier is making its best efforts to overcome the problems.

Indonesia is another attractive source as it is geographically well-placed in relation to the Philippines. Some development schemes in Kalimantan are being studied for production, probably from the mid 1990's with full scale production, it can become a main source of supply provided its coal quality is satisfactory.

It is considered that both China and Indonesia have huge potentialities for coal export to the future market. It is therefore recommended that NAPOCOR keep an eye on these two countries and shift some supply quantity from Australia to that from China and/or Indonesia in due course when the opportunity comes.

The current status and future potentialities of proposed coal mines in Australia, China and Indonesia are as stated in Appendix 5-2. In addition, information on proposed coal mines in Colombia U.S.A. and Canada are shown in Appendix.

The following diversification scheme is suggested for NAPOCOR assuming that NAPOCOR's additional amount of coal procurement would be around 1.5 million tons around the mid 1990's.

Table 5.4-5 Suggested Diversification Scheme for NAPOCOR (1.5 million tons per year basis)

Quantity ('000 tonnes)	Types of contracts & Diversification	Number of suppliers
800 - 900	Long-term contract from Australia	4 - 5 [Note (i)]
300	Long-term contract from China	One [Note (ii)]
400 - 300	Spot purchasing from (Australia, US, Canada, Indonesia, Colombia)	Several [Note (iii)]

(Note) (i) One of the short listed Australian suppliers might be categorised as a spot purchasing source upon negotiation.

(ii) It is assumed that China National Coal Import & Export Corporation - a government agency - will be the supplier of export abroad.

(iii) Indonesia, for the time being, is regarded to be a spot source.

(iv) South Africa, one of the most competitive sources for the world market, is excluded from the objective of this report.

In our view, the suggested diversification scheme provides adequate reliability, flexibility and economy.

Ratio of quantity shares between the long term contract and the spot purchase is in the order of 80:20 and is appropriate in view of the foregoing analyses.

The number of Australian suppliers would be four (4) or five (5), and would balance well for New South Wales and Queensland.

Examples of contract quantity are shown below in thousand tons:

In case of 4 suppliers	Example A	200 x 4 = 800
	Example B	250 x 2 + 200 x 2 = 900
In case of 5 suppliers	Example C	200 x 4 + 120 x 1 = 920

(4) Duration of Contract

There are no absolutes in determining the duration of contract. For each contract, it would be left open for negotiation.

From EPDC's experience, long-term contracts with extremely long or indefinite (or "ever green") duration are not recommended. This is because it would be to the buyer's advantage to limit the duration under a normal or sluggish state of the market.

Although most long term contracts are provided with the termination clause thereby allowing either the seller or the buyer to terminate the contract upon disagreement on the price over an extended period of time, usually it is very difficult to do so. The suggested maximum duration is therefore 10 years. For Chinese coal, a longer duration (e.g., 15 years) may be justified since it is a Government-to-Government transaction.

With regard to Australian suppliers, whose share of the total supply quantity should decrease with the passing of time, the duration of some contracts should be kept within three (3) to five (5) years.

(5) Suggested Procurement Mix

As a summary, the suggested procurement mix showing diversification, duration of contracts, number of suppliers, and contract tonnage is given below:

Table 5.4-6 Suggested Procurement Mix for NAPOCOR
(Unit: '000 tons)

- 1,500
  - 900 Australia
    - 450 QLD
      - 250 10 year contract with price escalation and review at 2 years intervals
      - 200 3 to 5 year contract, annual pricing
    - 450 NSW
      - 250 10 year contrat
      - 200 3 to 5 year contract
  - 300 China ---- 10-15 year contract, annual pricing
  - 300 Australia, US, Canada, Indonesia, Colombia
    - 150 US or Canada, 1 to 3 year contract annual pricing (semi-spot purchasing)
    - 150 Indonesia, Australia Colombia, spot purchasing

5.4.3 NAPOCOR's Fuel Unit Set-up

(1) Background

The significance of adopting the most suitable organizational set-up for NAPOCOR coal procurement should not be understated. This is chiefly because of (i) the large expenditure incurred from importing coal and (ii) the expertise required for import transaction of coal which is a unique energy commodity in a fairly new international market.

To illustrate and elaborate on the above, let us first assume an average CIF cost of coal delivered to the Philippines to be 45 US dollars per ton. NAPOCOR will spend annually 67.5 million US dollars to buy 1.5 million tons per annum of coal for burning at a power atation. The bulk of the payment will be in foreign currency, so that it will best serve NAPOCOR's interest as well as that of the Philippine Government to implement the procurement in an efficient and economical manner.

Secondly, it would be practically the first time yet for Philippines, let alone NAPOCOR, to utilize a large quantity of coal on a long-term basis. This makes the start-up still more difficult as coal experts are not readily available within the country.

International steaming coal trade has recently expanded and its market has not yet developed into such stage of maturity as that of other commodity markets. As a result, there is no price setting or controlling mechanism for coal, such as OPEC for crude oil and the LME for various metals like tin and copper.

Consequently, purchase prices of various grades of coals are individually determined solely on the basis of negotiations between sellers and buyers. In order to take advantage of the bargaining, sophisticated coal buyers continuously conduct market analysis investigating trends in world's energy supply and demand situation, volume and traffic of sea-borne trade, average market prices by origin, actually contracted prices of winning best prices, and it takes a great deal of experience to gain such know-how and learn the tactics.

Logistics and import processing also require experienced personnel. In order to secure stable supply and reduce ocean freight costs, advantageous shipping arrangements are imperative and timely dispatch of coal carriers must be made to avoid demurrages at ports. Clearance of import procedures and settlement of foreign exchange payment may be too specialised for NAPOCOR to carry out for themselves.

(2) Work Description for Coal Procurement

i) General

(a) Market research

Information is collected from trade journals, through enquires to and presentations from suppliers or discussions with other consumers. Analyses and evaluation are carried out concerning world demand and supply of coal, trend in market prices, situations in coal producing countries, suppliers, mines and infrastrucure. This forms the basis for planning and contract negotiations.

(b) *Procurement policy and planning*

Based on the long term demand projections and market research, procurement policy and planning are made with regard to optimum supply mix, types of contracts, quality requirements, criteria for selection of suppliers, etc.

(c) Purchase contract

Selection of suppliers, negotiations and execution of purchase contracts are performed. Subsequently, price review will take place every year or at intervals of a few years.

(d) Planning and administration of deliveries and consumption

Deliveries of coal to the power station stockyard, rate of consumption and stockpile volume are monitored. Coal handling is administered. Based on short term projections of demand and monitoring data, shipment schedules are planned and loading notices are provided to suppliers. Records are prepared for administration and account in purposes, and periodic inventories are carried out to confirm book values.

(e) Quality control

Based on coal quality analysis by sampling tests, compliance with contract terms and compatibility with combustion and handling facilities are monitored.

(f) Transportation policy and planning

Policy and planning related to ocean transport is made in conjunction with development plans for setting up receiving ports and unloading facilities.

(g) Shipping arrangement and administration

Contracts with shipping companies for ocean transport are concluded and operations of ships are supervised and monitored.

(h) Administration of associated work

Administration of import processing is carried out, including customs clearance, foreign exchange payment, cargo insurance, etc. Communication with suppliers is maintained and relevant information is provided to NAPOCOR.

Administration of deliveries and consumption and quality control are primarily the responsibilities of power station staff who actually supervise use of coal, but there must be a close cooperation with NAPOCOR's headquarter which will have an overall control over the logistics.

ii) Work Categories

For the purpose of this suggestion, the above-mentioned work is divided into several categories so as to facilitate explanation on the necessary work force for NAPOCOR's headquarters, like:

(a) Planning and contract
(market research; procurement policy and planning; transportation policy and planning; purchase contract)

(b) Delivery
(planning and administration of deliveries and consumption; quality control)

(c) Shipping
(shipping arrangement and administration)

(d) Associated work
(administration of import processing; communication with suppliers; provision of relevant information)

iii) Suggested Organization

The following organization chart is suggested:

Table 5.4-7 Suggested Organization Chart of NAPOCOR's Fuel Unit

Fuel Unit Manager

- **Planning and Contract**
  - Number of Staff: 2 to 3
  - Work Category : I
    - Market research
    - Policy and planning
    - Purchase contract
- **Logistics Group Leader**
  - Number of Staff: 3 to 4
  - Work Categories: II, III, IV
    - Delivery
    - Shipping
    - Associated work

Note: Number of staff indicates only professional staff excluding managerial members and will vary according to involvement of other fuels to be administered.

5.4.4 Ocean Transportation Scheme

(1) Transportation Contract

Long term stability and economy are the major objectives in the ocean transportation of coal.

To best attain these often-conflicting objectives, a best mix of different contract types should be studied, taking into account inherent characteristics of the shipping market.

The maritime market greatly fluctuates depending on world economic conditions, seaborne trade volume of materials and natural resources (such as oil, coal, iron ore, grain, etc.) and on availability of vessel space. (Refer to Fig. 5.4-1)

As indicated in Fig. 5.4-1, a long depressed maritime market has prevailed since late 1982. However, recent observations indicate that the market may tighten to some extent within several years as the present surplus in vessel space would be curtailed.

There are basically two types of shipping contract for coal: one is spot chartering of a vessel when actually needed and the other one is COA (contract of affreightment) in which shipping companies contract to transport a prescribed cargo quantity over a prescribed period of time.

A special form of COA is a dedicated carrier employed exclusively by a specific charterer for a period as long as 10 years. This arrangement is not very common and often uneconomical over the long term.

In spot chartering, freight rates are determined by prevailing market conditions at the time of charter. When the market is as slack as it is now, a vessel can be chartered at a considerably low freight rate. Should the market become very tight in several years, however, there is a certain risk in securing vessels at the right moment and even if they can be secured the freight rates could be extremely high.

In COA, on the other hand, 1 to 3 year term to be considered as contract period, it is customary to fix the freight rate on the basis of an estimated average market level during that period, and therefore transportation can be secured at a relatively stable cost. Consequently, when awarding coal shipping contracts, it is recommended that a best mix of COA and spot charter be adopted to maintain a good balance of stability and economy and thereby retaining operational flexibility to cope with fluctuations in the amount of coal consumption.

Concerning tonnage share of COA and spot charters, it would be logical to transport coal purchased under COA term, and coal purchased under spot arrangements by spot chartering.

(2) Vessel Size

In principle, the larger the vessel the lower the ocean freight per ton of coal. On the other hand, the capital investment required for the berth of the unloading port and the unloading facilities increases with an increasing vessel tonnage.

Berth occupancy factor is smaller for larger vessels when receiving the same amount of coal per year. A larger coal yard should also be prepared for larger vessels in order to cope with a larger coal stock fluctuation.

When a coal-fired thermal power plant is constructed on a seashore site where the sea is shallow, it may be physically impracticable to provide adequate water depth at the berth to accommodate large draft vessels. In such a case, a long jetty of some several kilometers in length must be constructed to provide a berth far off-shore, resulting in a prohibitive capital cost which negates the economy of the power plant.

Under these circumstances, a coal transshipment station (sometimes this is named as Coal Center) may be used or constructed at a site not too far from the power plant where deep water is available.

In such a scheme, coal from remote exporting countries are carried by large vessels of 100,000 to 150,000 DWT class, and then transferred at the transshipment station to small vessels accessible to the shallower berth of the power plant. The total transportation cost of coal is then the sum of the ocean freight from the coal supplying country to the transshipment station, the handling charge at the station, and the secondary freight to the power plant.

The scheme's economy is generally inferior to that of direct coal transport from the supplying country to the power plant, although the relative advantage depends on the type of vessels used.

From this viewpoint, we advise overseas coal is shipped to power plant directly and the cost comparison for two cases, 30,000 DWT and 60,000 DWT, was performed assuming transportation from New Castle, Australia to Calaca as follows:

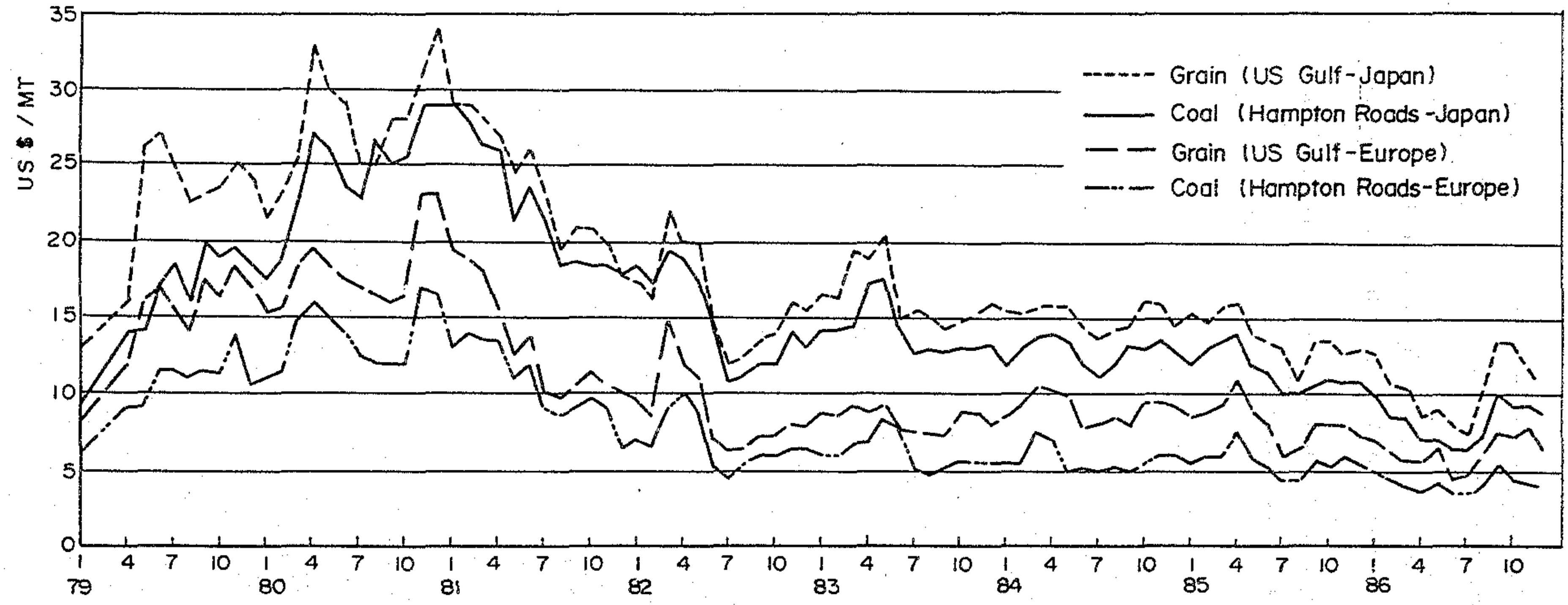
i)	Unit freight cost difference between: 60,000 DWT and 30,000 DWT vessels		2 US$/ton and over
ii)	Annual coal consumption for 2 x 300 MW plant	:	1.31 million tons
iii)	Annual freight cost saving with 60,000 DWT against 30,000 DWT vessel	:	US$2.61 million (370 million yen)
iv)	Investment cost saving equivalent the cost of iii) above	:	US$13 million to (1,800 million yen)
v)	Additional port construction cost US$ with 60,000 DWT against 30,000 DWT port	:	US$2.9 to 3.6 million (400 to 500 million yen)

As indicated by iv) and v) above, coal transportation cost savings with a 60,000 DWT vessel is a greater advantage than the lower construction costs of a 30,000 DWT vessel port.

Vessels most available in the world maritime market are between 60,000 and 70,000 DWT. Certain coal loading ports limit the allowable minimum vessel size for enhancing loading efficiency, which is an important factor to be considered for the vessel size selection, especially when planning of a coal supply to be required from the various sources.

For example, the lower limit at major coal loading ports in Australia is approximately 20,000 DWT by regulation.

Accordingly, a 60,000 DWT vessel should be selected for imported coal transportation.



Source: Platon Monthly

Fig. 5.4-1 Representative Ocean Freight

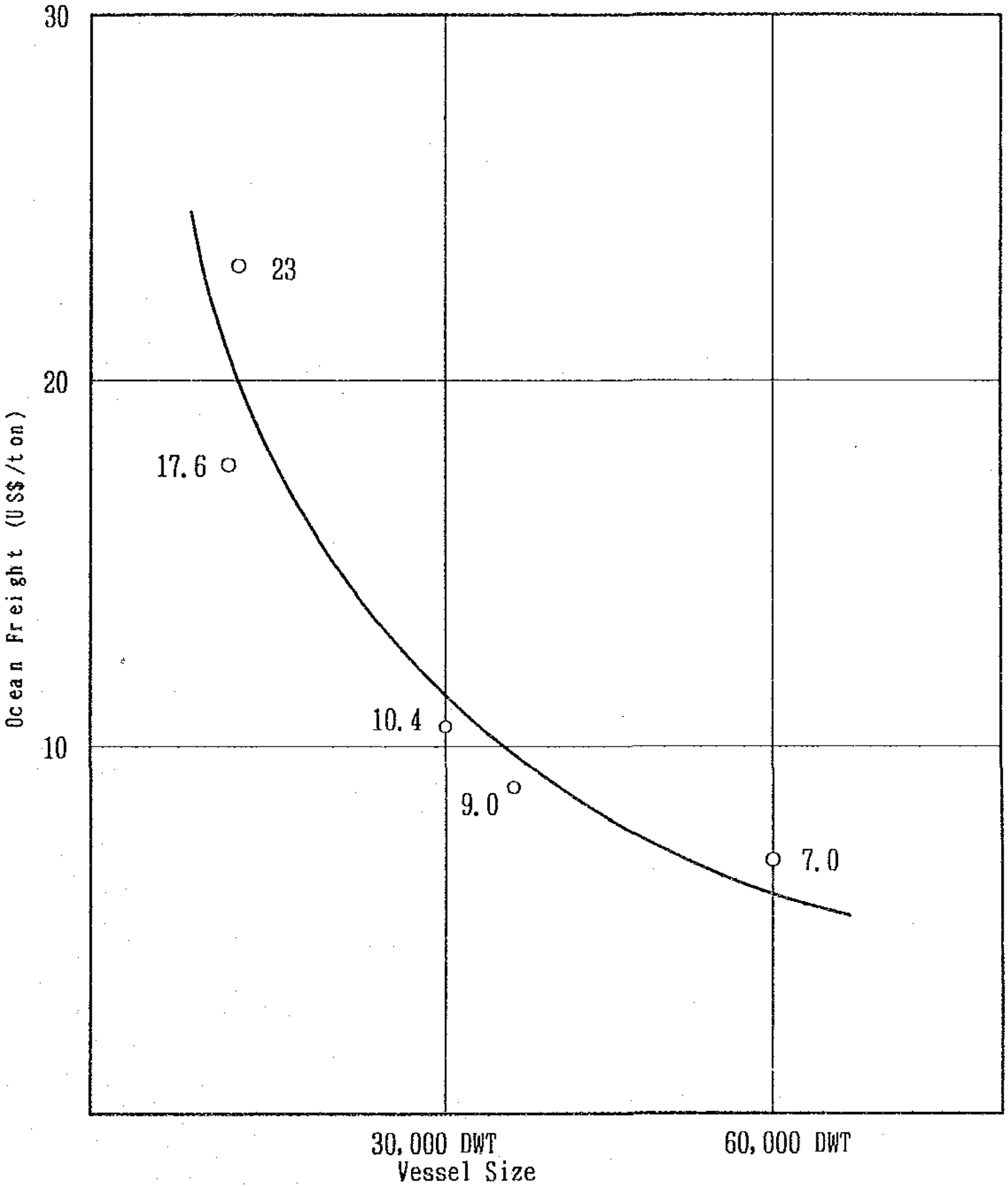


Figure5.4 − 2 Ocean Freight vs Vessel Size (New Castle, Australia - Calaca)

Table 5.4-8 Possible Coal Loading Ports for Proposed Power Plant

		South Africa	Colombia	United States				
		Richards Bay	Puerto Bolivar	Mobile	Davant (Electro-Coal Transfer Terminal)		Norfolk	Newport News
		Coal Berth No. 301-304		MacDuffie Terminal	No. 1 Dock	No. 2 Dock	Western Pier No. 6	C & O Pier # 14
Operator		South African Railways & Harbours Ad.		Alabama State Docks Dept.	Electro-Coal Transfer Corp.		Norfolk & Western Railway Co.	Chespeake & Ohio Railway Co.
Available Number of Vessel		2 - 4	1	1	1	1	2	1
Channel Depth (m)		19.0	19	12.19	(SWP) 12.50	(SWP) 12.50	13.72	13.72
Berthing Basin	Length (m)	1,400	-	319	442	486	549	332
	Depth (m)	19.0	17	12.19	16.76	16.76	14.33	13.72
Max. Acceptable Vessel	Size (1,000DWT)	170	150	130	130	60	(Partial) 160	(Partial) 160
	LOA (m)	314	300	292.61	290	290	488	297
	Beam (m)	47.25	45	35.05	40.8	40.8	45.72	45
Shiploader Capacity (t/h)		10,000 × 1 9,000 × 2	11,000 × 1	2,000 × 1	4,000 × 1 6,000 × 1	3,000 × 1	3,000 × 2	250 × 2
Shipping Capacity ('000 t/y)		44,000	15,000	7,250	25,000		32,000	15,000
Coal Stockyard Capacity ('000 t)		4,000	1,700	1,724	4,800		800	800

Table 5.4-9 Possible Coal Loading Ports for Proposed Power Plant

		Australia									
		N S W				Q L D					
		Port Kembla	Newcastle			Gladstone			Hay Point		Abbot Point
			Basin	Channel	Kooragang Coal Loader	Barney Point	Auckland point	Clinton Estate	Hay Point	Dalrymple Bay	Coal Berth
Operator		MSB	Loader : MSB Yard : PWCS	Loader : MSB Yard : PWCS	KCL	Bulk Handling Co.	GHB	GHB	Hay Point Service Pty., Ltd.	Dalrymple Bay Coal Terminal Pty., Ltd.	Abbot Point Bulk Coal Pty., Ltd. MIM
Available Number of Vessel		1	1	2	1	1	1	1	2	1	1
Channel Depth (m)		15.25	15.2	15.2	15.2	15.0	14.7	15.0	13.4	13.4	17.0
Berthing Basin	Length (m)	250	384	560	311	204	577.88	340	(No.1) 204 (No.2) 189	254	264
	Depth (m)	16.25	11.6	16.5	16.5	15.0	11.3	17.2	(No.1) 16.86 (No.2) 17.17	20	19.3
Max. Acceptable Vessel	DWT (1,000DWT)	110	60	110	250	80	60	150	(No.1) 150 (No.2) 200	200	16.5
	LOA (m)	290	250	290	290	242	238	270	(No.1) 300 (No.2) 300	320	297
	Beam (m)	45	33.53	43	46	43.5	32	42	(No.1) 50 (No.2) 50	50	47.5
Shiploader Capacity (t/h)		6,600 × 2	1,000 × 2	2,500 × 3	10,500 × 1	2,000 × 1	800 × 2	4,000 × 1	(No.1) 4,500×1 (No.2) 6,000×1	6,600 × 1	4,600 × 1
Shipping Capacity ('000 t/y)		1,4000	28,000		15,000	7,000	3,800	13,500	22,000	15,000	6,500
Coal Stockyard Capacity ('000 t)		600	90	700	900	400	300	2,000	2,500	1,500	1,250

Table. 5. 4-10 Possible Coal Loading Ports for Proposed Power Plant

		China	
		Qinhuangdao	Shijiusu
		New Berth Phase II	-
Operator		Ministry of Transport	Ministry of Transport
Available Number of Vessel		2	2
Channel Depth (m)		13.0	15.0
Berthing Basin	Length (m)	600	452
	Depth (m)	14.0	15.0 17.0
Max. Acceptable Vessel	Size (,000 DWT)	60	100
	LOA (m)	230	NA
	Beam (m)	33.0	NA
Shiploader Capacity (t/h)		6,600 × 2	6,000 × 2
Shipping Capacity ('000 t/y)		20,000	15,000 (7,500 for Export)
Coal Stockyard Capacity ('000 t)		1,000	1,200
Completion		July, 1985	Test loading commenced in May, 1986

CHAPTER 6

CONCEPTUAL DESIGN

FOR GENERATING FACILITY

Chapter 6 Conceptual Design for Generating Facility

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CHAPTER 6 CONCEPTUAL DESIGN FOR GENERATING FACILITIES

6.1 General

6.1.1 Basic Concept

The following items should be considered when conceptualizing a design for generating facilities, especially a coal-fired power plant using overseas coals.

(1) First of all, since a large amount of coal is imported from overseas, a large coal carrier is required. Thus, large-scale port is a must. This port plan must be a plan which enables a is necessary to acquire the services an expert who is well versed in navigating large-scale vessels.

(2) The coal handling facilities (including the study of capacity of coal storage yard) should be optimized for the following problems. A vessel for transporting overseas coal does not come into port as scheduled due to weather conditions and waiting at the loading port.

This factor is closely related to the capacity of coal handling facilities and coal storage yard. We succeeded in optimizing this problem by simulation when planning overseas coal power plant for the first time in Japan in 1981. Utilizing this program, we verified optimization of the coal handling facilities of the project.

(3) Regarding the layout of equipment in power stations, it is desirable that a series of flow from the receipt of fuel up to the transmission of electricity 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, topological 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 but reduction in construction cost as well as ease of maintenance should be also considered.

(4) Important items in the planning of boiler and turbine facilities are: the boiler should be suited for a selected fuel; and the steam conditions should be economical.

However, a problem when utilizing overseas coals is that it is not practical to consider that a particular coal can be obtained over the life time of a power station (in this case 30 years). Thus, it is necessary to select a standard coal for designing the boiler economically considering the tendency of overseas coal market. We selected Australian Lemington coal for this case.

Also, it is necessary to determine steam conditions considering the life of power station and ease of maintenance.

(5) Generator is connected to transmission line. Namely, the generator is subjected to electrical influence of the transmission line. This point is 250 km away from the consumption area, Manila, which greatly influences the determination of the characteristics of a generator including short-circuit ratio and power factor.

Also, it is necessary to select motor voltage of important equipment within the power station, taking into consideration reliability and economy.

The conceptual design of the generating facilities is prepared focused on the above points. We believe that it will serve to give guidance in the specifications of Tender Documents to be prepared by NAPOCOR.

6.1.2 Features of the Project

(1) The position of unloading jetty is selected considering the sea-bed terrain of Oyon Bay and berthing large coal carrier to a point as close as possible to the power station. This siting will place the berth in franguil sea and shorten conveyer length to the coal-storage yard.

(2) Ease of operation of vessel and improvement of safety are achieved by providing a turning basin at the front of jetty.

(3) Ash disposal area is located on land closer to the plant which enables to prepare an economical plan. The capacity of this ash disposal area is for a period of 30 years operation. A realistic approach is to prepare disposal area for about 10 years operation, as first step, and then expand it successively as the need arises for more space.

(4) As imported coal will be used, it is necessary to incorporate in the plan capacity of coal handling facilities (e.g., unloader, coal yard, conveyer, stacker, reclaimer). For this purpose, the plan for facilities were optimized by simulation. The coal yard is based on receiving and discharging systems by stacker and reclaimer. This system is better compared to using bulldozer from the point of view of mitigating dispersion of dust and noise.

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

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

(7) It is a recent tendency to adopt one casing for low-pressure turbine of 300 MW class. This improves the total economy of the equipment.

(8) As a result of studies for improving efficiency, the number of extraction stages has been selected to be eight (8).

(9) The short-circuit ratio of generator is 0.58 and the power factor is 0.9 taking into account the result of power system analysis.

(10) 6.9 kV motors have been selected for the power station. This will enable the motor to be compact and reduce the cost of cables.

(11) 120 m high stack has been selected for environmental consideration. The stack will be made of concrete adopting most recent construction practice to achieve economy.

6.2 Preliminary Design Conditions

6.2.1 Site Conditions

(1) Location and Access to the Site

Masinloc, a municipality of the province of Zambales within Region III, faces the South China Sea at the west coast of Luzon island and is situated at lat. 15°34' N, and long. 119°55' E. National road No. 3 (high way) and No. 7 extends to the project area from Metro Manila via the main cities/municipalities of San Fernando, Olongapo, and Iba. The distance is approximately 250 km.

The power plant site is accessible from Masinloc by travelling north on the national road for approximately 5 km and then to the west (Bani Point) for a distance of approximately 2.6 km. (See Fig. 6.2-1)

(2) Climate

i) Outline

The Philippine archipelago has a tropical climate and has a relatively high humidity, mild temperature, and abundant rainfall with three pronounced seasons: wet or rainy from June to September; cool, dry from October to February and hot, dry season from March to May.

For the preliminary design we used the observation data obtained at the National Institute of Climatology (PAGASA) in Iba municipality at approximately 37 km south of site as a climate.

Table 6.2-1 and Fig. 6.2-2 show the climatological normals at Iba, Zambales and Table 6.2-2 shows the climatological extremes.

ii) Temperature

The average value of maximum temperature of a day is 31.5 degrees, the average temperature is 27.0 degrees, and the average value of minimum temperature of a day is 22.5 degrees for the past 35 years. The maximum temperature of a day is 33.3 degrees in April and the minimum temperature of a day is 20.3 degrees in January. The monthly difference of temperature is only 2.7 degrees.

Also, the maximum temperature for the past 47 years is 38.8 degrees in April and the minimum temperature is 12.2 degrees in September.

iii) Rainfall

The annual average rainfall for the past 35 years is 3,702 mm, which is concentrated during the rainy season from June to September. During this period, the rainfall is approximately 83% of the annual total. Also, the rainy days are approximately 66% of the total days in a year.

The maximum rainfall in a day in the past 76 years is recorded as 624 mm in September.

iv) Relative humidity

The average relative humidity for the past 35 years is 79% and the average relative humidity during the rainy and dry seasons is 86% and 76%, respectively. There is a difference of 10%.

v) Wind

The wind distribution diagram is shown in Fig. 6.2-3 using the data of direction and speed of wind for each 3 hours for 5 years (1981 - 1984) at the National Institute of Climatology (PAGASA) stations in Iba, Zambales.

According to the table and figure, prevailing wind directions is NE to E and NW. Wind velocity of less than 2.0 m/s accounts for 54% and less than 8 m/s accounts for 97% during the above period. Wind velocity over 8 m/s accounts for 3% and the direction is SE to SW.

Also, the maximum wind velocity for the past 21 years is 47 m/s (SW) as shown in Table 6.2-2.

(3) Marine Condition

i) Tide

The tidal level data in this sea area are listed in the sea chart "Ports Masinloc and Matalvis and Palauig Bay", and the tidal level of port Masinloc is shown below:

Tides (refer to mean lower low water)	Port Masinloc
Mean higher high water	2.8 ft. (0.85 m)
Mean sea level	1.5 ft. (0.46 m)
Lowest tide to be expected	-1.5 ft. (-0.46 m)

The mean monthly-highest water level for four years calculated from the tidal table from 1981 to 1984 is 1.3 m from the datum level and the mean-monthly lowest water level is ±0.0 m.

The frequency of occurrence of high tide and low tide in this sea area is two times per day for approximately 40% of the year and once per day for the remaining 60%.

ii) Tidal stream

The flood and ebb tides flow to the south and north, respectively, at the west coast of Luzon and their average highest flow rate is approximately one (1) knot. Although the ocean current in the South China Sea changes according to the seasonal wind, the ocean current at the west coast of Luzon mainly flows to the north and the average highest flow rate is approximately one (1) knot.

There is only limited data of tidal current and ocean current in Oyon Bay. According to observations near the cooling water-intake site performed by the JICA study team, the tidal current was 0.3 knot or less (full moon: July 19/20). On the other hand, there is another information from ships which entered Masinloc harbor that there is a relatively strong tidal current.

iii) Wave

The South China Sea is a vast open sea area extending in the direction of north east - south west. Continuous north east seasonal winds generate high waves from north and north-east.

The south west seasonal winds generate waves from south and south west. Also, tropical low pressures causes extremely high waves and resultant swells reach far into the remote areas.

According to the Ocean Wave Data (See Table 6.2-4), approximately 85% of the waves have a height of 2 m or less and last for a period of 3 to 8 seconds. These indicate the features of wave when a wind of approximately 10 m/s is generated continuously in a wide open sea.

A high wave with a height that exceeds 4 m is less frequent but last for a longer period of 7 to 9 seconds. It shows the features of the wave when a strong wind is generated for a short time.

iv) Sea water temperature

Fig. 6.2-2 shows the monthly change of surface water temperature observed by ships in the South China Sea. According to this figure, annual mean water temperature is 28.1°C, maximum water temperature is 35°C in June and minimum water temperature is 20°C in February. Also, according to observation of water temperature made at the proposed cooling water intake site by the JICA study team on July 19 and 20, the sea water temperature was 29 to 30 degrees and the change in water temperature in vertical direction was small.

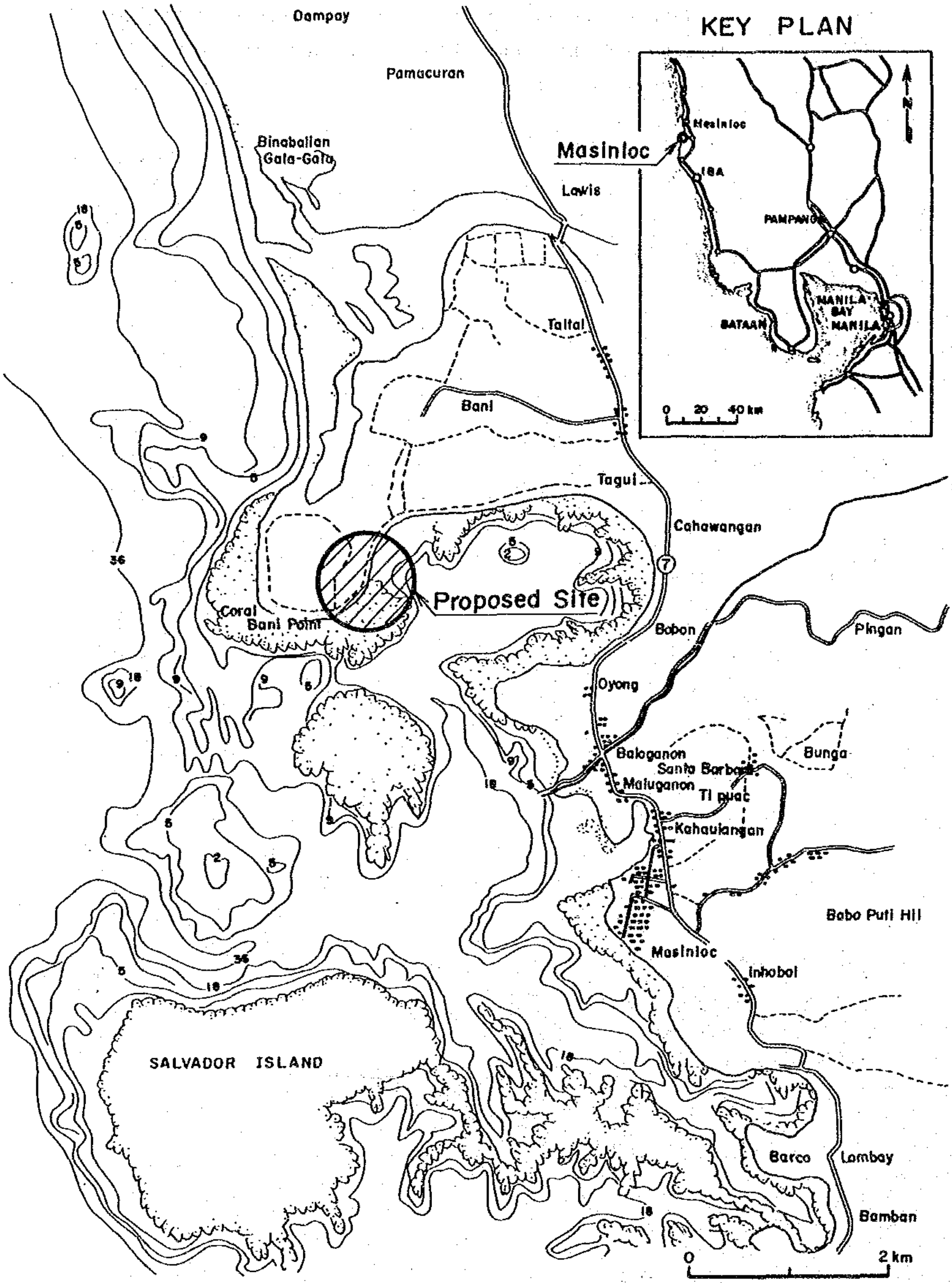


Fig.6.2-1 Site Location (Masinloc, Zambales)

Table 6.2-1 <Climatological Normals>

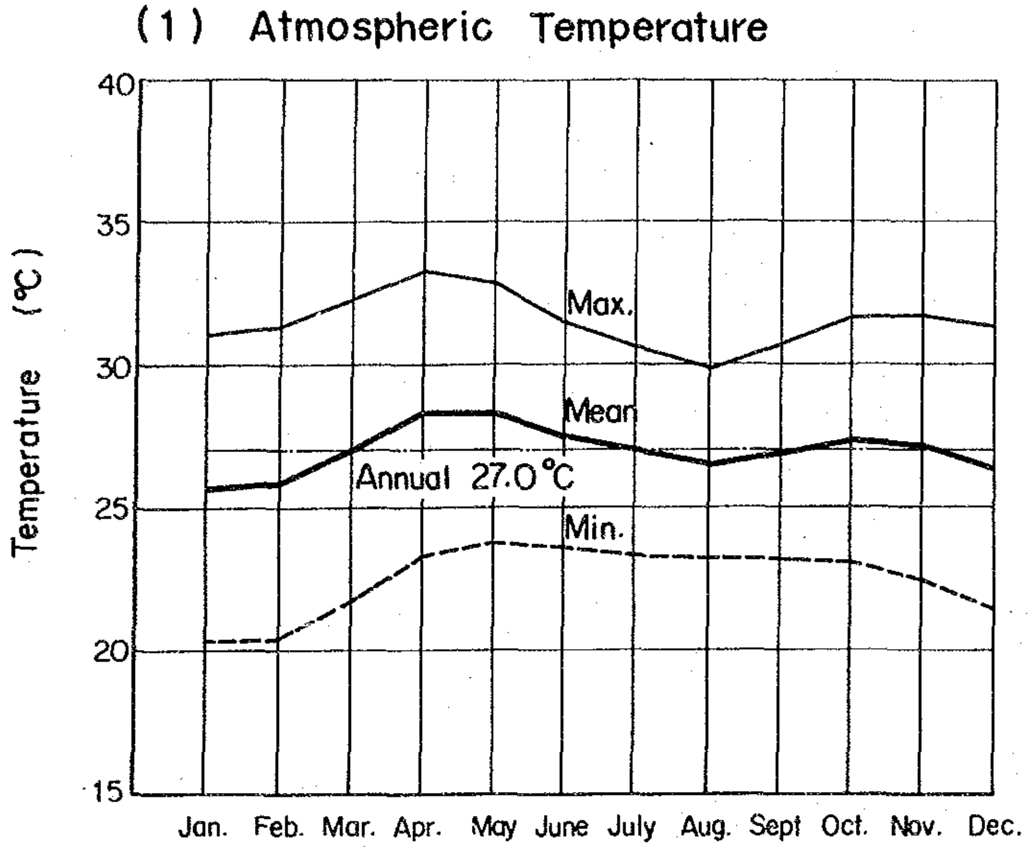
Period of Records (1951~1985)

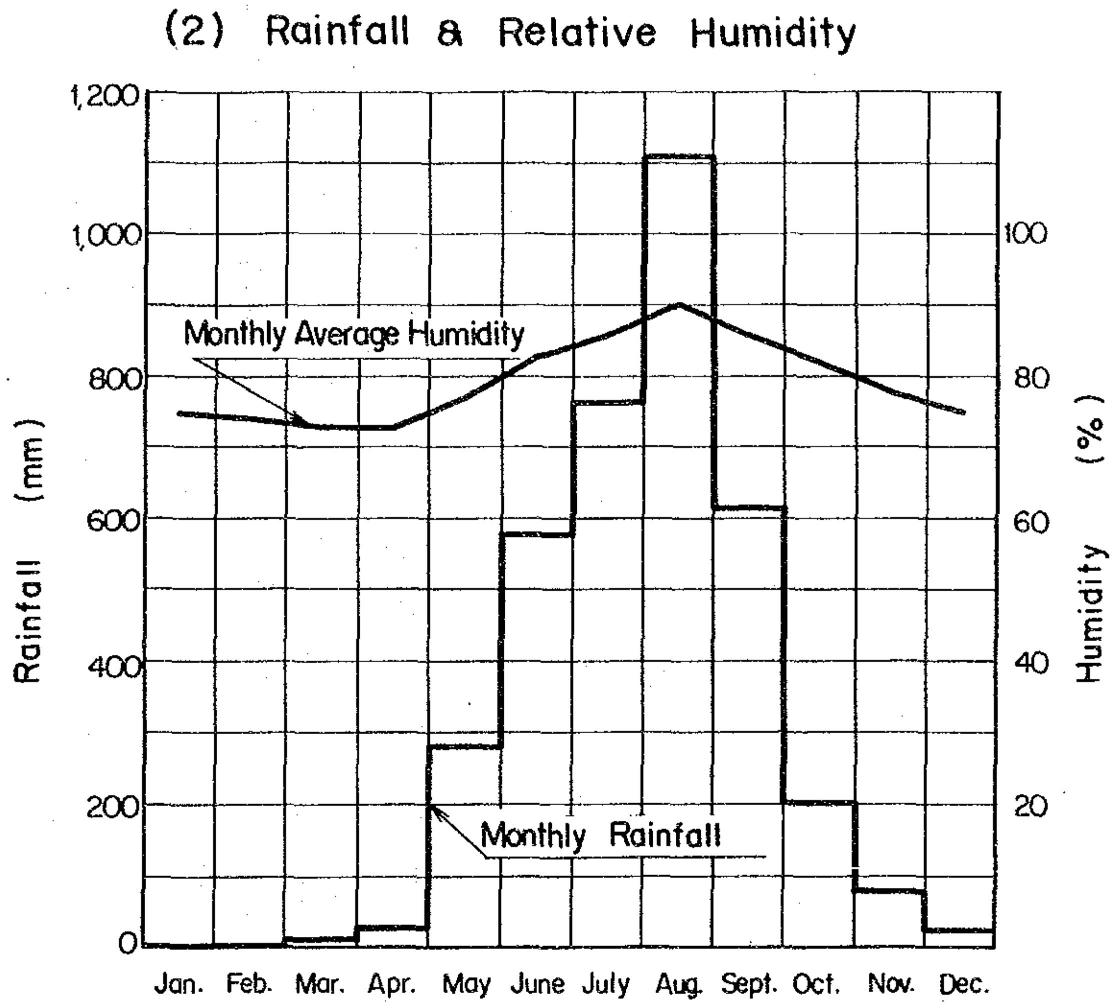
Month	Rain-fall (mm)	Rainy days	Temperature (°C) Max-imum	Min-imum	Mean	Dry bulb	Wet bulb	Dew pt.	RH (%)	Prevailing Wind Direc-tion	Speed (mps)	Cloud (octa)
JAN	3.0	1	31.0	20.3	25.6	25.3	22.0	21	75	E	2	2
FEB	2.7	2	31.3	20.4	25.8	25.6	22.2	21	74	NW	3	2
MAR	12.1	2	32.3	21.7	27.0	27.0	23.3	22	73	NW/W	3	2
APR	28.8	4	33.3	23.3	28.3	28.4	24.6	23	73	E	3	2
MAY	280.7	12	32.9	23.8	28.3	28.5	25.3	24	77	E/W	2	4
JUN	579.0	18	31.5	23.6	27.5	27.5	25.2	24	83	E	3	5
JUL	763.1	24	30.7	23.3	27.0	26.7	24.9	24	86	SW	2	6
AUG	1105.9	25	29.9	23.2	26.5	26.1	24.8	24	90	SW	3	6
SEP	615.8	21	30.7	23.2	26.9	26.6	24.8	24	86	E	2	6
OCT	203.9	14	31.6	23.1	27.3	27.0	24.6	24	82	E	2	5
NOV	80.9	7	31.7	22.5	27.1	26.7	23.8	23	78	E	2	4
DEC	25.6	4	31.3	21.4	26.3	26.1	22.8	22	75	E	2	3
Annual	3701.5	134	31.5	22.5	27.0	26.8	24.0	23	79	E	2	4

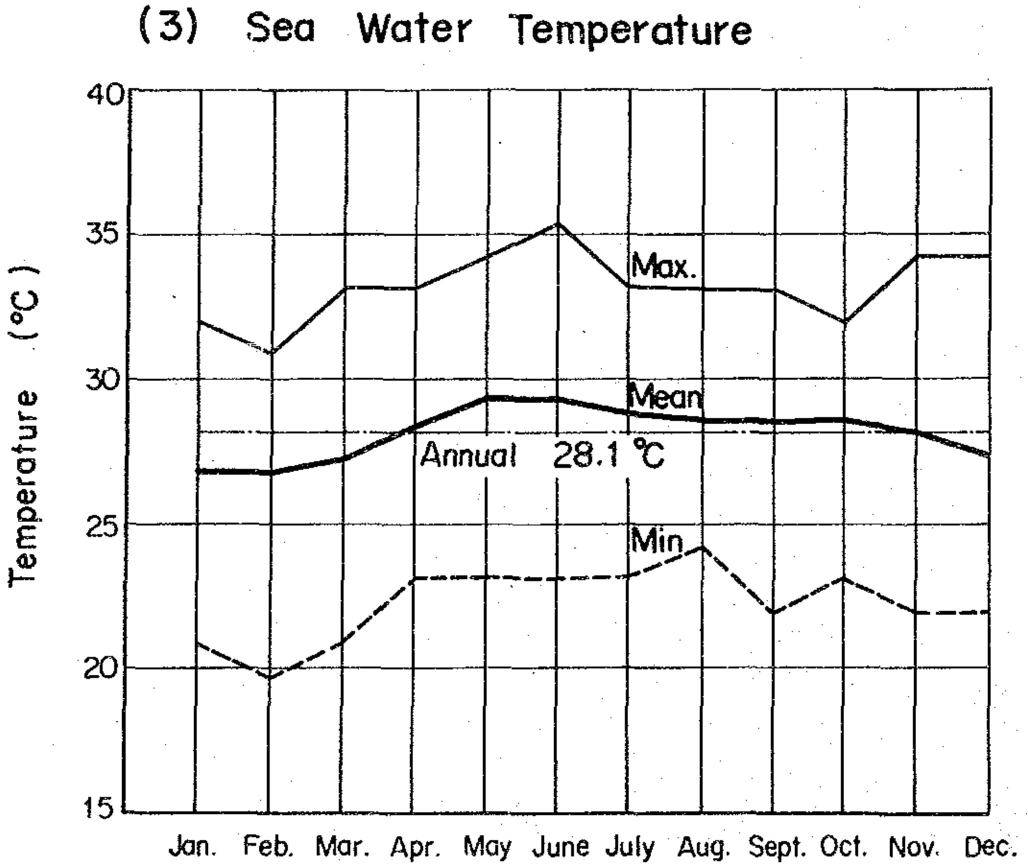
Table 6.2-2 <Climatological Extremes>

Period of Records - As of 1986

Month	Temperature (°C) High	Date	Low	Date	Greatest Daily Rainfall (mm) Amount	Date	Highest Wind (m/s) Spd/Dir	Date
JAN	37.2	30'71	13.0	12'71	29.7	24'35	18/NW	19'74
FEB	37.2	20'72	13.2	8'16	18.8	13'71	16/E	11'74
MAR	38.5	27'73	14.0	24'78	87.1	17'49	16/ESE	5'77
APR	38.8	22'73	17.0	27'78	23.8	22'62	24/SW	20'78
MAY	38.0	11'16	15.5	28'78	543.4	23'76	41/SW	22'78
JUN	36.9	4'75	17.8	12'78	356.4	22'60	47/SW	23'76
JUL	36.0	5'73	18.1	27'69	313.4	20'74	36/W	25'80
AUG	35.7	27'69	14.5	6'78	437.7	31'70	29/S	25'78
SEP	35.6	24'72	12.2	10'78	623.7	21'35	30/SW	16'77
OCT	37.0	23'72	17.8	21'60	325.9	13'60	36/S	27'78
NOV	38.3	7'72	16.7	12'11	291.4	14'77	31/NNW	4'80
DEC	38.1	20'71	15.6	24'18	138.5	4'36	18/E	25'80
Overall	38.8	4/22/1973	12.2	9/10/1978	623.7	9/21/1935	47/SW	6/23/1976
Period of Records	1910 - 1918 1949 - 1986				1903 - 1940 1949 - 1986		1966 - 1986	







Source

(1),(2) Climatological Normals / Averages (1951 - 1985)
: National Institute of Climatology PAGASA

(3) Observation Period : 1855 - 1971
Area of Observation : 10 - 16° N, 117 123° E

ZAMBALES COAL-FIRED POWER PROJECT

CLIMATE & SEA WATER TEMPERATURE

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.6.2-2

D.R.; SUBMITTED;
T.R.; RECOMMENDED;
C.K.; APPROVED;

Table 6.2-3 Record of Wind Direction and Speed

Station : Iba PAGASA Station
Latitude : 15deg. 20min. North
Longitude : 119deg. 58min. East
Elevation : 4.68m

R =Speed range in m/s
D =Direction
LT0.4 =All direction less than 0.4 m/s
Data period ······ 1981 to 1985

R \ D	LT 0.4	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total	Percent	Percent (Accumu-lated)
0.0 – 0.3 m/s	1,450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,450	11.4	11.4
(%)	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
0.4 – 1.9 m/s	0	523	278	784	135	1,504	282	289	42	174	69	241	101	268	84	604	59	5,437	42.8	54.2
(%)	0.0	4.1	2.2	6.2	1.1	11.8	2.2	2.3	0.3	1.4	0.5	1.9	0.8	2.1	0.7	4.8	0.5			
2.0 – 3.9 m/s	0	192	135	339	41	650	141	253	32	170	70	176	58	290	61	419	25	3,052	24.0	78.2
(%)	0.0	1.5	1.1	2.7	0.3	5.1	1.1	2.0	0.3	1.3	0.6	1.4	0.5	2.3	0.5	3.3	0.2			
4.0 – 7.9 m/s	0	63	21	47	6	357	161	201	30	279	74	239	45	199	97	539	24	2,382	18.8	97.0
(%)	0.0	0.5	0.2	0.4	0.0	2.8	1.3	1.6	0.2	2.2	0.6	1.9	0.4	1.6	0.8	4.2	0.2			
8.0 – 12.9 m/s	0	3	1	1	1	20	13	36	15	109	27	69	6	15	1	16	0	333	2.6	99.6
13.0 – 16.9 m/s	0	0	0	0	0	1	0	5	1	7	4	3	0	3	0	1	0	25	0.2	99.8
17.0 – Max m/s	0	0	1	1	0	1	3	6	0	0	1	0	0	1	0	5	0	19	0.2	100.0
(%)	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.3	0.1	1.0	0.2	0.5	0.0	0.1	0.0	0.1	0.0			
Total	1,450	781	436	1,172	183	2,533	600	790	120	739	245	728	210	776	243	1,584	108	12,698		
Percent	11.4	6.2	3.4	9.2	1.4	19.9	4.7	6.2	0.9	5.8	1.9	5.7	1.7	6.1	1.9	12.5	0.9			100.0

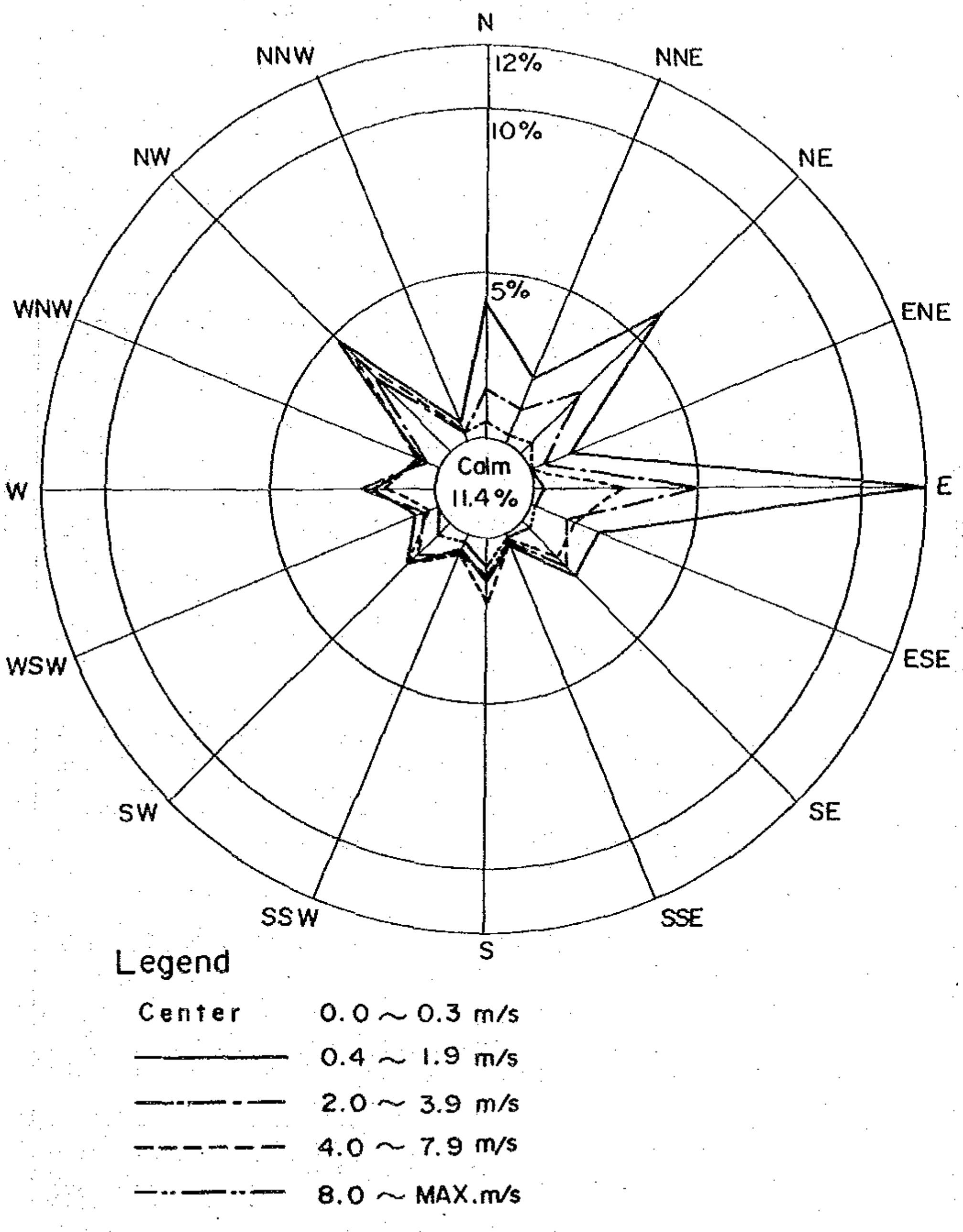


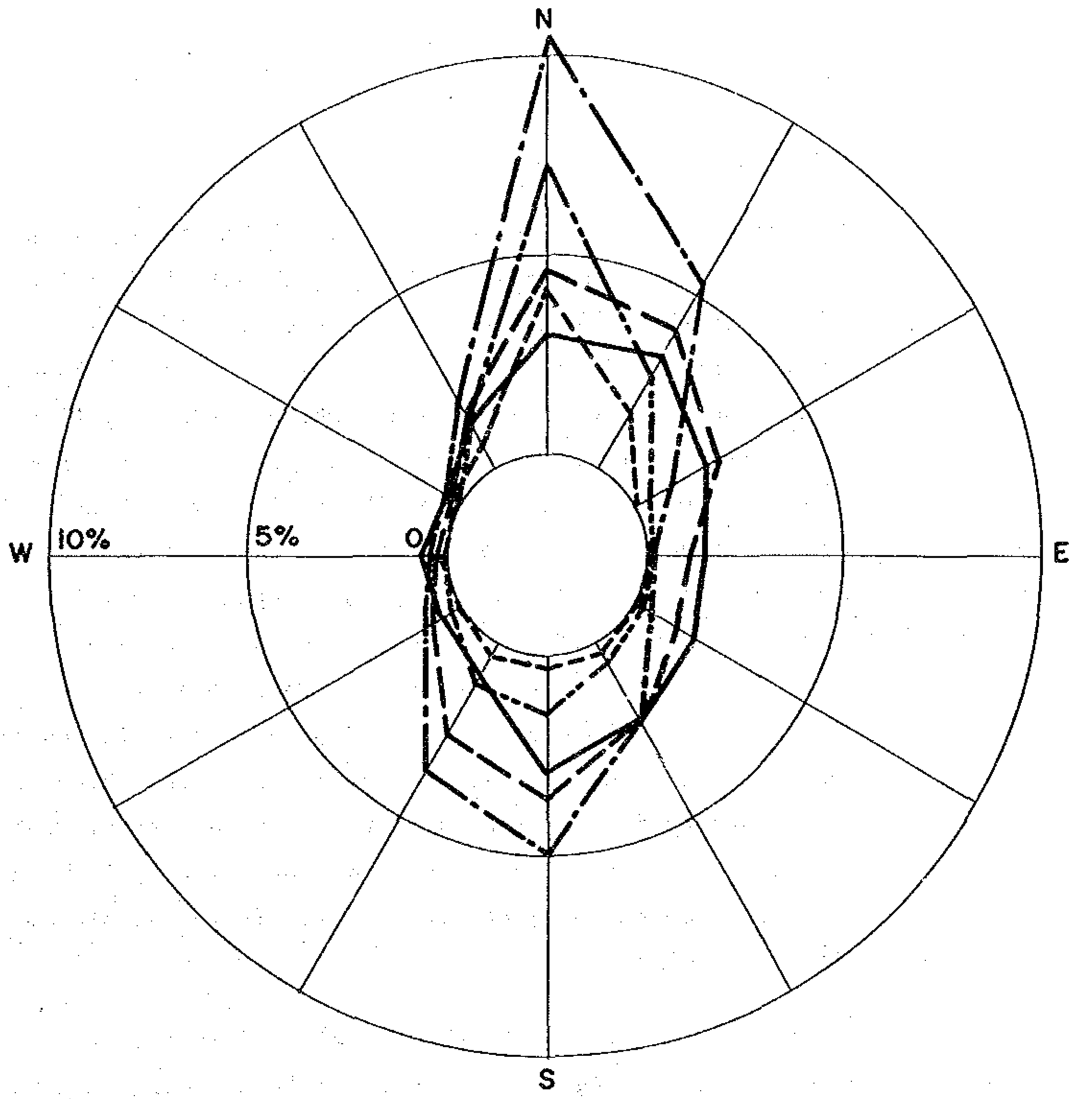
Fig.6.2-3 Distribution Diagram of Wind Direction and Speed (Iba)

Table 6.2-4 Frequency Distribution of Wave Height on South China Sea

Source : Ocean Wave Statistics

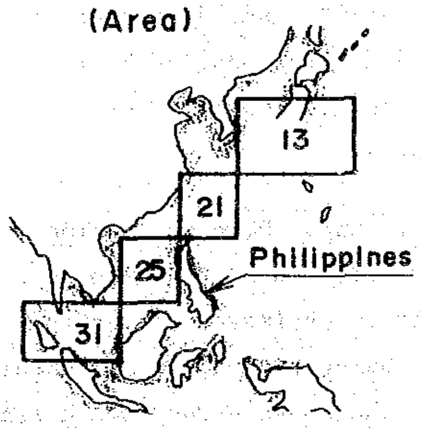
Wave Height (m) Calm	Wave Direction N			E			S			W			Total
0.25	49 (0.8)	47 (0.8)	43 (0.7)	28 (0.5)	32 (0.5)	36 (0.6)	45 (0.7)	19 (0.3)	9 (0.1)	9 (0.1)	13 (0.2)	34 (0.5)	364 (5.8)
0.5	137 (2.2)	150 (2.4)	88 (1.4)	61 (1.0)	66 (1.1)	94 (1.5)	130 (2.1)	37 (0.6)	29 (0.5)	26 (0.4)	21 (0.3)	50 (0.9)	889 (14.4)
1.0	291 (4.7)	238 (3.8)	146 (2.4)	67 (1.1)	66 (1.1)	135 (2.2)	219 (3.5)	163 (2.6)	58 (0.9)	21 (0.3)	24 (0.3)	90 (1.5)	1,518 (24.4)
1.5	346 (5.6)	214 (3.5)	43 (0.7)	9 (0.1)	20 (0.3)	108 (1.7)	216 (3.5)	136 (2.2)	37 (0.6)	18 (0.3)	20 (0.3)	65 (1.1)	1,232 (19.9)
2.0	302 (4.9)	110 (1.8)	24 (0.4)	3 (0.1)	4 (0.1)	34 (0.5)	86 (1.4)	86 (1.4)	31 (0.5)	12 (0.2)	10 (0.2)	54 (0.9)	756 (12.4)
2.5	259 (4.2)	100 11.6)	13 (0.2)	4 (0.1)	6 (0.1)	15 (0.2)	56 (0.9)	48 (0.8)	14 (0.2)	3 (0.1)	3 ( )	47 (0.8)	568 (9.2)
3.0	183 (3.0)	63 (1.0)	5 (0.1)	1 ( )	3 ( )	13 (0.2)	23 (0.4)	26 (0.4)	4 (0.1)	1 ( )	5 (0.1)	28 (0.5)	355 (5.8)
3.5	106 (1.6)	42 (0.6)	4 (0.1)	1 ( )	0 ( )	0 ( )	10 (0.3)	8 (0.1)	2 ( )	2 ( )	6 (0.1)	15 (0.7)	196 (3.5)
4.0	67 (1.1)	23 (0.4)	1 ( )	0 ( )	0 ( )	0 ( )	1 ( )	5 (0.1)	1 ( )	2 ( )	3 ( )	7 (0.1)	110 (1.7)
4.5	42 (0.7)	35 (0.6)	2 ( )	1 ( )	0 ( )	1 ( )	3 ( )	7 (0.1)	0 ( )	1 ( )	2 ( )	9 (0.1)	103 (1.5)
5.0	6 (0.1)	1 ( )	1 ( )	1 ( )	0 ( )	0 ( )	1 ( )	0 ( )	0 ( )	1 ( )	0 ( )	12 (0.2)	23 (0.3)
5.0<	37 (0.6)	6 (0.7)	3 (0.1)	0 ( )	0 ( )	3 ( )	0 ( )	1 ( )	1 ( )	2 ( )	1 ( )	16 (0.3)	70 (1.1)
Total	1,825 (29.5)	1,029 (16.6)	373 (6.1)	176 (2.9)	197 (3.2)	439 (6.9)	790 12.8)	536 (8.6)	186 (2.9)	98 (1.4)	108 (1.5)	427 (7.6)	6,184 (100.0)

Remark
Upper : Number of Observation
Lower : Per Cent of Occurrence



Remark

(Area)



(Wave Height)

- ~0.5 m
- 0.6~1.0
- 1.1~2.0
- 2.1~3.0
- 3.0~

Fig.6.2-4 Distribution Diagram of Wave Height on South China Sea (Area 25)

(4) Topography and Geology

i) General

The project site is located south of the mouth of Lawis river which is approximately 4 km northwest of Masinloc. The topography of the land area of the project site is gently sloping hills which is 15 to 25 m above sea level along Oyon Bay and alluvial plain which are nearly flat. Especially, there is a wide flat land which is approximately 2 m above sea level along the Lawis river which is used for rice cultivation. There are coral reefs, Salvador island, and winding approach channels which are 40 m to 10 m deep to the seabed in the offshore area, which make the topography complex. The Zambales Ultramafics mainly consisting of Gabbro is distributed at the mountain land to the east side from a point which is approximately 8 km to the east of the project site. Coto mine producing chromite is located approximately 17 km to the east from the project site and is within the ultramafic rock bodies.

In the bedrock around the project site, Zambales Formation belonging to the middle to late Miocene Age is distributed. This formation consists mainly of sandstone, shale or mudstone, conglomerate, and these beds gently dip 5° to 15°.

Fine sandstone, which strikes N 20° E and dips approximately 20° south east is exposed at the coast of Bani Point. Also, weathered conglomerate and shale or mudstone are exposed on the hills.

According to the result of drilling, there are marine deposits which are 10 to 20 m thick in addition to coral reef in the offshore area. It is estimated that extremely hard sand and silt found below the marine and coral reef deposits are products of the above strong weathered bedrock but they may be deposits of younger age than the Zambales Formation.

ii) Geological analysis based on investigation results

Four offshore drillings and five drillings (one of them is offshore drilling) have been executed by JICA and NAPOCOR up to the present as shown in Figs. 6.2-5 and 6.2-6, respectively.

Fig. 6.2-8 shows the geological profile by a line connecting drill holes No. 2 to No. 3 and a line connecting drill holes No. 1 to DH-1, DH-2 and DH-3.

According to these investigation results, the stratum distributed over the project site is classified as follows:

- Cr: Coral reef deposits
- Uc: Silt layer (Holocene, marine deposits and alluvial deposits)
- Us: Sand layer
- L : Hard sand and silt layer (Strongly weathered, bedrock, or deposits)
- Ss: Sand stone, silt stone (Zambales Formation)

Distribution as well as geotechnical and soil mechanical properties which have been clarified up to present are as follows:

a) Coral reef (Cr)

It extends over a wide range in the offshore area where the depth from the sea surface is less than approximately 5 m.

According to the result of drill hole No. 4 executed at the approach channel, coral reef deposits have been confirmed from the seabed to a depth of approximately 13 m. At this point, these deposits cover the L layer, and also, mostly consists of calcareous sediments composed of broken coral and shell fragments, which is considered to be coral sand.

According to the drilling core inspection, the sediments have not solidified and are still soft and it is estimated that dredging operations are relatively easy.

b) Silt layer (Uc) and sand layer (Us)

They have been confirmed by drill holes No. 1, No. 2 and No. 3 in the offshore area.

Especially, the Us layer consisting of fine sand or medium sand which are approximately 10 m in thickness are found at drill hole No. 1 and the N value indicates 19 or less.

The part which is less than 4 m deep is partially extremely loose. The 50% grain size of the sand layer is approximately 0.1 to 0.2 mm according to laboratory tests. Also, they contain 30% to 40% of soils finer than 74 micron sieve from sea bottom.

Consequently, the sand includes a large amount of fine grains.

The Uc layer mainly consists of silt or clay and it was confirmed that it is 10 m and 23 m in thickness at drill holes No. 2 and No. 3. This silt layer in places indicates N value of 15 to 24 due to mixture of sand, but is relatively soft as the N value is 3 to 10. According to laboratory tests executed by JICA, unconfined compressive strength is 0.1 to 0.55 kg/cm^2, and the average value is 0.27 kg/cm^2.

In the on-land area, there is fine sand with silt from the surface to a depth of 7 m according to drill hole DH-3 executed at the coal storage yard site, but the sand layer is extremely thin (approximately 1 m) at the tip of the peninsulae, namely Bani Point, as confirmed by drill hole DH-2 and the lower part consists of sand stone and silt stone.

According to the result of drillhole DH-4 executed at the embankment of ash disposal area which is planned at the west side of the power station, it was found that there is an extremely thick sand and clay layer from the ground surface to a depth of 35 m or deeper.

c) Hard sand and silt layer (L layer)

It was confirmed by the drill holes No. 1 to No. 4 at the offshore area that they exist underneath the marine deposits (Uc or Us) or coral reef deposits (Cr). This layer consists of dark-gray fine sand or sandy silt. The N value is nearly 60 or more, which is extremely dense. It has a sufficient strength as foundation of structures.

d) Sand stone and silt stone layer (Ss layer)

This layer is confirmed by each of the drillholes (DH-1, DH-2 and DH-3) executed within the plant site and drillhole PH-1 which is located at the neighboring hills.

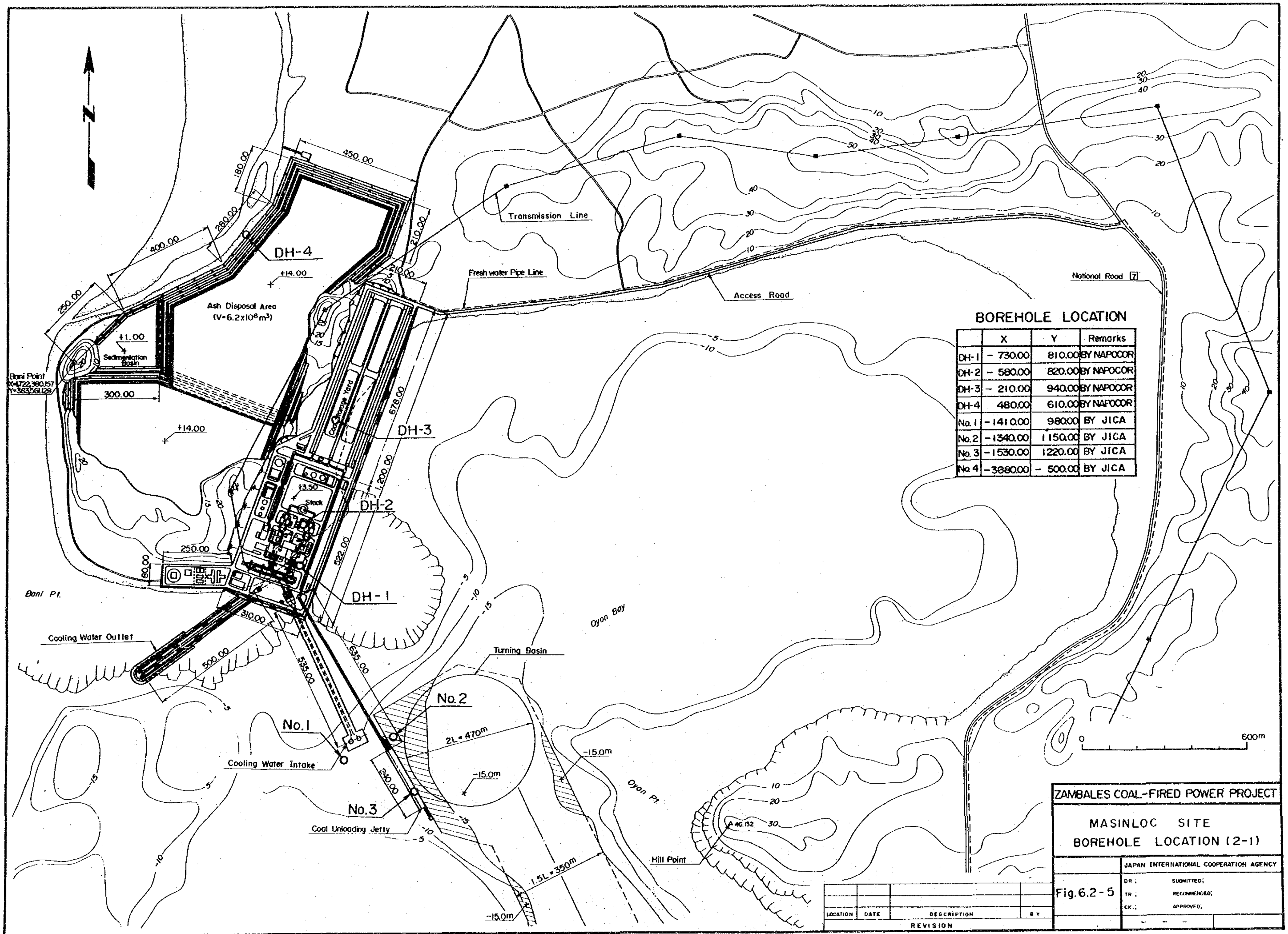
They consist mainly of fine sandstone and silt stone, intercalated with conglomerate. Although they are relatively strongly weathered near the surface, the N value exceeds 50, indicating a sound ground.

Also, these strata are classified into weak rocks excluding certain parts of conglomerates and it is judged that they can be excavated with a ripper.

Table 6.2-5 Stratigraphy in the Zambles Range

Source ; Geology and Mineral Resources of the Philippines, 1986

Million Years	Geologic Time: Era	Period	Epoch	Age	Formation
	Cenozoic	Quaternary	Holocene		Terrace Gravel
.01			Pleistocene	Late	
				Early	
1.8		Tertiary	Pliocene	Late	
				Early	
5.0			Miocene	Lat	Sta. Cruz Formation
				Middle	Zambales Formation
				Early	
22.5			Oligocene	Late	
				Early	Aksitero Formation
38.0			Eocene	Late	
				Early	Chert Spilite and Rubble Breccia Diabase Gabbro Zambales Ultramafics
55.0			Paleocene	Late	
				Early	
65.0	Mesozoic	Cretaceous		Late	
				Early	
141		Jurassic		Lat	
				Middle	
				Early	
195					



BOREHOLE LOCATION

	X	Y	Remarks
DH-1	- 730.00	810.00	BY NAPOCOR
DH-2	- 580.00	820.00	BY NAPOCOR
DH-3	- 210.00	940.00	BY NAPOCOR
DH-4	480.00	610.00	BY NAPOCOR
No. 1	-1410.00	980.00	BY JICA
No. 2	-1340.00	1150.00	BY JICA
No. 3	-1530.00	1220.00	BY JICA
No. 4	-3880.00	- 500.00	BY JICA

ZAMBALES COAL-FIRED POWER PROJECT

MASINLOC SITE
BOREHOLE LOCATION (2-1)

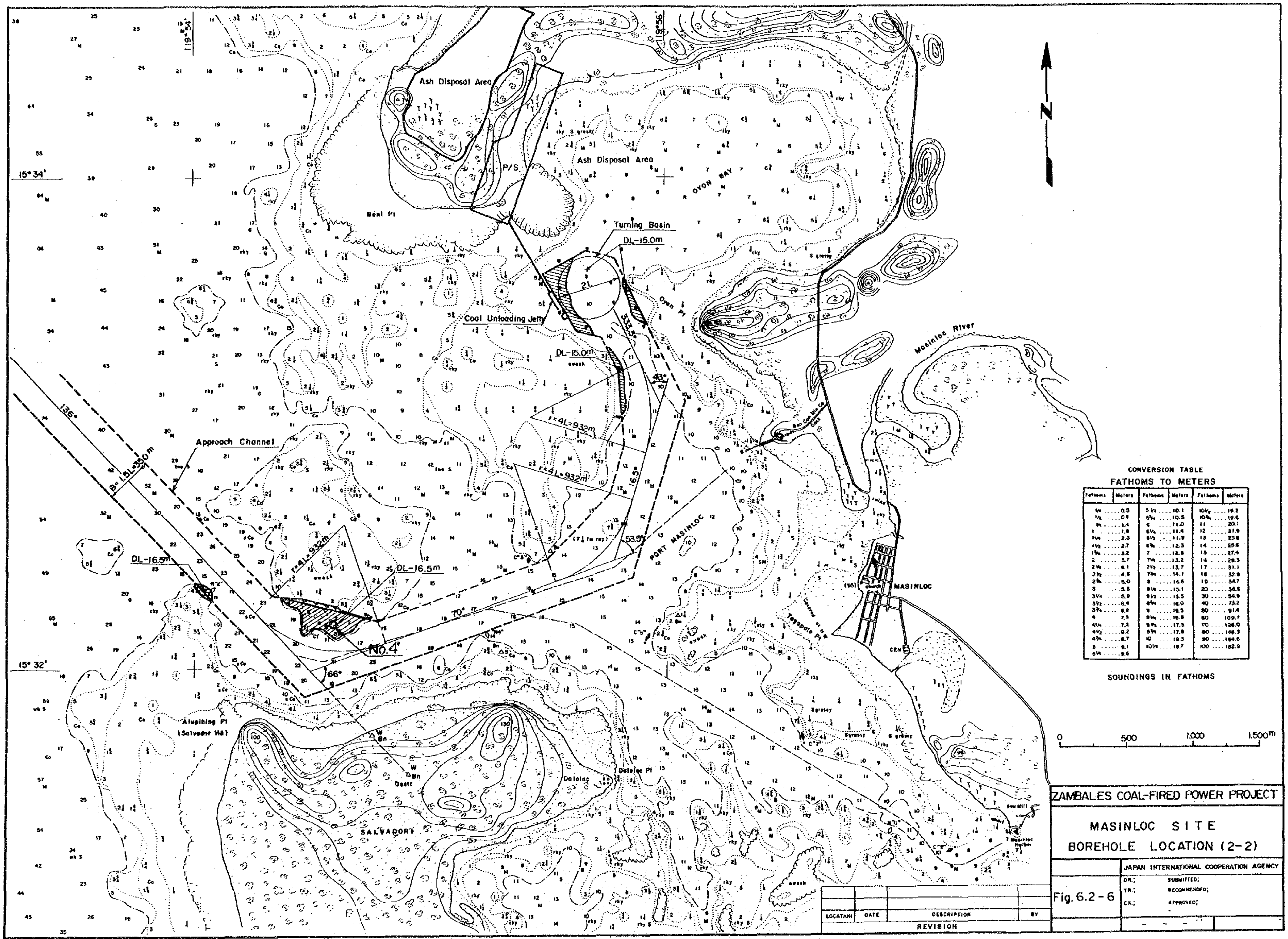
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.6.2-5

DR.: SUBMITTED;
TR.: RECOMMENDED;
CK.: 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 SITE

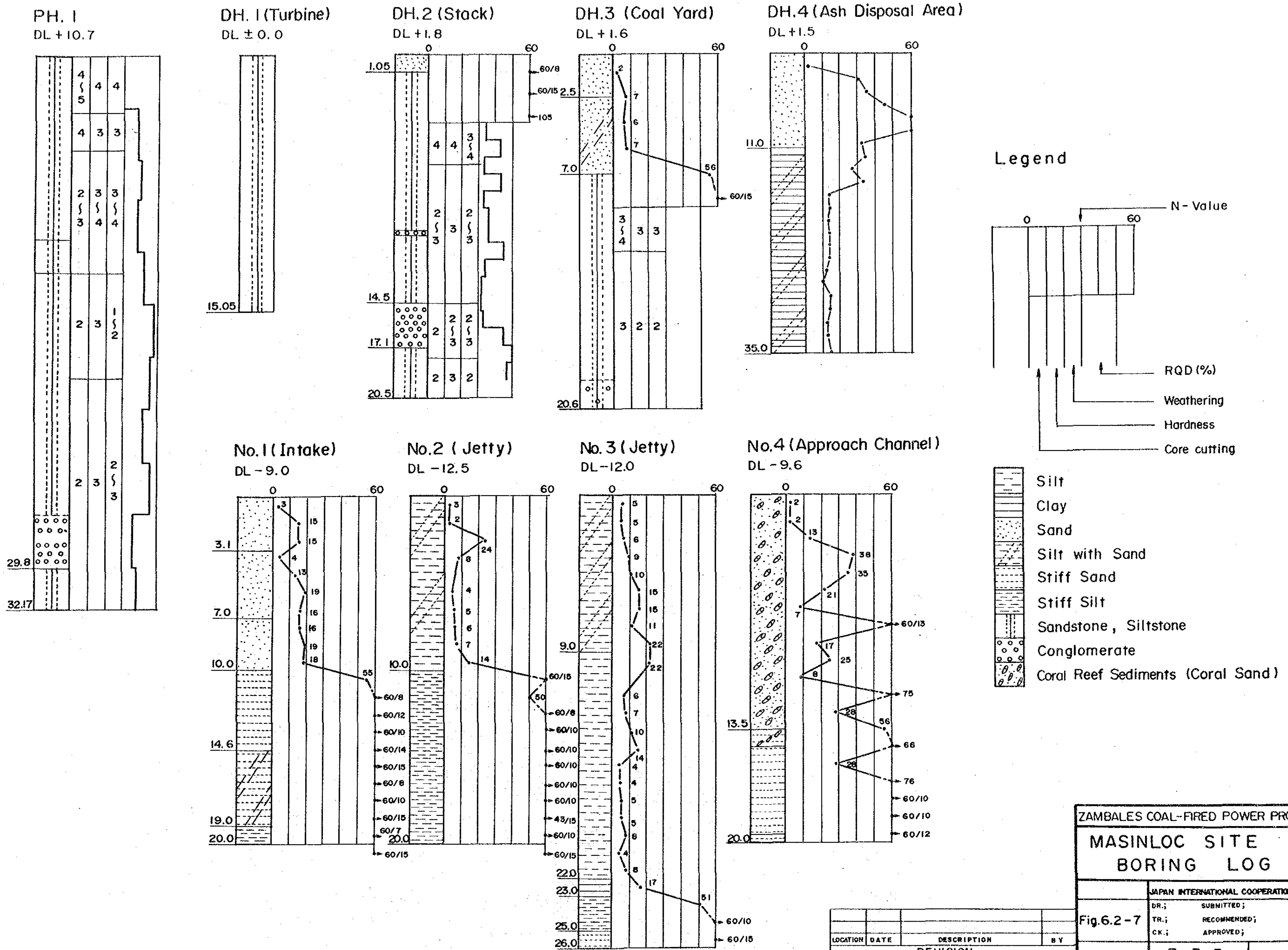
BOREHOLE LOCATION (2-2)

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.2-6

DR.; SUBMITTED;
TR.; RECOMMENDED;
CK.; APPROVED;

LOCATION	DATE	DESCRIPTION	BY
REVISION			



ZAMBALES COAL-FIRED POWER PROJECT

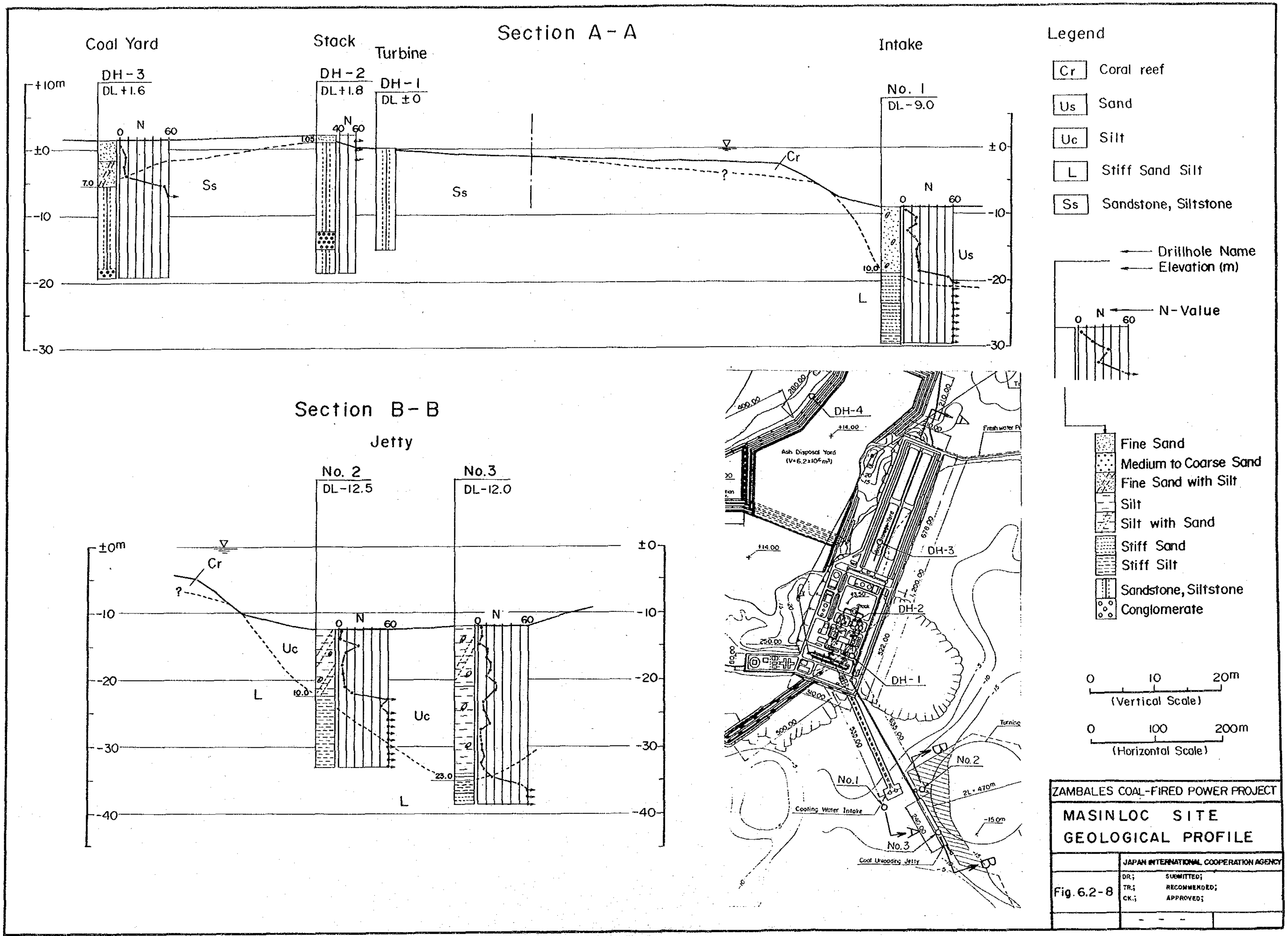
MASINLOC SITE
BORING LOG

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.2-7

DR.;	SUBMITTED;
TR.;	RECOMMENDED;
CK.;	APPROVED;

LOCATION	DATE	DESCRIPTION	BY
REVISION			


Section A-A
Coal Yard
Stack
Turbine
Intake
DH-3
DL+1.6
DH-2
DL+1.8
DH-1
DL ±0
No. 1
DL-9.0
Cr
Ss
Us
L
Section B-B
Jetty
No. 2
DL-12.5
No.3
DL-12.0
Uc
Legend
Cr Coral reef
Us Sand
Uc Silt
L Stiff Sand Silt
Ss Sandstone, Siltstone
Drillhole Name
Elevation (m)
N-Value
Fine Sand
Medium to Coarse Sand
Fine Sand with Silt
Silt
Silt with Sand
Stiff Sand
Stiff Silt
Sandstone, Siltstone
Conglomerate
(Vertical Scale)
(Horizontal Scale)
DH-4
Ash Disposal Yard
DH-3
DH-2
DH-1
No.1
No.2
No.3
Cooling Water Intake
Coal Unloading Jetty
ZAMBALES COAL-FIRED POWER PROJECT
MASINLOC SITE
GEOLOGICAL PROFILE
JAPAN INTERNATIONAL COOPERATION AGENCY
Fig. 6.2-8

(5) Existing Harbors

There are two harbors in Masinloc. An ore loading pier is operating at Port Masinloc where less than 40,000 DWT bulk carriers enter 15 to 20 times every year.

Masinloc harbor has a small pier used by vessels, operated by a petroleum company. Since shallow sea-bed is spread widely in the port, the sea channel is threaded in the deepest part and there are some narrow and winding channel. Because of this condition bouys are installed for navigation aid.

All ocean going vessels which enter this port are forced to use pilotage. From information obtained from a pilot, operation of large vessels is difficult because tug boats are not provided.

The depth of the berthing basin at Port Masinloc has been maintained by dredging.

6.2.2 Design Conditions and Basic Factors

Design conditions and basic factors used for preliminary design were determined as follows using the investigation results at the site and the regional characteristics of the Philippines.

i) Temperature 27°C

ii) Relative humidity 79%

iii) Wind velocity

The following value was adopted as the basic wind velocity being in conformity with the "National Structural Code of the Philippines".

Wind speed V = 175 km/h = 49 m/s

iv) Sea water temperature 31°C (Max. 35°C)

v) Tidal level

The basic tidal level was determined as follows using the sea chart and tidal table:

Tidal Level		Height (m)
Highest Water Level on Record	(H.H.W.L)	1.6
Mean Spring High Water Level	(H.W.L)	1.3
Mean Sea Level	(M.S.L)	0.4
Datum Level	(D.L)	±0
Mean Spring Low Water Level	(L.W.L)	±0
Lowest Water Level on Record	(L.L.W.L)	-0.5

The above water level is a value based on datum level (D.L.) and offshore sounding map and topographic map are created based on this datum level.

vi) Seismic coefficient

The average value of 200 gal of the Iba Fracture dislocation model, namely 0.2 G, is adopted as the seismic coefficient considering the calculation result of seismic acceleration on bedrock by dislocation data and seismic record obtained from NAPOCOR, etc. and the research report "Seismic Map in World Seismic Activity Areas" by the Research Institute of the Ministry of Construction (Japan).

This value is the same as that adopted for Calaca I and the above two points are within the same zone according to the Seismic Map of the Philippines issued by the Association of Structural Engineers of the Philippines (ASEP).

vii) Design wave height

Design wave height is three (3) meters at the cooling water outlet, 2 meters at the coal unloading jetty and revetment (Refer to Section 6.6).

6.2.3 Operation Conditions for Power Plant

Operation conditions for power plant are determined on the basis of power demand forecast. The following operation conditions has been set in accordance with results of the above-stated study.

Furthermore, operation conditions are important matters that should be considered in designing equipment for the power plant.

(1)	Unit Capacity	300 MW
(2)	Annual Utilization Factor (base-load use)	70%
(3)	Required Days for Annual Inspection	40 days

The required days for annual inspection at a coal fired thermal power plant of 300 MW class is about 30 to 50 days. In this plan, an average of 40 days is adopted.

(4) Outage Ratio

About 8% is adopted. This figure was the average value in 1976 to 1985 for all U.S. thermal power plants, announced by the North American Power Reliability Council, and that value is adopted in this plan. It is possible to estimate outage days and operative days or available days of the plant under this plan on the basis of this value.

Estimated outage days = (365 days - 40 days for annual inspection) x 8%

= 25 days

Operative days = (365 days - 40 days for annual inspection - Estimated outage days 25)

= 300 days

(5) Annual Availability Factor

Annual availability factor can be calculated on the basis of number of available days (or hours) and 365 days (or 8,760 hours).

$$\text{Annual availability factor (\%)} = \frac{\text{300 days}}{\text{365 days}} \times 100 = 82.2$$

(6) Annual Load Factor

Annual load factor represents ratio of actual generated energy to nominal energy in given hours of operation. The following formula can be established between load factor and annual utilization factor and availability factor:

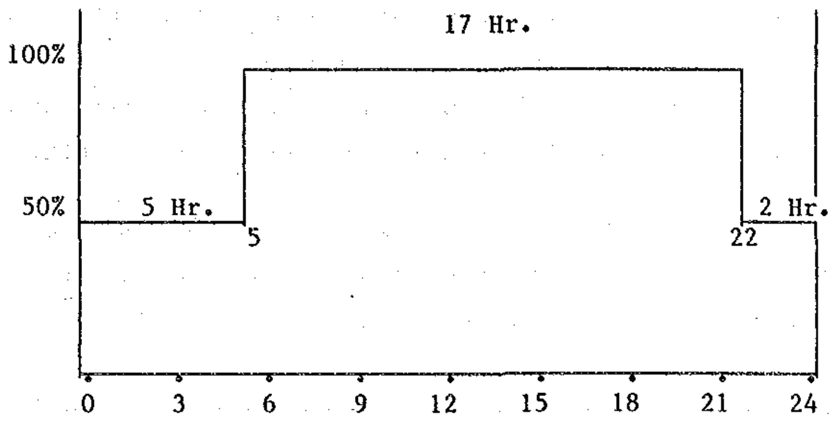
$$\text{Annual load factor (\%)} = \frac{\text{Annual utilization factor}}{\text{Annual availability factor}} \times 100$$

$$= \frac{70}{82.2} \times 100 = 85.2$$

(7) Planned Daily Load Curve

Daily load pattern is formulated based on the premise that the above estimated daily load factor (85.2%) as this power plant will be operated to supply base load.

100% load time	17 Hr.
50% load time	7 Hr.
	24 Hr.



It is believed necessary, however, to adjust this planned daily load curve to the condition of power flow in the Philippines.

The respective factors stemming from the above load curve are shown below and the possibility of attainment of 70% annual utilization factor are shown below:

$$\text{Daily load factor} = \frac{17 + (7 \times 0.5) \quad \times 300 \text{ MW}}{24 \times 300 \text{ MW}} \times 100$$

$$= 85.4\%$$

$$\text{Annual utilization factor} = 85.4 \times 82.2 \ / \ 100$$

$$= 70.2\%$$

6.2.4 Basic Factors in Designing a Power Plant

The basic factors for the conceptual design of a power plant must meet site characteristics (site condition, natural condition, etc.) and the plant's operational requirements.

In other words, it is necessary to set the basic factors in consideration of economic operation of the power plant.

(1) Economic Continuous Rating (ECR) and Maximum Continuous Rating (MCR) of a Power Plant

The ECR of a power plant can be defined as the state in which continuous operation of planned output is possible while maintaining the efficiency guaranteed under certain basic conditions.

In contrast, even when the basic conditions of ECR change within a certain range or conditions, maintenance of the rated output of 300 MW can be achieved by increasing the boiler evaporation volume, then this increment is called MCR.

This condition is called capability condition and the boiler evaporation volume increment is usually at about 3 to 5% more than the rated evaporation volume.

	Rated Output	Capability
Boiler evaporation (ton/h)	approx.930	approx 960
Turbine output (MW)	300	300
Turbine load condition		
Design sea water temperature (°C)	31	35
Condenser vacuum (mmHg)	695	680
Make-up factor (%)	1.0	3.0

In general, the amount of evaporation at MCR is assumed as 1.05 times of the evaporation at ECR. In this study, reference was made to actual boilers in operation and the amount of evaporation at MCR is assumed as 1.03 times of the evaporation at turbine capability resulting in 990 t/h evaporation at MCR.

(2) Steam Condition for Power Plant

As to the method of selecting steam condition for a thermal power plant, it is considered wise from the viewpoints of cost and manufacturing period to select it from among standard specifications.

Standard conditions for a thermal power plant of 300 MW class are: steam pressure is 2,400 psi class (169 kg/cm^2) and steam temperature is 1,000°F (538°C) to 1,050°F (566°C).

To choose the optimum steam temperature from the above-stated values, an economic appraisal was carried out for the following three (3) items: plant efficiency, fuel price and plant cost. As a result, it was decided to adopt the following steam conditions for this power plant:

Steam pressure : 169 kg/cm^2

Steam temperature: 538°C/538°C

Cost study of Economy for Selection of Steam Conditions of Power Plant

Item	unit	symbol	formula	Case-1	Case-2	Case-3	Case-4
Steam Pressure	kg/cm²G			169	169	169	169
Steam Temperature	℃			538/538	566/538	538/566	566/566
Turbine Heat Rate	kcal/kWh	A		Base	-15.3	-15.8	-31.0
Plant Heat Rate	kcal/kWh	B		Base	-17.0	-17.5	-34.4
Annual Power Generation	10^6kwh/y	C	300 MW×10^3 ×8760×0.7	Base	1839.6	1839.6	1839.6
Annual Fuel Consumption	10^3kcal/y	D	C×B	Base	-31273200	-32193000	-63282240
Annual Fuel Cost	million¥/y	E	D×fuel Cost	Base	-41	-42	-84
N.P.V difference of annual fuel	million¥	F	an×E	Base	-269	-276	-552
Difference of Relative Plant Cost	million¥	G		Base	300	300	600
Total Economy	million¥	H	G+F	Base	31	24	48

The following conditions were applied for the above case study

Plant output : 300 MW
Annual utilization factor : 70 %
Fuel cost : ¥1.32/10^3kcal
Discount rate (r) : 15 %
Equivalent coefficient of accumulated N.P.V. on Annual operating cost (a_n) : 6.566=$((1+r)^{n-1})/(r(1+r)^n)$ n =30 year

(3) Thermal Efficiency of Power Plant

The thermal efficiency of a power plant can be computed on the basis of boiler thermal efficiency, turbine thermal efficiency and heat loss of the plant.

In this study, loss was estimated for fuel under the following study conditions is combusted in a proposed boiler, and the thermal efficiency was computed.

Regarding the thermal efficiency of the power plant, thermal efficiency during rated output and thermal efficiency under certain operation mode were studied.

1) Study conditions

o Coal sources	Design coal (Semirara coal 50 Wt%: Lemington coal 50 Wt%)
o Steam condition	169 kg/cm^2, 538°C/538°C
o Condenser vacuum	65 mmHga
o Make-up factor	1%

ii) Thermal efficiency of power plant during rated output

Symbol	Item	Calculation Formula	Thermal Efficiency Indication	
			Percentage (%)	Heat Rate (Kcal/kWh)
a	Heat input into the boiler		100	2,260
b	Boiler loss		12	270
c	Plant loss	(a-b) x 0.02	2	50
d	Heat input into the turbine	a - (b + c)	86	1,940
e	Machinery loss in the turbine		0.2	5
f	Generator loss		0.5	10
g	Heat diffusion loss in the condenser		47.3	1,065
h	Plant total (at generating end)	d - (e+f+g)	38	860
ηB	Boiler thermal efficiency	$\frac{a - b}{a} \times 100$	88	
ηT	Turbine thermal efficiency	$\frac{h}{d} \times 100$	44	
ηP	Plant thermal efficiency at generating end	$\eta B \times \eta T \times (1 - 0.02)$	38	

iii) Annual Thermal Efficiency of the Power Plant

Regarding the annual utilization of this power plant, a plant utilization factor of 70% was adopted.

The annual thermal efficiency can be calculated under a certain condition applying a compensation coefficient based on annual utilization factor.

Thermal Efficiency Compensation Coefficient
Based on Annual Utilization Factor

Annual Utilization Factor	90%	80%	70%	60%
Compensation Co-efficient	0.98	0.97	0.96	0.95

Annual average thermal efficiency = 38% x 0.96
= 36.5%

iv) Thermal efficiency used for design of facilities and coal consumption

Design thermal efficiency and annual average thermal efficiency are applied for each purpose.

a. Annual coal consumption (calculation of coal yard, etc.)

For this purpose annual average thermal efficiency is considered as 36%.

- Annual coal consumption

$$\frac{300{,}000 \text{ KW} \times 860 \text{ Kcal/kWh} \times 8{,}760 \text{ hr} \times 0.7}{5{,}262 \text{ Kcal/kg} \times 0.36} \times \frac{1}{1{,}000}$$

= 840,000 ton/year-unit

b. Hourly coal consumption (calculation of capacity of pulverizer, etc.)

For this purpose, 38% of design thermal efficiency is assumed. Coal consumption to calculated under condition of MCR.

- Hourly coal consumption

$$\frac{300{,}000 \text{ KW} \times 860 \text{ Kcal/kWh}}{5{,}262 \text{ Kcal/kg} \times 0.38} \times \frac{1}{1{,}000} \times \frac{990}{930}$$

= 138 ton/h.

6.3 Outline Description of Generating Facilities

6.3.1 Basic Factors 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)	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 is assumed as overseas.

	(Semirara Coal)	(Lemington coal)
Heating Value (AR)	4,000 kcal/kg	6,524 kcal/kg
Ash Contents	12%	10.39%

(6) Annual Coal Consumption	1,680,000 ton (2 x 840,000 ton)
(7) Coal Storage Capacity	300,000 ton (maximum)
(8) Size of Coal Vessels	60,000 DWT (for overseas coal) 5,000 DWT (for indigenous coal)
(9) Annual Ash Generation	208,000 m^3

6.3.2 Land Reclamation

(1) Site Area

Total	106 ha
Power station	18 ha
Coal storage yard	15 ha
Ash disposal area	
(for 10 years)	31 ha
(for 30 years)	73 ha

(2) Site Formation Level: DL + 3.5 m

(3) Mounted Height of Ash Disposal Area — DL + 1.5 m to 13.5 m (12 m)

(4) Revetment — 1,400 m

(5) Excavation Volume — 710,000 m^3

6.3.3 Port Facilities

(1) Coal Unloading Jetty

Type	Steel pipe piles	
Dimension	Length	240 m
	Width	25 m
	Depth	15 m

(2) Approach Channel

	Length	5,500 m
	Width	350 m
	Depth	16.5 m

(3) Turning Basin

	Area diameter	470 m
	Depth	15 m

(4) Total Dredging Volume — 900,000 m^3

6.3.4 Coal Handling and Storage Facilities

(1) Coal Unloader

Type	Bucket-chain type continuous unloader
Capacity	700 t/h
Quantity	2

(2) Unloading Berth Belt Conveyor

Capacity	1,600 t/h
No. of Line	1

(3) Coal Yard Supply Conveyor

Capacity	1,600 t/h
No. of Line	1

(4) Coal Yard Conveyor

	(for stacking)	(for reclaiming)
Capacity	1,600 t/h	800 t/h
Quantity	1	2

(5) Stacker

Type	Travelling, boom slewing and luffing type
Capacity	1,600 t/h
Quantity	1

(6) Reclaimer

Type	Travelling, boom slewing and luffing, bucket wheel type
Capacity	800 t/h
Quantity	2

(7) Coal Storage yard

Yard Area	Approx. 96,600 m^2 (615 m x 157 m)
Storage Capacity	300,000 ton 150,000 ton (indigenous) 150,000 ton (overseas)
Coal Pile	2 x 47 mW x 13 mH

(8) Bulldozer (for cleaning of coal storage yard)

Type	Caterpillar D5 class
Quantity	2

(9) Discharge Conveyor (Yard to Blending conveyor)

Capacity	800 t/h
No. of Stream	2

(10) Crusser

Type	Impact
Capacity	80 t/h
Quantity	2

(11) Coal Bunker Supply Conveyor (After blending conveyor)

Capacity	400 t/h
No. of Line	2
Frame Type	Girder with belt cover

(12) Coal Bunker

Type	Steel plate
Capacity	700 m^3/bin
Quantity	5 bins/unit
Charging Equipment	Belt scraper

6.3.5 Fuel Oil Storage Tank

(1) Heavy Oil Tank

Type	Steel plate, cone roof
Capacity	4,000 kL
No. of Set	2 tanks/2 units

(2) Light Oil Tank

Type	Steel plate, cone roof
Capacity	1,000 kL
No. of Set	1 tank/2 units

(3) Oil Retaining Wall

Length	270 m
Height	1.7 m

6.3.6 Fresh Water Supply System

(1) Quantity — Max 2,600 m^3/day

(2) Intake Facility — Concrete weir in Masinloc River

(3) Intake Pipe Line

Diameter	250 mmø
Length	10 km

(4) Fresh Water Tank

Capacity	10,000 m^3
Number	1 set/2 units

(5) Portable Water Head Tank

Capacity	40 m^3
Number	1 set/2 units

(6) Service Water Head Tank

Capacity	40 m^3
Number	1 set/2 units

(7) Demineralization Plant

Type	2 bed 3 tower type
Capacity	500 m^3/day.set
Number	2 sets/2 units

(8) Neutralization Tank

Number	1 set/2 units

(9) Demineralized Water Tank

Capacity	1,000 m^3
Number	2 sets/2 units

(10) Filtered Water Tank

Capacity	1,400 m^3
Number	1 set/2 units

6.3.7 Boiler System (per unit)

(1) Boiler

Type	Single drum, outdoor type
Evaporation	(MCR) 990 t/h
	(ECR) 930 t/h

(2) Economizer	Horizontal bear tube type
(3) Air Preheater	Rotary regenerative type
(4) Steam Air Preheater	Finned steel pipe type

(5) Soot Blower

Type	Steam blowing type with electric motor drive
Kind	Long retractable Deslagger Air preheater cleaner

(6) Draft System

i) Induced draft fan

Type	Centrifugal type
Capacity	16,000 m^3N/min
Number	2 sets

ii) Forced draft fan

Type	Centrifugal type
Capacity	6,390 m^3N/min
Number	2 sets

(7) Fuel Firing System

i) Coal feeder

Type	Gravimetric type
Capacity	41 t/h
Number	5 sets

ii) Coal pulverizer

Type	Pressurized vertical type
Capacity	41 t/h
Number	5 sets

iii) Primary air fan

Type	Centrifugal type
Capacity	4,630 m^3/min
Number	2 sets

iv) Coal burner

Capacity	8.6 t/h
Number	20 sets

v) Heavy oil injection pump

Type	Rotary screw type
Capacity	38 t/h
Number	2 sets

vi) Heavy oil heater

Type	Horizontal u-tube type
Capacity	38 t/h
Number	1 set

vii) Heavy oil burner

Type	Steam atomizing type
Capacity	3.5 t/h
Number	12 sets

6.3.8 Turbine System (per unit)

(1) Turbine

Type	Tandem compound, reheat, regenerative two-casing condensing type
Rated Output (at generator end)	300 MW
Steam Condition (at MSV)	Pressure 169 kg/cm^2
Steam Temperature	Temp. (MSV) 538°C (RSV) 538°C
Number of Extraction	8 stages
Exhaust Vacuum	695 mmHg (at 31°C)
Rotating Speed	3,600 rpm

(2) Turbine Attachment

Governor	Electro-hydraulic type
Protective Device	1 set
Hydraulic Control System	1 set

Lubricating Oil System	Main oil pump
	Auxiliary oil pump
	Emergency oil pump
	Main oil tank
	Turning oil pump
	Oil cooler
	Vapour extractor
	Oil purifier
	Oil storage tank
Turning Gear Device	1 set
Gland Sealing System	Gland steam seal
	Regulator
	Gland steam condenser

(3) Condensate System

i) Condenser

Type	Double pass, divided water box type, surface condenser
Cooling seawater Temperature (Design)	(inlet) 31°C (Outlet) 39°C
Quantity	41,500 m^3/h
Number	1 set

ii) Circulating water pump

Type	Vertical mixed flow type
Capacity	22,500 m^3/h (at 31°C)
Number	2 sets

iii) Condenser vacuum pump

Type	Rotating water sealed vacuum pump
Number	2 sets

iv) Condensate pump

Type	Vertical centrifugal type
Capacity	390 t/h
Number	3 sets

(4) Boiler Feed Water System

i) Low pressure feed water heater

Type	U-tube type
Number	4 sets

ii) Deaerator

Type	Horizontal, tray type
Number	1 set

iii) Boiler feed water pump

Type	Motor driven, horizontal barrel centrifugal type
Capacity	520 t/h
Number	3 sets

iv) High pressure feed water heater

Type	U-tube type
Number	3 sets

(5) Miscellaneous Facilities

i) Bearing cooling water pump

Type	Centrifugal
Capacity	1,400 t/h
Number	2 sets

ii) Bearing cooling water cooler

Type	Horizontal
Number	2 sets

iii) Boiler chemical dosing equipment

Type	Injection
Kind of chemicals	Phosphate, ammonia, hydrazine

iv) Fire fighting system

Air foam type fire extinguishing equipment	1 set
Water type fire extinguisher	1 set
Fire extinguishing pump	1 set/2 units

v) Powerhouse crane

Type	Overhead travelling crane
Capacity	60 ton
Number	1 set/2 units

vi) House service boiler

Type	package type
Steam condition	8 kg/cm^2
Capacity	5 t/h
Fuel	Light oil
Number	1 set/2 units

6.3.9 Condenser Cooling Water Facilities

(1) Intake

Type	Deep water intake
Diameter	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) Inlet Pipe Line

Type	Embedded steel pipe
Dimension	Inner diameter 1.8 m
	Length-mean 4 lines x 135 m/2 units

(5) Outlet Pipe Line

Type	Embedded steel pipe
Dimension	Inner diameter 2.6 m
	Length-mean 2 lines x 150 m/2 units

(6) Outlet Pit

Type	Reinforced concrete structure
Dimension	Width 12.0 m
	Height 10.5 m
	Length 25.0 m

(7) Outlet

Type	Rubble stone revetment
Dimension	Width 6.0 m
	Height DL + 3.0 m
	Length 500 m

(8) Intake Facilities

Type	Bar, Rotary, Mesh screen
Number	1 set

(9) Chlorine Injection Equipment

Number	1 set

(10) Intake Crane

Type	Gantry
Capacity	15 tons
Number	1 set/2 units

6.3.10 Electrical Facilities (per unit)

(1) Generator

i) Type	Horizontal shaft, 3 phase, hydrogen-cooled
ii) Rating	
Generator output	334,000 kVA
Voltage	18 to 24 kV (according to Manufacturer's standard)
Power factor	90%
Short circuit ratio	0.58
iii) Excitation	Brushless or static excitation

(2) Main Transformer

i) Type	Outdoor type, 3 phase, forced oil circulating, forced air cooled

ii) Rating

Capacity	320,000 kVA
Voltage	18 to 24/230 kV

iii) Connection method — Δ - Y connection, neutral point direct earthing, 30 degree lag.

(3) House Transformer

i) Type — Outdoor type, 3 phase, oil immersed self-cooled transformer

ii) Rating

Capacity	30,000 kVA
Voltage	18 to 24/6.9 kV

iii) Connection method — Δ - Δ connection

(4) General Service Transformer

i) Type — Outdoor type, 3 phase, forced oil circulating forced air-cooled

ii) Rating

Capacity	40,000 kVA
Voltage	230/6.9 kV

iii) Connection method — Y - Δ connection, neutral point direct earthing, 30 degree lead

iv) Number — 1 set/2 units

(5) Switchyard

i) System — Outdoor double bus bar

ii) Circuit breaker

Type	Porcelain type, SF_6 type circuit breaker
Rating	242 kV, 2,000 A 31.5 kA (Interrupting current)
Number of unit	4 units/2 units

iii) Disconnecting switch

Type	Porcelain type single or double breaking switch

iv) Others

Steel structure
Insulator
Bus bar
Instrument potential transformer
Instrument current transformer
Arrester
Compressor

(6) 6.9 kV Metal Clad Switchgear

i) Cubicle type — Indoor, single bus, metal enclosed type power board

ii) Circuit breaker

Type	SF_6 type or vacuum type circuit breaker 6.9 kV 40 kA (Interrupting current)

iii) Number of group — 7 groups/2 units

(7) 460 V Power Center

i) Cubicle type — Indoor, single bus, metal enclosed type power board

ii) Circuit breaker

Type	Air circuit breaker
Rating	600 V

iii) Number of group — 11 groups/2 units

(8) 460 V Control Center

i) Cubicle type — Indoor, single bus, enclosed type power board

ii) Circuit breaker

Type	Air circuit breaker
Rating	600 V

iii) Number of group — 18 groups/2 units

(9) Power Center Transformer

i) Type — Indoor, 3 phase, dry type

ii) Rating

Capacity	2,000 kVA, 1,500 kVA
Voltage	6,900/460 V

iii) Connecting method — Δ-Y 30 degree lag.

(10) Emergency Power Source

i) Type — Diesel-engine generator

ii) Rating

Output	500 kVA
Voltage	460 V
Power factor	80%

iii) Fuel — Light oil

iv) Number — 1 set/2 units