Republic of Indonesia
Ministry of Energy and Mineral Resources
PT PLN（Persero）

Republic of Indonesia

The Project for Promotion of Clean Coal Technology (CCT) in Indonesia

FINAL REPORT

Separate Volume 1

Preliminary Feasibility Study Report of CCT 1,000MW Coal-fired Model power plant(s)

October 2012

Japan International Cooperation Agency (JICA)

Chubu Electric Power Co., Inc.
Electric Power Development Co., Ltd.
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INTRODUCTION

1.1 Background of Model Power Plant

The economy of Indonesia is in rapid growth and electricity supply is needed to be increased to catch up with the demand increase along with this economic growth. According to RUPTL 2011-2020, the electricity demand in 2020 will be almost twice of the demand in 2011. Especially, the Jawa-Bali area requires approximately 70% of the demand in 2020.

Table 1.1-1 Electricity Demand Forecast of Indonesia

	Unit	2011	2012	2014	2016	2018	2020
1.Energy Demand							
- Indonesia	TWh	162,4	177,8	210,1	246,2	284,4	328,3
- Jawa-Bali		125,2	135,8	158,5	184,5	211,1	241,2
- Indonesia Timur		13,1	15,1	18,7	22,4	26,6	31,7
- Indonesia Barat		24,0	26,9	32,9	39,3	46,6	55,3
2.Pertumbuhan							
- Indonesia	%	11,5	9,5	8,6	8,2	7,5	7,4
- Jawa-Bali		10,4	8,4	8,0	7,9	7,0	6,8
- Indonesia Timur		16,4	15,1	10,6	9,2	9,2	9,1
- Indonesia Barat		14,5	12,0	10,4	9,1	8,8	9,0
3.Rasio Elektrifikasi							
- Indonesia	%	71,9	74,4	79,9	85,5	90,3	94,4
- Jawa-Bali		72,8	75,4	81,5	88,1	93,7	97,8
- Indonesia Timur		65,5	67,6	72,1	76,7	81,3	86,4
- Indonesia Barat		74,3	76,7	81,5	85,0	88,2	91,6

Source: RUPTL 2011-2020

The produced electricity is 169.79 TWh[1] in 2010 and it will not be sufficient to cover the demand by 2012. Therefore, the construction of additional power plants to enhance the generation capacity in Indonesia is the pressing issue for the country. This high demand for electricity is expected to continue after 2020 and the additional capacity required for 5 years from 2021 to 2025 is forecasted to be 15,000 MW in Jawa-Bali region.

In order to examine the optimal power development plan (energy mix) until 2025, the simulation was run using the same simulation tool (WASP-IV) as RUPTL. The optimal power development plan is the least cost plan in terms of the total cost including the fuel cost and the operation cost (The characteristic of the operation cost and availability factor is also considered). However, based on the renewable energy development promotion policy, geothermal development was also incorporated. The assumption for simulation is as follows:

[1] Source: PLN statistics 2010

Table 1.1-2 Assumption for simulation

Type of Primary Energy	Price	Calorofic Value
Coal - Sub Bituminous	USD 80/Ton	5.100 kcal/kg
Coal - Lignite	USD 50/Ton	4.200 kcal/kg
Coal - Lignite at Mine Mouth	USD 35/Ton	4.200 kcal/kg
Natural Gas	USD 6/MMBTU	252.000 kcal/Mscf
LNG	USD 10/MMBTU	252.000 kcal/Mscf
HSD(HighSpeed Diesel)	USD 0,62/Liter	9.070 kcal/l
MFO(Marine Fuel Oil)	USD 0,48/Liter	9.370 kcal/l
Geothermal Steam	(does not affect the result of planning simulation as these plant are treated as *fixed plants*)	

Source: PLN

The following table is the simulation result. Out of 15,000MW, the coal fired will account for 86.7%. The coal-fired source will be the base load together with geothermal power and partly in charge of the middle load. The peak and middle load will be supplied by the existing gas-fired plants, pumped storage power plants and hydropower stations.

Table 1.1-3 Power development plan in Java-Bali region (2021-2020)

(Unit: MW)

Generation	Year	2021	2022	2023	2024	2025	2020-2025
Coal	Development	3,000	2,000	3,000	2,000	3,000	13,000
	Total	28,171	30,171	33,171	35,171	38,171	86.70%
Gas	Development	0	0	0	0	-170	-170
	Total	12,551	12,551	12,551	12,551	12,381	-1.1%
Diesel	Development	0	0	0	0	0	0
	Total	229	229	229	229	229	0%
Geothermal	Development	330	330	330	330	330	1,650
	Total	4,351	4,681	5,011	5,341	5,671	11.00%
Hydropower	Development	0	0	0	0	0	0
	Total	2,597	2,597	2,597	2,597	2,597	0%
Pomped Storage	Development	520	0	0	0	0	520
	Total	2,968	2,968	2,968	2,968	2,968	3.50%
Total	Development	3,850	2,330	3,330	2,330	3160	15,000
	Total	50,867	53,197	56,527	58,857	62,017	100%

Source: JICA study team

In Indonesia, construction of the coal-fired power plants using ultra super critical (USC) boilers is planned and these plants are expected to commence the commercial operation in 2016 and 2017. (e.g. Central-Java by IPP and Indramayu by ODA) Therefore, USC is likely to be the mainstream technology for the coal-fired plants in the near future.

The application of USC is financially rational in terms of the cost. The lifetime cost comparison across major coal-fired plant technologies was made based on the following assumption:

- The coal with low calorif ic value has high moisture in the coal. Thus, degradation of thermal efficiency due to drying in mills to satisfy calorie requirements for was taken into account.
- In case of 2,400/3,000 kc al/kg except IGCC (Integr ated coal Gasification Com bined Cycle), a boiler needs to be designed for lignite. viz., the large furnace is necessary to be adopted in order to avoid slugging, fall in fla me temperature and ensure flame holding. Therefore, the lar ge increase of boiler capacity was taken into account in the construction cost.
- Gasification boilers are the same configuration even if the coal is 2,400/ 3,000 kcal/kg. So, construction cost for IGCC is the same. Howeve r, there is no commercial pl ant for IGCC at present, so the target in 2020 for manufacturers was utilized for the construction cost.
- The coal price in 2020 was assumed to be twice of 2011, considering the future coal price increase.

Table 1.1-4 Assumption for cost comparison

(Construction cost, thermal efficiency, O&M cost, coal price)

Precondition of cost comparison		Sub Critical	SC	USC	IGCC	Coal Price ($/ton)	
Gross Power		1,000MW	1,000MW	1,000MW	1000MW Class	Y 2011	Y 2020
Plant Efficiency	4,200kcal/kg	36%	39%	42%	49%	53.8	107.6
	3,000kcal/kg	33%	36%	39%	45%	31.4	62.8
	2,400kcal/kg	30%	33%	36%	42%	21.7	43.4
Construction Cost	4,200kcal/kg	100% (Base)	106.5%.	108.5%	130.0%	-	-
	3,000kcal/kg	107.0%	111.0%	115.0%	130.0%	-	-
	2,400kcal/kg	110.5%	115.5%	119.0%	130.0%	-	-
Coal Consumption (kg/kWh.net)		100% (Base)	90%	84%	75%	-	-
O & M cost		2.5%	3%	3%	3.%	-	-

Source: JICA study team

(SC: Super Critical)

Based on the assu mption in Table 1.1-4, the cost wa s compared in terms of the generation cost (p er kWh). (IGCC is not yet at the commercial stage, so the cost f or IGCC is a referential value.) The capital cost is equally divided using the capital r ecovery factor. The capital recovery factor i s calculated assuming the project life of 30 years and 12% as the interest rate. The result is as follows:

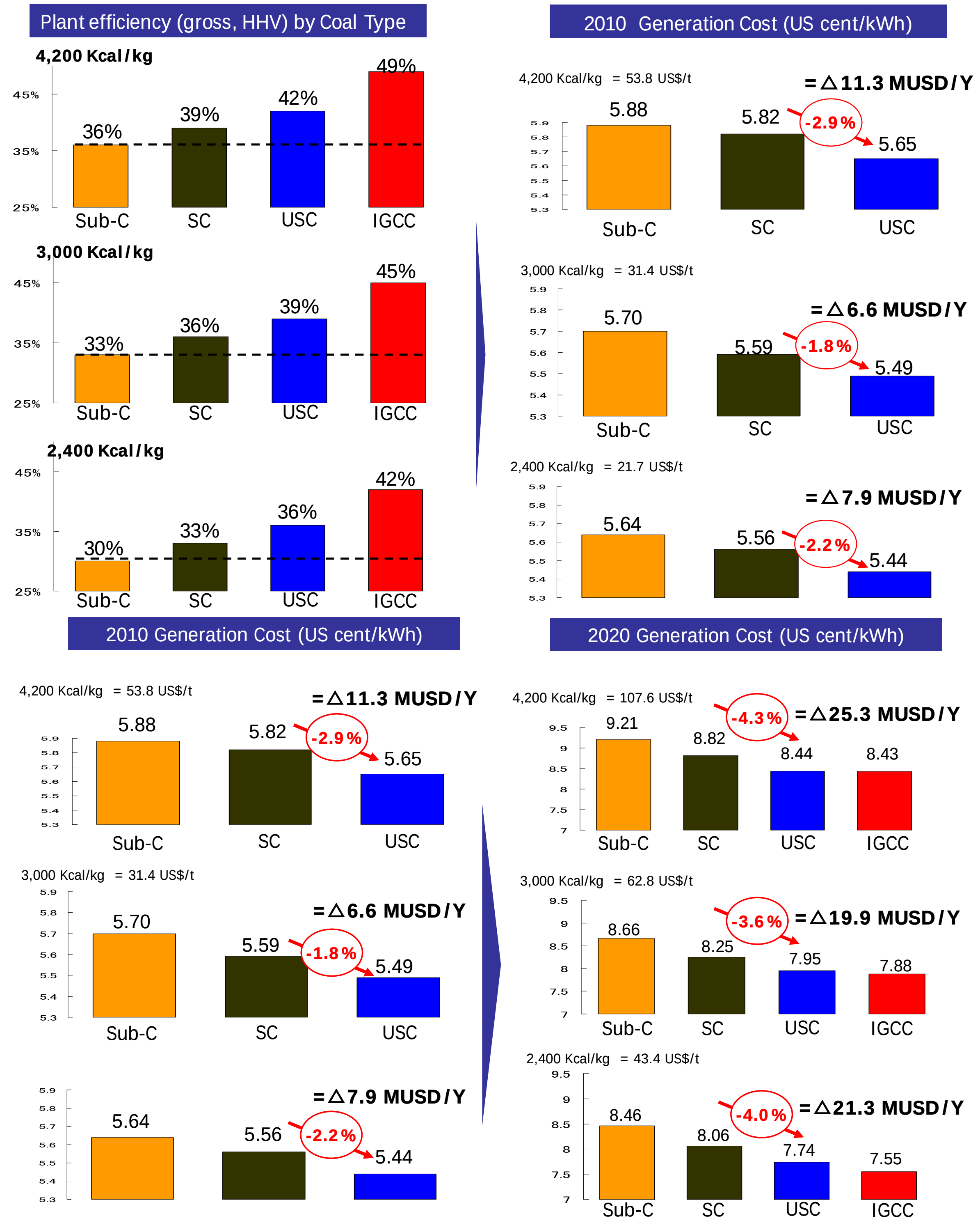


Figure 1.1-1 Lifetime cost comparison

Source: JICA study team

- Based on the coal price of 2011, USC coal power plant is the least cost for all coal type, but the difference is small. However, based on the coal price of 2020, it is obvious that USC coal power plant is advantageous. USC coal power plant consumes less coal. So, when the coal price becomes higher, the impact on the generation cost becomes higher.

- Based on the coal price in 2020 in which IGCC's commercial plants become available, IGCC becomes advantageous than USC coal power plant especially in case of the low rank coal use.

In case of 1,000 MW plants, the construction cost for USC coal power plant is US$24 million/year higher than SC coal power plant and its O&M cost is US$1 million/year higher. However, the fuel cost can be saved by US$30 million/year, so increase of the construction cost can be recovered approximately in 1 year.

Based on above, the following roadmap for CCT (Clean Coal Technology) was proposed.

- USC coal power plant is introduced worldwide and its technology is already matured. Therefore, it is the key technology to realize the lifetime cost reduction and CO_2 emission reduction. As the fuel price increase is expected in the future, economic advantage of USC coal power plant will be further clearer.
- For IGCC, operation experience by demonstration plants will be accumulated and it is the promising technology of which introduction in commercial plants is expected after 2020. In Indonesia, low rank coal will be used for power generation and IGCC's economic advantage to USC is likely to be ensured.
- Timing to introduce IGCC in Indonesia will be after data is obtained in other countries such as construction costs and O&M costs.

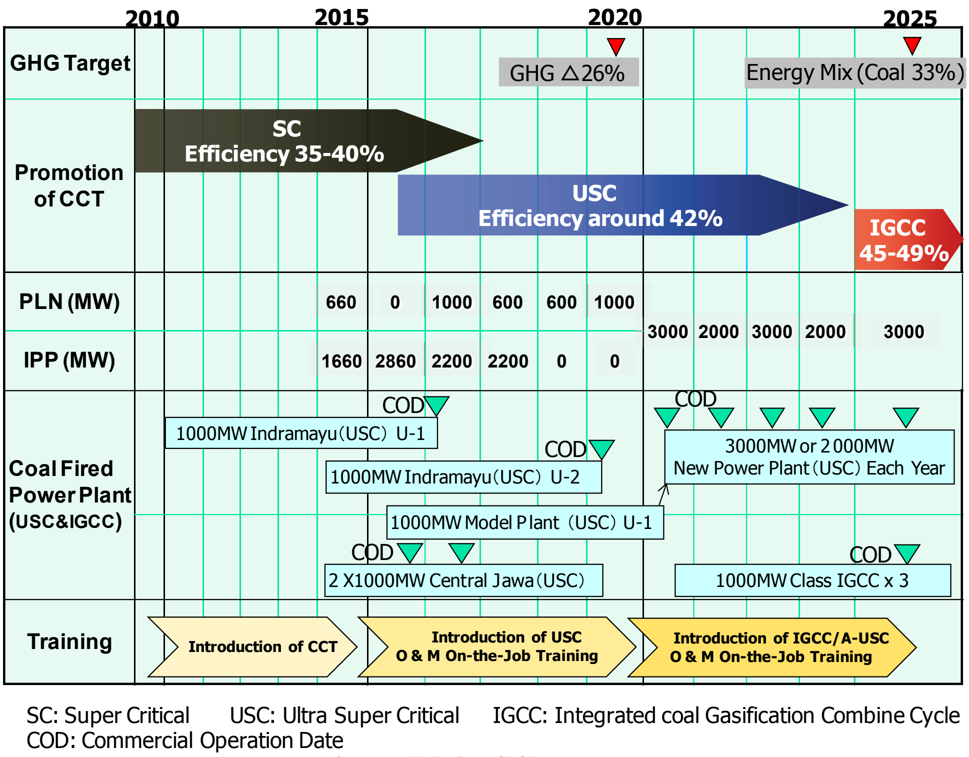


Figure 1.1-2 CCT Roadmap

Source: JICA study team

As one of the potential plant sites to introduce additional USC coal power plant, Bojonegara was selected by starting the commercial operation in 2021. The detailed screening process to identify

Bojonegara and the applied technology (Ultra Super Critical steam condition) is discussed in Main Report of JICA Study Team. Before making the final decision to construct a power plant in Bojonegara, the preliminary feasibility study ("pre-FS" hereinafter) is conducted in order to roughly examine the feasibility of this power plant. In the following section, the potential power plant in Bojonegara was called as "Model Power Plant".

1.2 Outline of the Model Power Plant

The Model Power Plant is to develop 1,000 MW × one (1) unit Coal-Fired Thermal Power Plant and additional 1,000 MW × one (1) unit in the future. This Model Power Plant is to use Ultra Super Critical (USC) steam condition of high-technology, and USC steam condition of the Model Power Plant is temperature of 600 deg C/620 deg C pressure 25.0 MPa at a steam turbine inlet. The location of Model Power Plant is in Java and designed to deliver 1,000 MW to the PLN 500 kV transmission line though 500kV substation will be constructed in power plant.

1,000 MW × one (1) unit Coal-Fired Modal Power Plant including with as following;
(Refer to Figure: 1.2a & 1.2b 1,000 MW Coal Fired Thermal Power Plant)

(1) Steam Generator (Boiler)

Model power plant should be installed one through type of boiler such as Benson type or another type for USC steam condition boiler including fuel supply system such as coal feeders, pulverizers and burners.

Boiler thermal efficiency will be ≥84% (HHV)

(2) Steam Turbine and Generator

Model power plant should be installed steam turbine such as tandem compound type of turbine with generator. Also, the boiler water supply system includes boiler water heating system such as heat exchangers and condenser system as well.

Turbine thermal efficiency will be ≥47%

(3) Electrical equipment and control system

Electrical equipment and control system has to include main transformer, house transformer, staring transformer, high voltage switch gears, down transformers, low/middle voltage switch gears, motors, cables and their control systems.

(4) Coal handling system

Coal handling system has to include coal unloading facilities, coal receiving conveyers, coal storage yard with stacker/reclaimer and coal delivery conveyers. Coal circulation conveyer should be included in the coal storage yard as well because, it is protection against fire.

(5) Ash handling system

Ash handling system includes fly ash collecting system, bottom ash collecting system, those ash transportation systems and discharging system with conveyers to ash disposal area in Model Power Plant.

(6) Flue gas treating system

Model Power Plant shall apply technical m easures for absolute treating pollution caused by flue gas, including:

- Particulate Collecting System
- Fuel Gas Desulfurization (FGD) System

(7) Plant Water System

Model Power Plant shall apply followings Plant Water System but not limited to:

1) Chlorination system
2) Desalination system
3) Water Treatment System
4) Potable Water System
5) Service Water System

1.3 Outline of Project Site

PLN and JICA study team selected one (1) location below of the official construction site for 1,000 MW coal fired model power plant (for the locations, refer to Figure 2.1.2-1 and Figure 2.1.2-2).

Bojonegara site

1) Site Area : Applicable for 1,000 MW × 2 Units Coal Fired Power Plant
   (Figure: 1.3-1 and Figure 1.3-2 show the "Bojonegara 1,000 MW Coal Fired Thermal Power Plant")
2) Site Access; The site is along a national road (Refer to Map of Bojonegara)
3) Soil Condition; Approx. 60% is wet land and the other 40% is low ground or mangrove tree area.
   (Shoreline) therefore, the site renovation and pile work is required.
4) Seabed Level; Slope gently away from the shore.
   The location of coal unloading berth and jetty may be required for 2.5 - 3 .0 km from shoreline, due to water depth for coal barges.
5) Fuel; Berth and jetty for coal unloading will be constructed in Project site sea shore.
   Coal is transported from Sumatra or Kalimantan by coal vessel or coal barge, and unloading jetty will be used for the unloading of fuel oil as well.
6) Cooling Water for Condenser; Possible cooling water intake from sea
7) Plant water supply; Used by Desalination plant water
8) HV transmutation grid; Available of 500 kV Transmission towers near the site area.

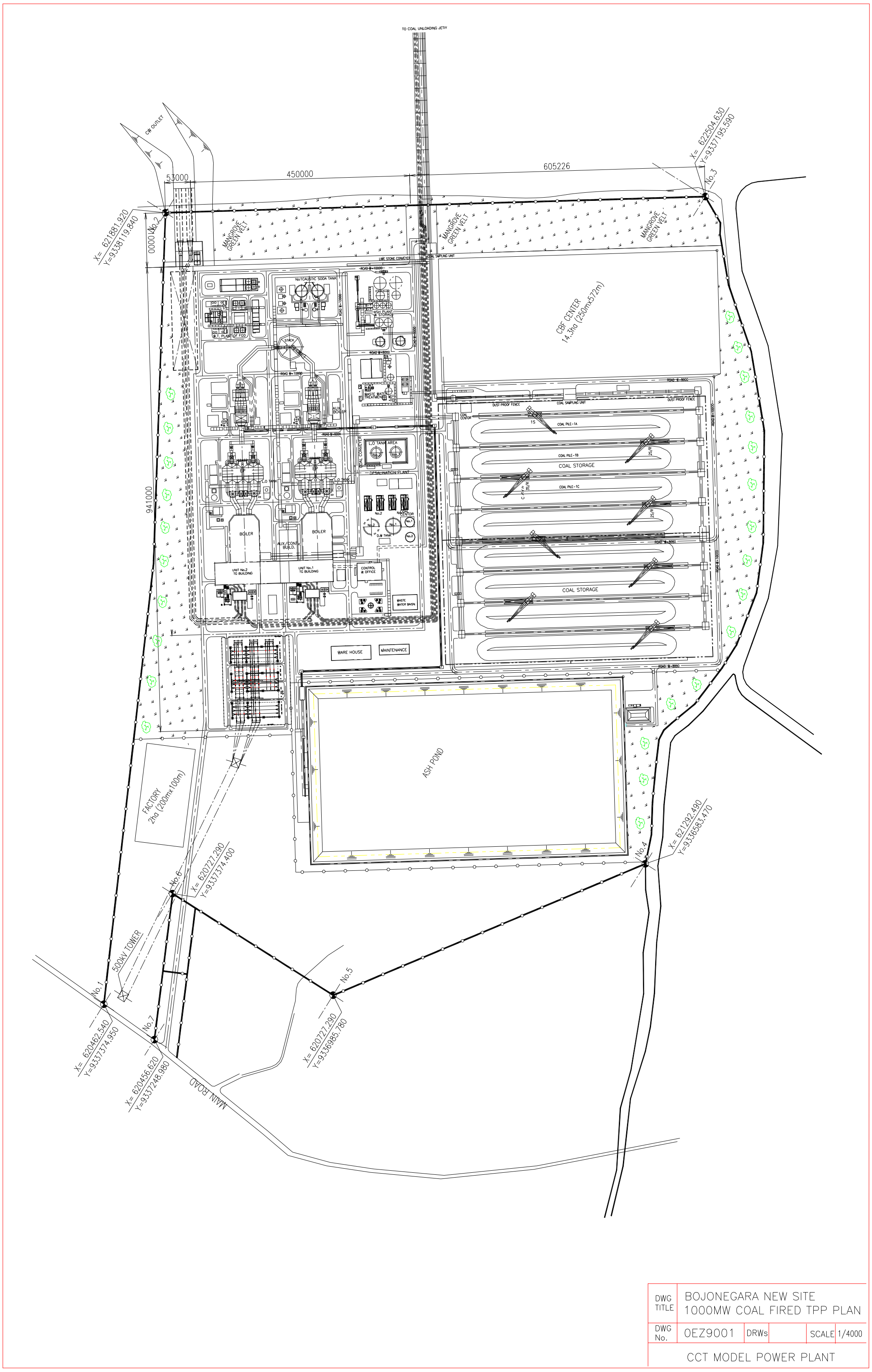


Figure 1.3-1 General layout for Planed Coal Fired Power Plant

Source: JICA study team

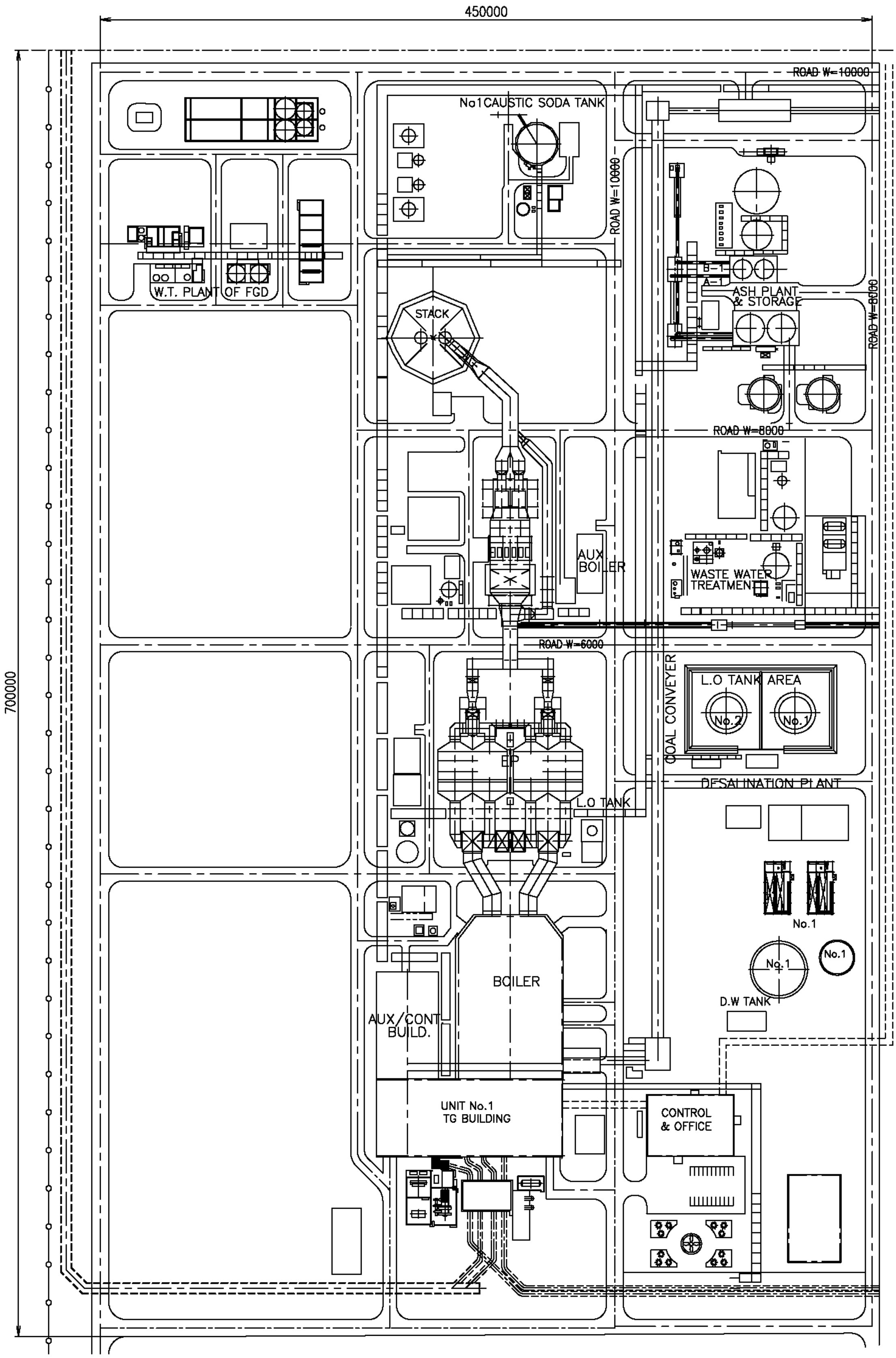


Figure 1.3-2 1,000 MW × 1 Unit Coal Fired Thermal Power Plan

Source: JICA study team

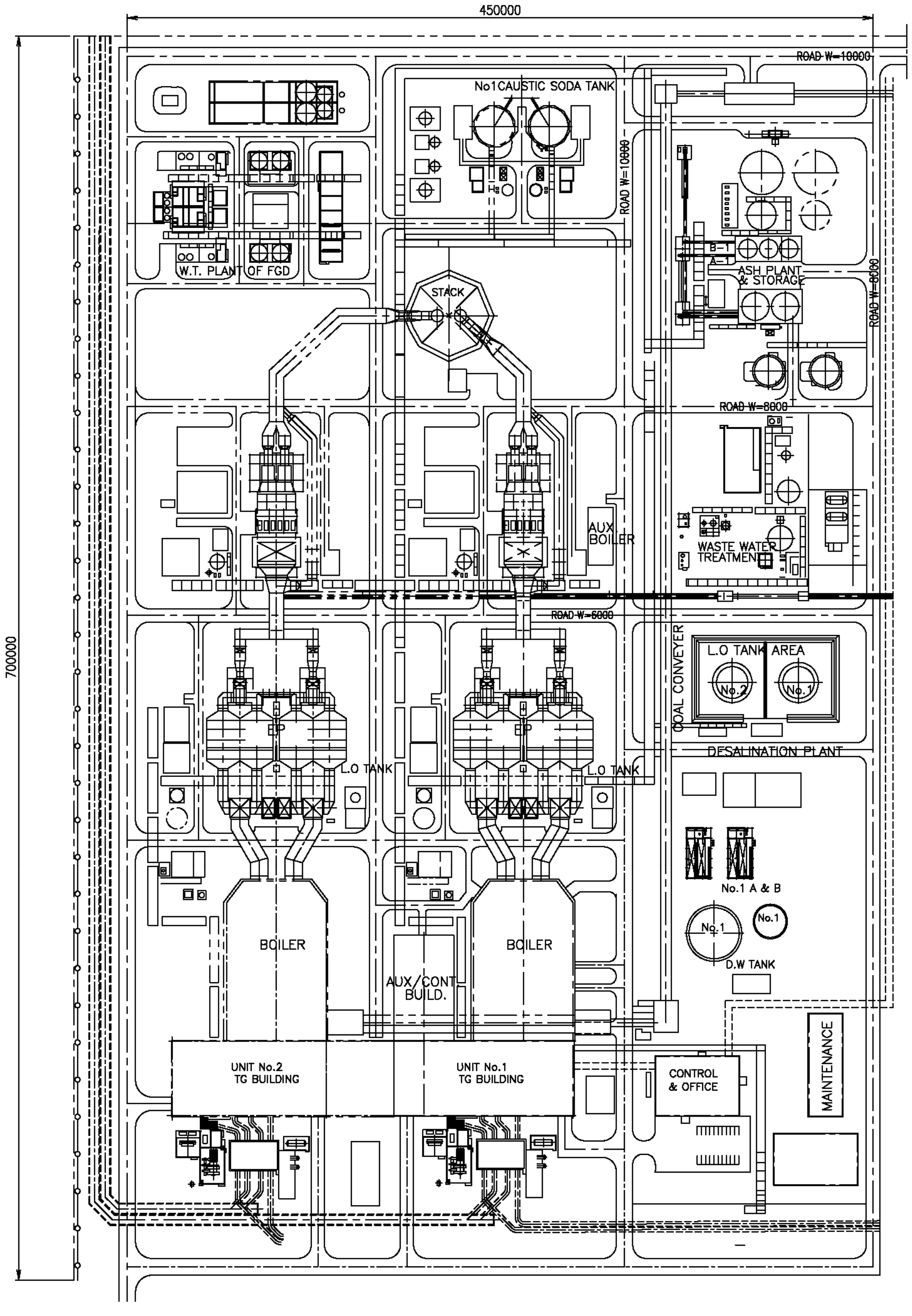


Figure 1.3-3 1,000 MW × 2 Units Coal Fired Thermal Power Plant

Source: JICA study team

CHAPTER 2

CONDITION OF MODEL POWER PLANT SITE

CHAPTER 2
CONDITION OF MODEL POWER PLANT SITE

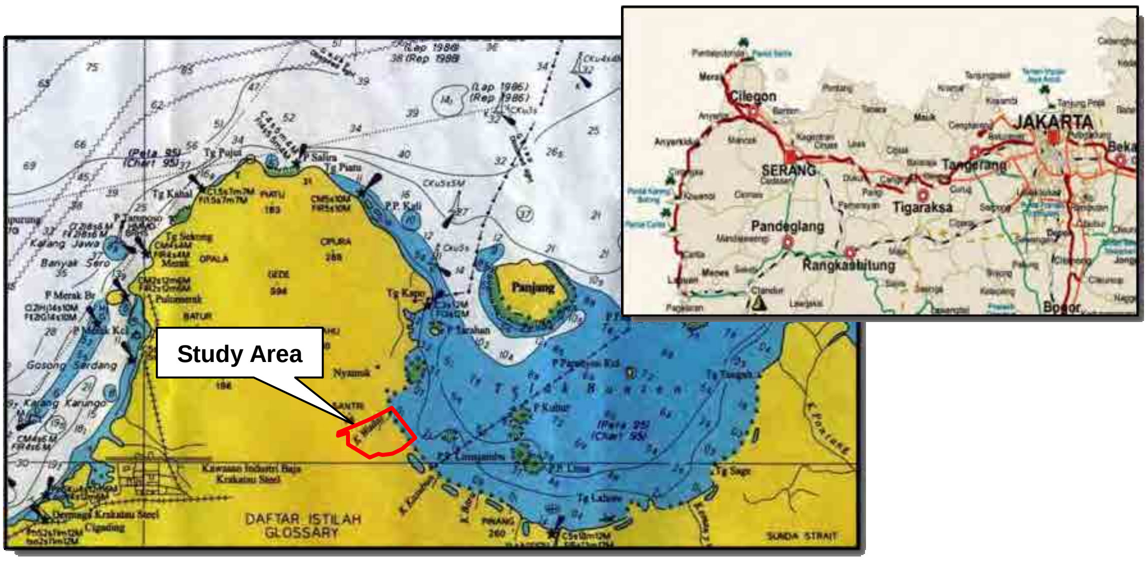
2.1 Condition of Preset Site Area for Model Power Plant

Site Location

The selected study site is possessed by *PT. PLN* (State Owned Electric Company), located at *Terate* Village, *Kramatwatu* Sub-District, *Serang* District of *Banten* Province and being part of the *Jababeka* Industrial Estate.

Bojonegara site location is approximately 98.5 km far from the Jakarta, location of which is as on the following Photo-100. Location can be reached from *Jakarta* through toll road until *Cilegon Timur* tollgate and continued northward through province road approximately 2 km. This site is also indicated as approximately 20 km east side of the existing *PT. PLN Suralaya* Coal-fired Power Plant.

The location map of the study area is shown below.



Source: JICA Study Team

Figure 2.1-1 Location Map of Study Area

2.1.1 Condition of Preset Site Area

2.1.1.1 Topographic General Conditions

The location is situated with natural boundary of shore line on east side and river on south side, while north and west side adjacent by factory area.

Overall industrial zone, where the Model plant site is located, originally is relatively low-level flat area. The average elevation is 1.3 to 2.6 m above M.W.L. (Mean Water Level). Part of the land had been filled until elevation of 1.65 meter above the highest sea water level and the other part of the area is remaining as a consisting of 60% fishponds area while 40% area is paddy fields and dry land, and the average elevation is 0.2 to 0.8 m above M.W.L.

(1) Bench Mark

There are no existence of official bench mark around the study site, not from both National Land Agency (*BPN*) and National Survey and Mapping Coordination Board (*Bakosurtanal*).

But according to information from the National Land Agency (*BPN*), there is second-order BM located in the front of *Bojonegara* District Office, approximately 6.0 km far from the study site.

(2) River

There is a river namely *Kedungingas* river (*Sungai Kedungingas*) as the natural south side boundary of study site that flows directly to the shore at the east side.

The river is the downstream side of the previous Rubber Dam which located across the road bridge at the up-stream of this river. The capacity of the river is wide enough to become the passage route for fisherman boat and fishing activities.

(3) Mangrove Vegetation

Along the shoreline of *Bojonegara* study site, located a green belt zone in the form of mangrove vegetation with the area approximately 10 ha area. Decided from the height of vegetation for about more than 2 m high, and estimated density of hundreds of trees, it seem this green belt was planted & remain un-disturbed on this area for quite a long time.

2.1.1.2 Geological Condition

A soil investigation and geotechnical analysis had been conducted through previous study on the study site. The study covered the field investigation consisting of deep soil boring points on 25 boring points spread over the planned location of the study site, undisturbed soil sampling, standard penetration test, and core penetration test. The respective geotechnical analysis had been aimed to analyze geotechnical aspects in the proposed study site, and to select the type of foundation required.

Geological survey was conducted to check the geological condition around the study site such as soil/rock unit, stratigraphy and other geological features. The survey was carried out by field observation using hand held GPS to check the boundary between rock/soil unit.

Based on the field observation, the rock/soil unit exposed at the study site are divided into 3 rock/soil units, they are:

(1) Coastal deposit

Coastal deposit occupied the north part of the study site and spreads along the coast. The material consisting of sand, silt, and mud with some gravels and fragment of mollusk shells. This lithology formed a wide plain area along the coast.

The sand is white to yellowish brown color, loose, fine to medium grain, and contain of mollusk shell. The sand exposed alongside the coastal periphery with wide about 5 to 10 m.

Silt and mud exposed from coastal and spread toward the land up to approximately 1 km at survey site. The silt and mud is brown to light brown in color, soft to very soft, low plasticity with some mollusk shells fragment. This lithology forms a wide plain area and is used by local people as fish pond.

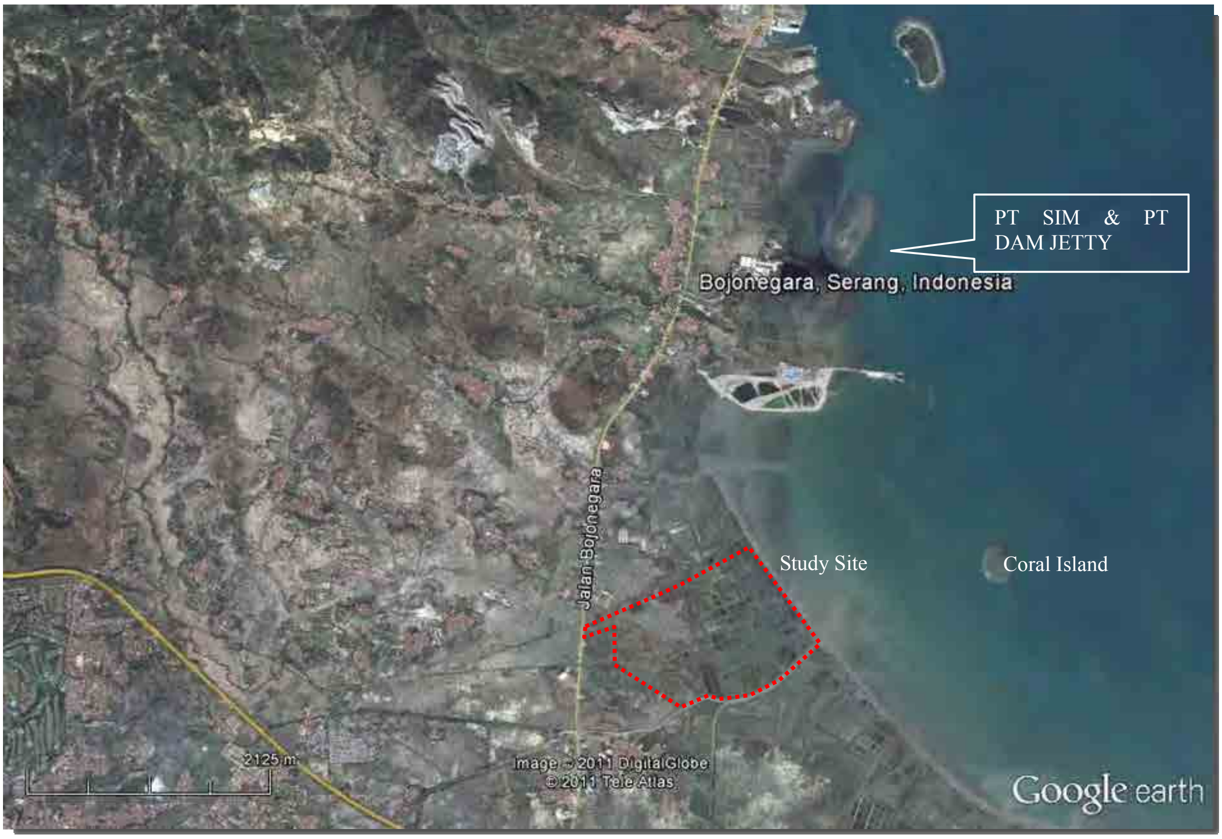
(2) Swamp deposit

Swamp deposit observed at south part of the coast al deposit form a plain area. The material is clay, gray to yellowish gray, soft and high plasticity. The local people use this area as paddy field.

(3) Volcanic deposit

Volcanic deposit exposed at south part of survey site. The material is gravely sandy Silt (derived from tuff and breccias weathered), red, brown to yellowish brown in color, contain of landsite and tuff gravels. This deposit lay s upper the swamp deposit with 1.0 up t o 2.0 m in thickness. Local people used this area as plantation.

The location Map of the 1,000 MW Model Coal-Fired TPP Site is shown below;



Source: JICA Study Team

Figure 2.1.1-1 Location Map of Study Site

2.1.1.3 The Photo of the 1,000 MW Model Coal-Fired TPP Site is shown below;

View to Access Gate Area

View to Natural Ground Area

View to Fish Pond & Grass Field Area (to Seaside)

Source: JICA Study Team

View to Fish Pond Area (to Seaside)

View to Fish Pond Area (to Seaside)

Source: JICA Study Team

2.1.2 Geographical Condition of Preset Site Area (On-Shore and Off-Shore)

2.1.2.1 Geographical Condition of Preset Site Area (On Shore)

A. Site Boundaries

Site Boundary was subjected on the land property of *PT. PLN*, therefore the survey was conducted by identifying each existing boundary marking for Model Power Plant including the boundary area of *PT. PLN* property.

The survey was carried out by using hand held GPS Garmin 76CSx providing the coordinate position of each marking point. There are 7 points of the existing marking which can be identified, and tabulated as follows:

Table 2.1.2-1 Coordinate Position of Site Boundaries

No.	X	Y
1.	620462.54	9337374.95
2.	621881.92	9338119.84
3.	622504.63	9337195.59
4.	621292.49	9336583.47
5.	620727.29	9336985.78
6.	620727.29	9337374.40
7.	620456.62	9337248.98

Source: JICA Study Team

The total area of the *PT. PLN* property for study site as calculated from the obtained coordinate of site boundary is 173.3 ha.

The coordinate positioning obtained during on-site reconnaissance survey on the site boundaries and other infrastructures, then overlaid onto the official topographic map to provide overall ma p as shown in t he 2) Bench Mark, A. Topographi c General Conditi ons 2.1.1 Condition of Pr eset Site Area

B. Topsoil and Ground Surface Condition

The topsoil lay er consists of very soft, whic h is highly compressible, the thickness range s of which are from 8m to 15 m. Whereas the depth of bearing stratum, consisting of breccias/and side layer varies from 44 m to 51 m below ground surface;

Because the topsoil layer consists of very soft soil that is highly compressible, surcharge loading will generate large settlement. The degree of consolidation settlement (Sc) of topsoil layer due to various embankment height is esti mated as follows (assumed unit weight of e mbankment fill material = 17 kN/m^3);

a) Embankment height = 0.5 m, Sc = 0.30 m
b) Embankment height = 1.0 m, Sc = 0.52 m
c) Embankment height = 1.5 m, Sc = 0.68 m
d) Embankment height = 2.0 m, Sc = 0.82 m
e) Embankment height = 2.5 m, Sc = 0.94 m

The consolidation time to reach 90% of total conso lidation is estimated ±30 years. Vertical drain may be used to accelerate the rate of consolidation. The consolidation time (Month) as a function of vertical drain spacing (s) is estimated as follows;

1. s = 1. 00 m: time = 3.0 months
2. s = 1. 25 m: time = 5.0 months
3. s = 1. 50 m: time = 7.5 months

Upon filed observation, most of the ground surface at proposed model plant location is submerged by water. Consequently, round reclamation (fill) is required at proposed model plant location. The ground surface has low bearing capacities, therefore the reclamation height should not exceed 1.0m. If higher embankment fill is required to reach the design ground surface level, then the embankment should be constructed in staged construction method and embankment fill should be compacted properly. Filling material s quantity should consider the amount of settlement, where the total height of embankment is estimated as;

"Total embankment height = final ground surface – existing ground surface + settlement"

C. Borrow Area Location

Basically around the study site there are many rock mining company, however based on field observation only 2 companies with adequate capacity in product are located. The companies are *PT. Bukit Lambang Sari Makmur* and *PT. Sumber Gunung Maju*.

PT. Bukit Lambang Sari Makmur located on coordinate (61861, 9340595) or about 4 km far from study site. The product capacity of this company is 500 m^3/day. The price for coarse aggregate is Rp. 105,000/m^3.

PT. Sumber Gunung Maju has 2 locations of rock quarry. This company is the biggest rock mining company in this area. The first location coordinate is (617754, 9341155) and the second location coordinate is (620425, 9336683).

During site visit on 12 October 2011, the first location is still under construction and plans to be operated in the next 2 months. The second location has been operates since 1997. The product capacity of this company is 1,000 m^3/day. The materials product and price is tabulated as the following:

Table 2.1.2-2 Price of Rock Materials

No	Product	Price (Rp)	Remark
1.	Stone dust	1,782.000 367,000	21 – 23 m^3 7 – 8 m^3
2.	Aggregate 1-2 cm & 2-3 cm (*Split*)	2,002,000 637,000	21 – 23 m^3 7 – 8 m^3
3.	Screening (uniform size: 5 mm)	2,002,200 637,000	21 – 23 m^3 7 – 8 m^3
4.	Aggregate 3-5 cm (*Macadam*)	2,002,000 637,000	21 – 23 m^3 7 – 8 m^3
5.	Base coarse	2,002,000 637,000	21 – 23 m^3 7 – 8 m^3
6.	Sand stone (*Sirdam Giling*) (for land filling)	1,672,000 532,000	21 – 23 m^3 7 – 8 m^3

Source: JICA Study Team

Concerning to the huge quantity estimation of rock or soil material required for land filling, so far there are no single company or supplier of material will able to provide such quantity of

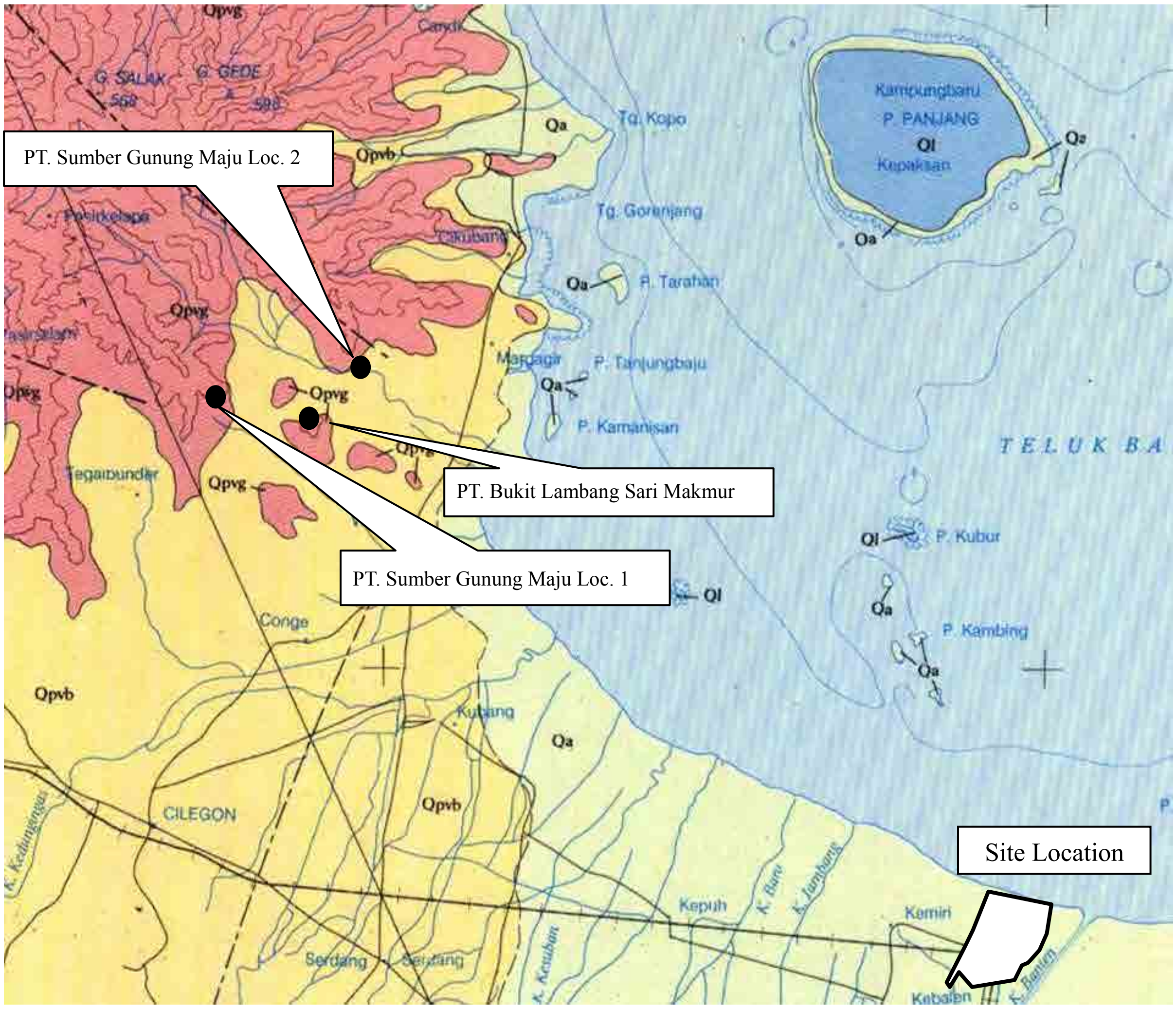
3,000,000 – 4,000,000 m^3. Therefore the possible option to provide such huge quantity is to from several material providers and quarries which not necessarily located very near to study site.

Geological Conditions of Borrow Area

Based on coordinate positioning on-site and overlaid onto Regional Geological Map *Serang Quadrangle* (by *E. Rusmana, K. Suwitodirdjo* and *Suharsono*, 1978), the borrow area is located on *Gede* volcanic product. The *Gede* volcanic product is consisting of lava of pyroxene andesitic, volcanic breccias and compact volcanic mudflow. The best material for concrete aggregate is andesitic lava.

Coral Reef

The coral reef is located at north part of the site at coordinate (624086.72, 9337864.85) approximately 2.0 km far from the coastline toward the sea. The coral reef forms an island with 9.0959 ha wide (based on GPS tracking). The coral is yellowish and white to gray, hard, cavernous and rough at the surface. The coral reef island looks at the surface when low tide, and when high tide the coral reef was submerged for about 2.0 m depth.



Qa	River and Coastal deposits, pebbles, gravel, sand, silt, m ud and plants remains with fragments of mollusk shells. River deposit, principally founded along the river streams. Coastal deposits are present along the coast
Qpvb	Banten tuff, consisting of Tuff, pumice tuff, and tuffaceous sandstone
Qpvg	Gede volcanic product, Lavas of pyroxene andesitic composition, volcanic breccias and compact volcanic mudflow. Advance stage of erosion but cone shape is still distinct.

Source: JICA Study Team

Figure 2.1.2-1 Location of Rock Quarry in Correlation with Rock Unit based on regional geological map

(*E. Rusmana*, *K. Suwitodirdjo* and *Suharsono*, 1978)

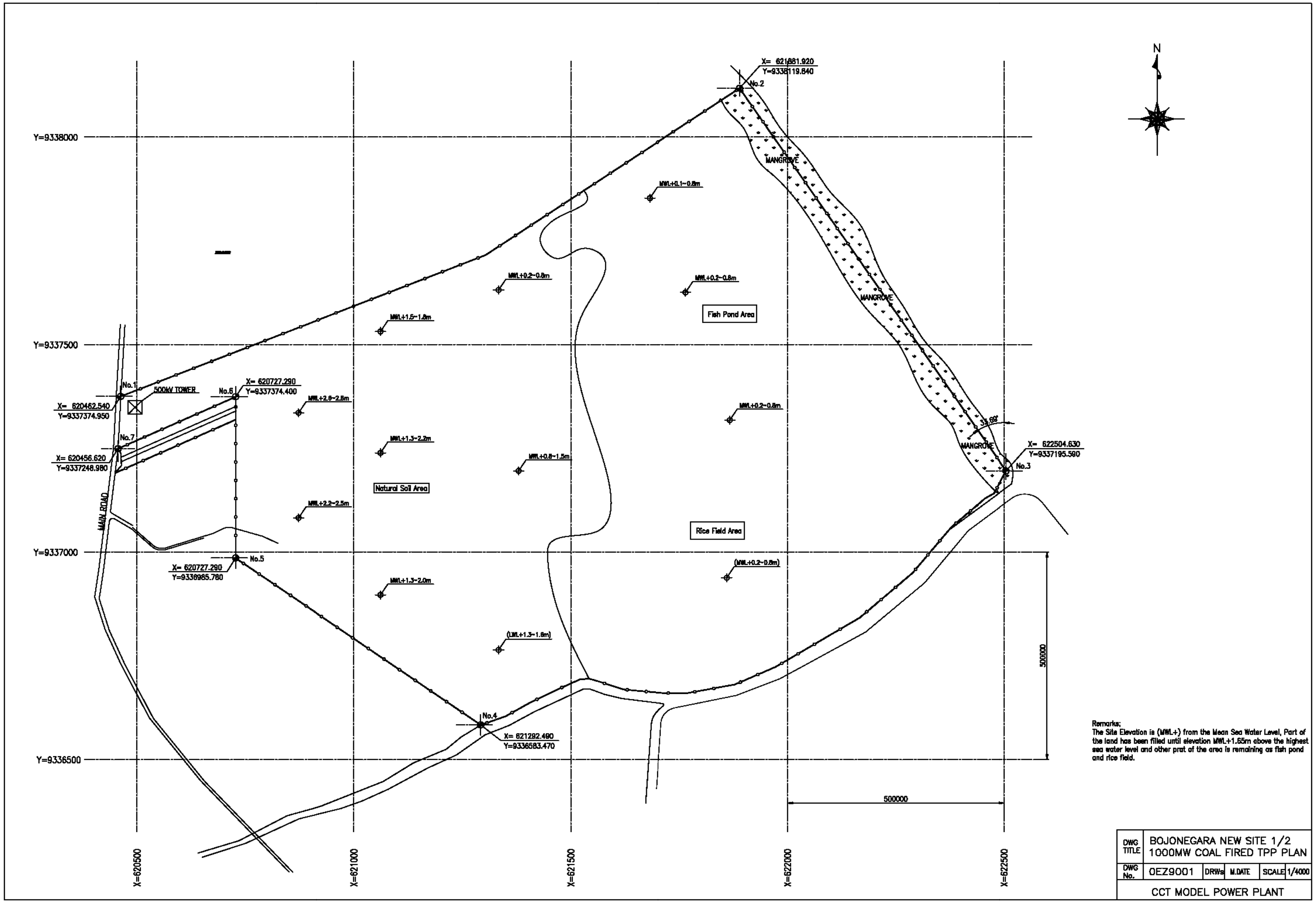


Figure 2.1.2-2 Location Map of Study site (On Shore)

Source: JICA Study Team

2.1.2.2 Geographical Condition of Preset Site Area (Off Shore)

A. Sea Water Conditions

(1) Sea Water Level

The predicted historical low water is -0.0 meter, high water is 1.5 meters, thus the range is 1.5 meters at *Labuan* Tide Station (105º 49'E, 06º 22'S).

The predicted historical low water is -0.1 meter, high water is 1.2 meters, thus the range is 1.3 meters at *Tanjung Cikoneng* Tide Station (105º 53'E, 06º 04'S).

- H.H.W.L. : 1.40 m
- H.W.L. : 1.20 m
- M.W.L. : 0.60 m
- L.W.L. : 0.00 m
- L.L.W.L. : - 0.20 m

(2) Tide

The type of component tide on study site is mixed semi diurnal with tide constants given in the following table.

Conponent Tide	M2	S2	N2	K1	O1	M4	MS4	K2	P1
A (cm)	16	13	1	14	9	1	1	3	5
g (º)	192	285	186	161	145	122	163	285	161

Source: Tidal List of the station at the *Cikoneng* and *Labuan*

Where,

A = Amplitude

g = Phase lag

(3) Current

Result of current measurement by Holland Study Team in 1997 at *P. Kubur* and *P. Pamujan Besar* shows, that the direction of currents is eastern and western with a speed of 35 cm/second during western season, and in the eastern season the direction of current turns to west with speed reaching 35 cm/second.

(4) Wave

The height of wave on shore line is maximum 1 m, but on off shore the height of wave could reach 2 to 3 m during winter storm of western and eastern season. However due to the loose nature of the lithology of the off coast, even the 1 m of wave height is able to erode the beach.

(5) Sea Water Temperature

Refer to result of survey by Research Center for Oceanography, Indonesian Institute of Sciences (2002), the sea water temperature shown in table below:

MONTH	Depth (approximate 12 m bottom)	Sea Water Temp (ºC)	Average (ºC)
April - May	Surface	30.23 – 30.57	30.38
	Middle	30.20 – 30.51	30.33
	Bottom	30.15 – 30.39	30.24
July	Surface	29.17 – 29.61	29.32
	Middle	29.17 – 29.46	29.30
	Bottom	29.18 – 29.42	29.29
September	Surface	28.40 – 29.91	28.59
	Middle	28.41 – 28.85	28.01
	Bottom	28.33 – 28.85	28.39
November - December	Surface	29.43 – 30.00	30.00
	Middle	29.47 – 29.78	29.56
	Bottom	29.42 – 29.84	29.74

Source: Research Center for Oceanography, Indonesian Institute of Sciences (2002)

(6) Sea Water Quality

The quality of sea water on the study site given he rewith is referring to m onitoring results by *Bapedda* (Local Development Agency) of *Banten* Province.

Some of the water quality parameters are higher than the quality standard:

- •BOD = 95 mg/l
- •COD = 226 mg/l
- •H_2S = 0.10 mg/l
- •NH_3N = 1 mg/l

(7) Salinity

The survey result of the salinity of sea water is shown as follows:

MONTH	Depth (approximate 12 m bottom)	Salinity (psu)	Average (psu)
April - May	Surface	31.465 – 32.027	31.801
	Middle	31.550 – 31.954	31.776
	Bottom	31.040 – 32.071	31.955
July	Surface	31.614 – 31.946	31.869
	Middle	31.637 – 31.947	31.854
	Bottom	31.294 – 31.497	31.847
September	Surface	32.857 – 33.072	92.949
	Middle	32.641 – 33.157	32.72
	Bottom	32.864 – 33.245	33.036
November - December	Surface	32.561 – 32.920	32.337
	Middle	32.708 – 32.928	32.842
	Bottom	32.829 – 33.231	33.828

Source: Research Center for Oceanography, Indonesian Institute of Sciences (2002)

(8) Sediment and Suspension Distribution

The data given herewith is referring to the result of Study for Sediment and Suspension Distribution in *Banten Bay*, carried out by Central of Oceanographic, *Pusat Penelitian Oseanografi, Lembaga Ilmu Pengetahuan Indonesia*, in April, June, August and October 2001.

<u>Sediment Condition</u>

In April (transitional season I), mud dominated the widest area of this waters, indicating the weak current, while pebbly sand and sand were found in the northernmost of *Ciujung* river mouth, indicating strong current.

In June (the end of transitional season I), mud, sandy mud and silt were found on this area except in the northern most of *Ciujung* river mouth, there was still found pebbly sand.

In August muddy sand was found in the northeast of *Panjang* Island, indicating moderate current and at the other parts of the bottom was supposed weak.

In October, the sediment which indicated strong current was found in northeast of *Panjang* Island and in the northern most of *Ciujung* river mouth. The silt was found around *Pamujan Besar* Island and in the south of *Bojonegara*. The muddy silt was found in the north of *Ciujung* river mouth while in April and June the mud was found.

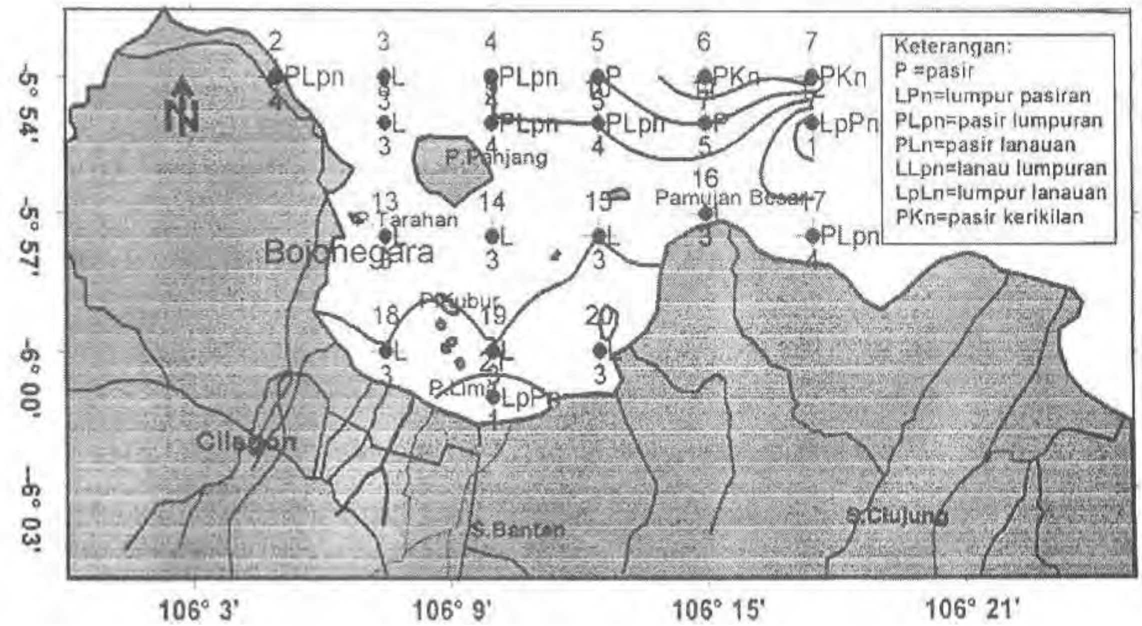


Figure 2.1.2-3   Result of Sediment Survey on April 2001

Note:
P = Pasir = Sand, L = Lanau = Silt, LP = Lumpur Pasiran = Sandy Mud,
PLpn = Pasir Lumpuran =Muddy Sand, PLn = Pasir Lanauan = Silty Sand,
LLpn = Lanau lumpuran = Muddy Silt, LpLn = Lumpur Lanauan = Silty Mud,
PKn= Pasir Kerikilan = Gravelly Sand

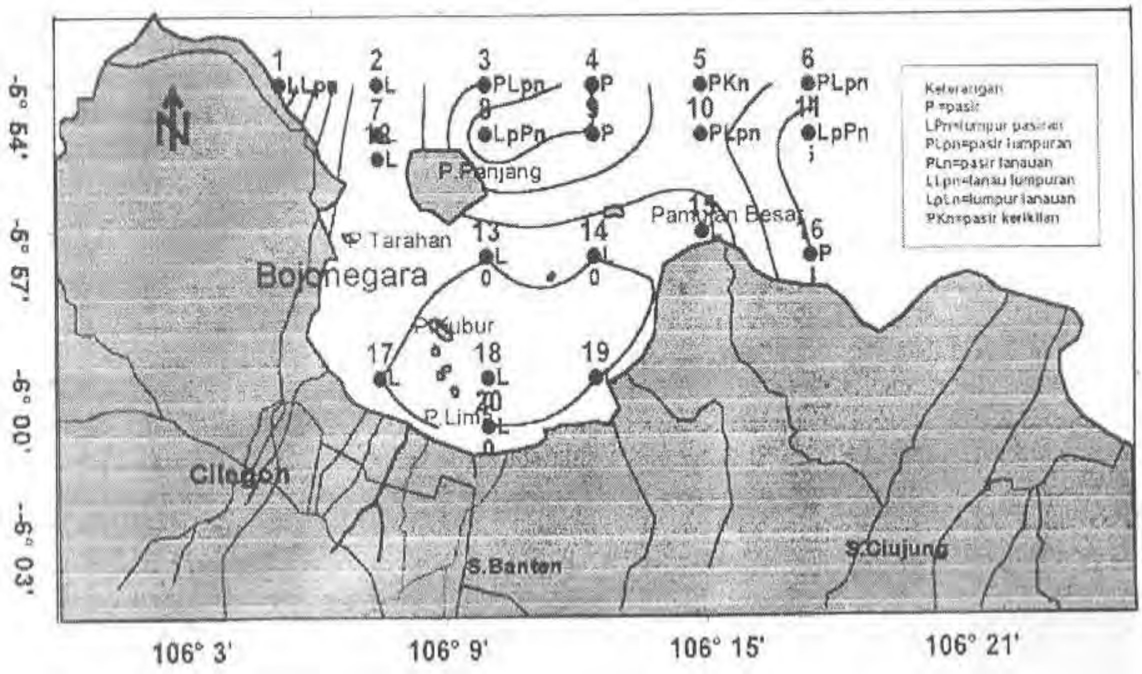


Figure 2.1.2-4   Result of Sediment Survey on June 2001

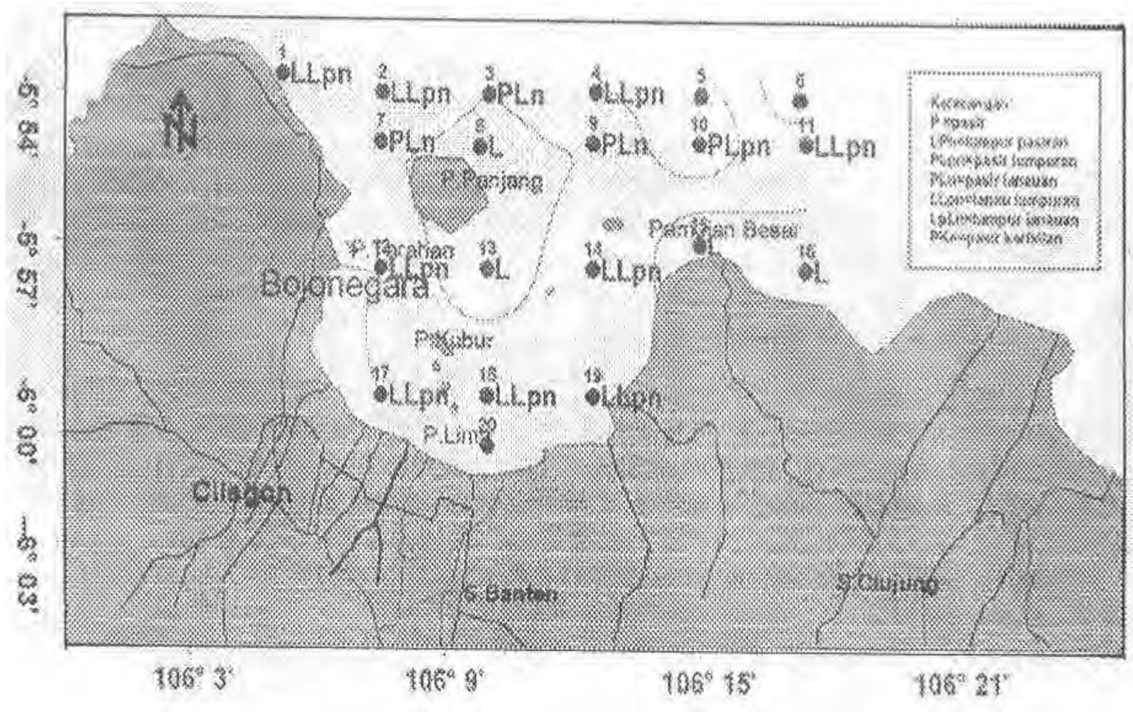


Figure 2.1.2-5 Result of Sediment Survey on August 2001

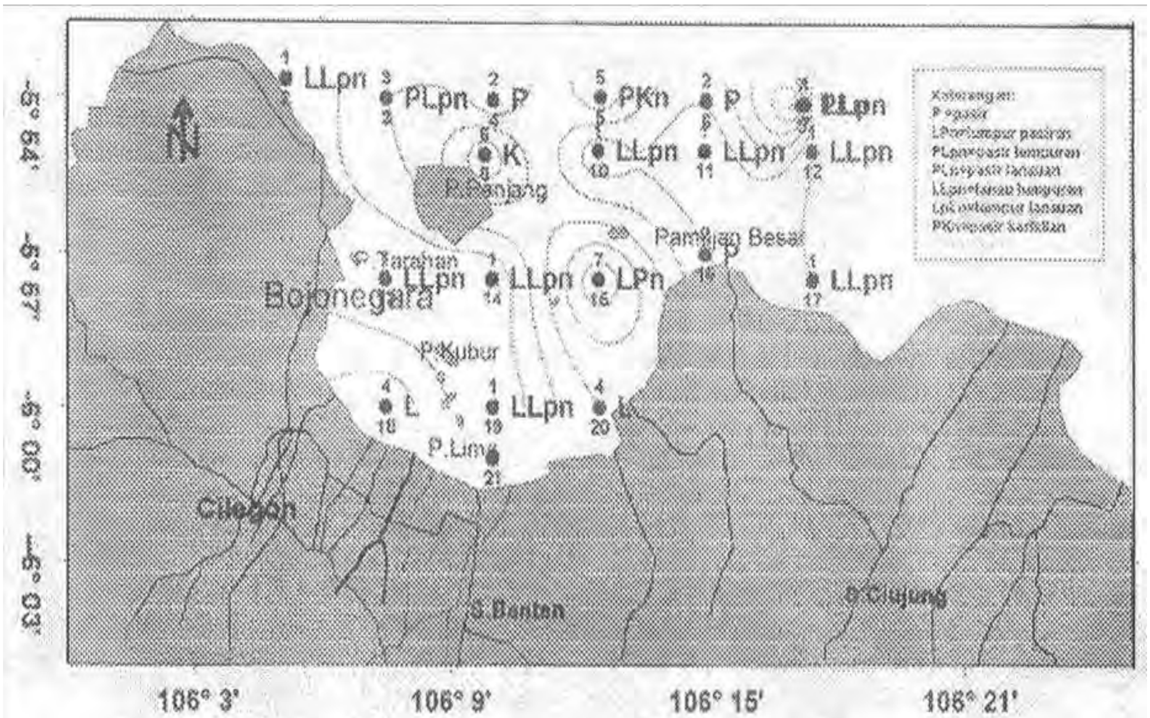


Figure 2.1.2-6 Result of Sediment Survey on October 2001

<u>Suspension Distribution</u>

Suspension distribution of the surface layer in April, June and August 2001, shows that in general, the quality of *Banten* Bay was relatively good with the suspension concentration below 70 mgr/l except at the areas around *Lima* Island, *Panjang* Island and *Kubur* Island, of the middle layer in April, June, August and October was relatively good, while of the bot tom layer in the same months the suspension distribution indicated that the quality of the waters was relatively bad.

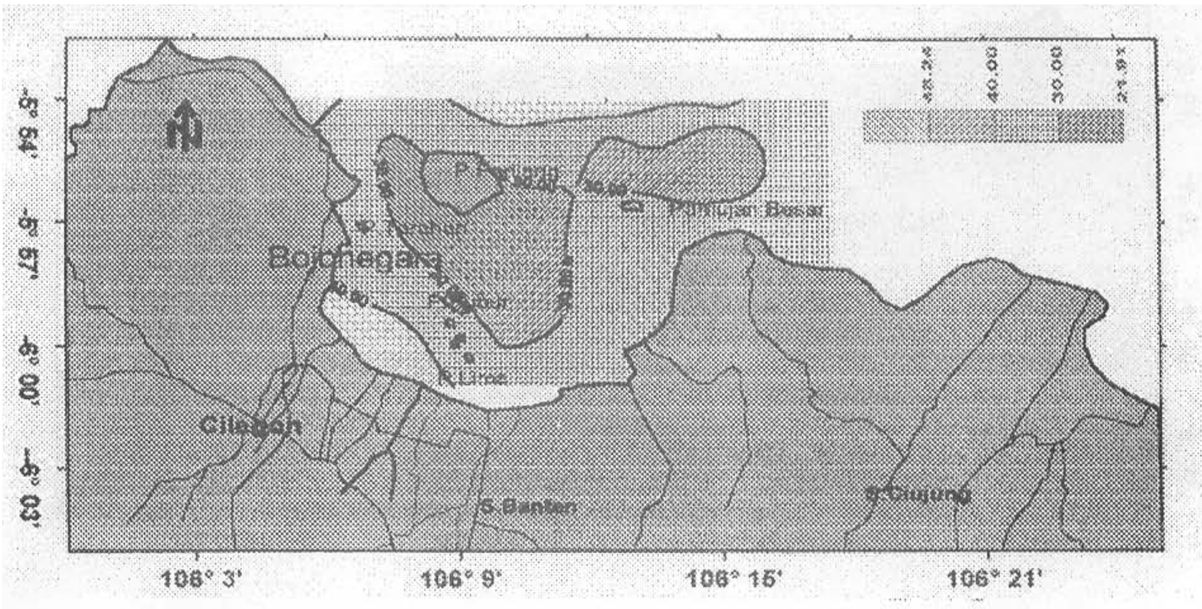


Figure 2.1.2-7 Surface Suspension Distribution (mgr/l) On April 2001

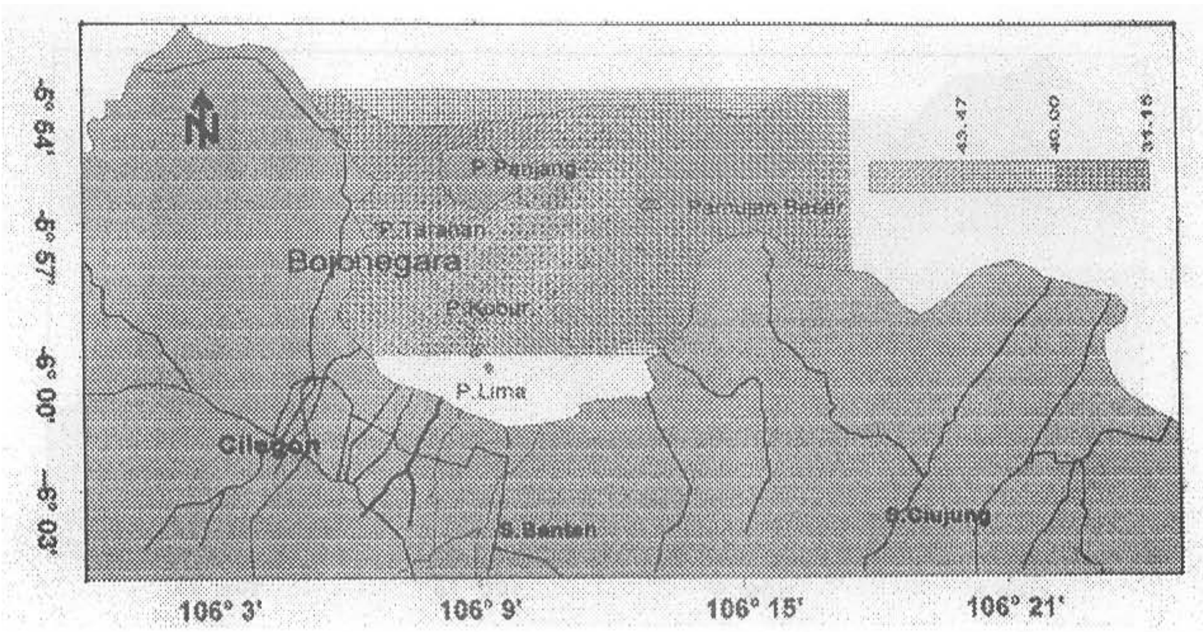


Figure 2.1.2-8 Surface Suspension Distribution (mgr/l) On June 2001

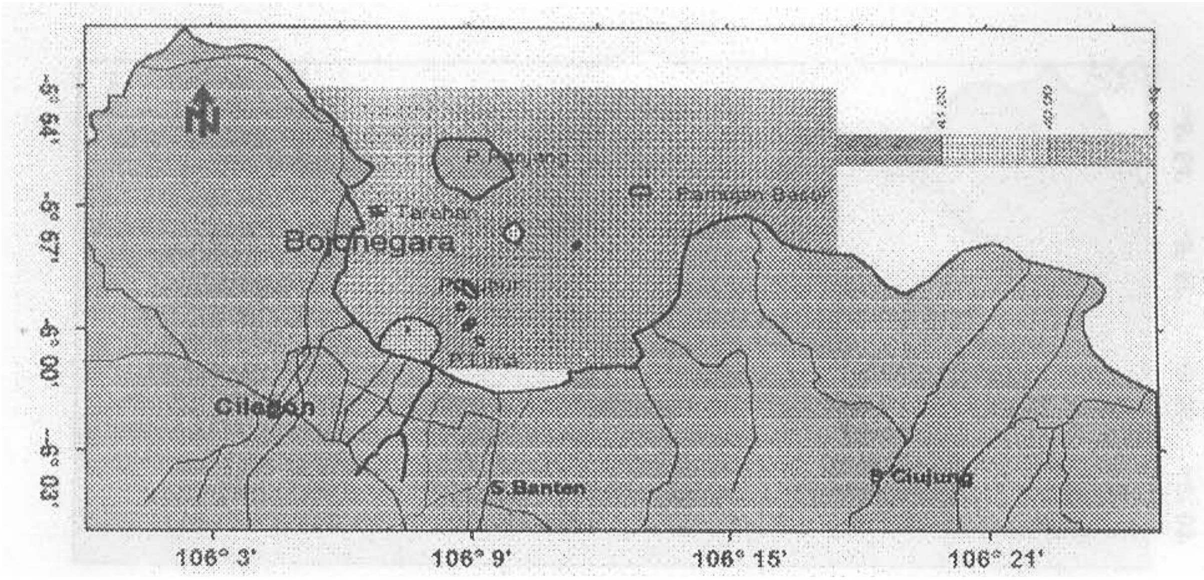


Figure 2.1.2-9 Surface Suspension Distribution (mgr/l) On August 2001

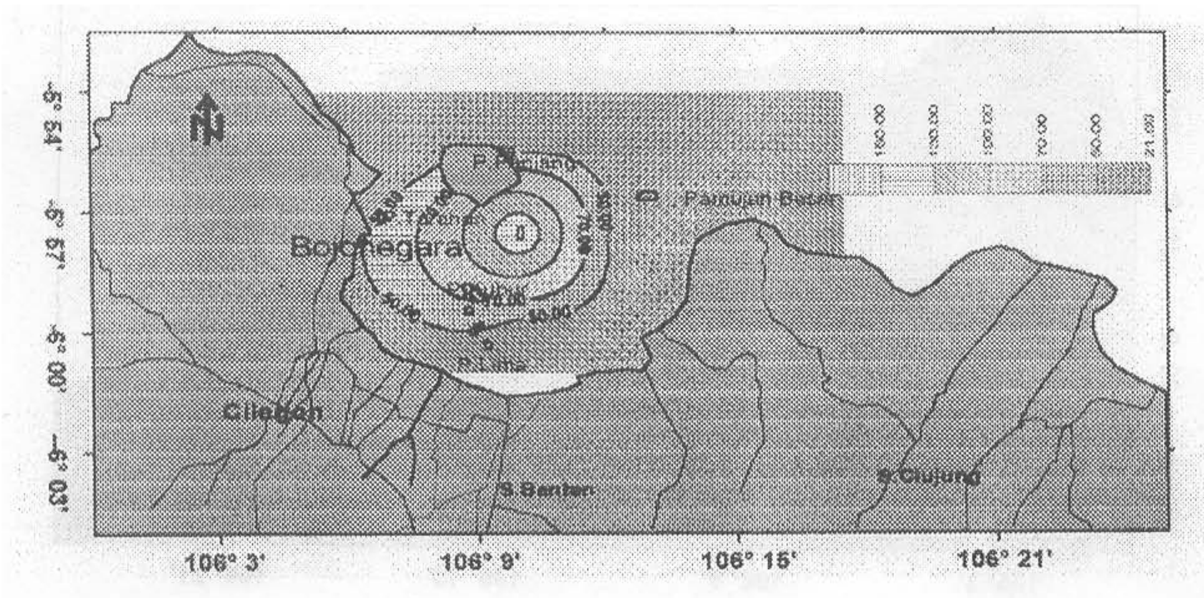


Figure 2.1.2-10 Surface Suspension Distribution (mgr/l) On October 2001

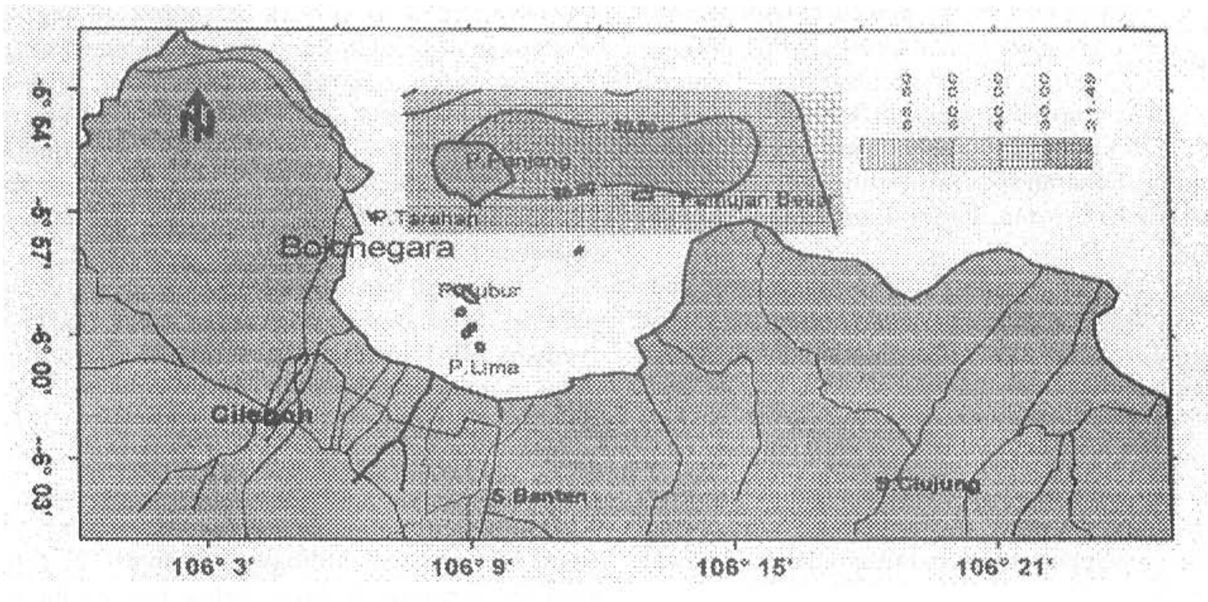


Figure 2.1.2-11 Middle Depth Suspension Distribution (mgr/l) On April 2001

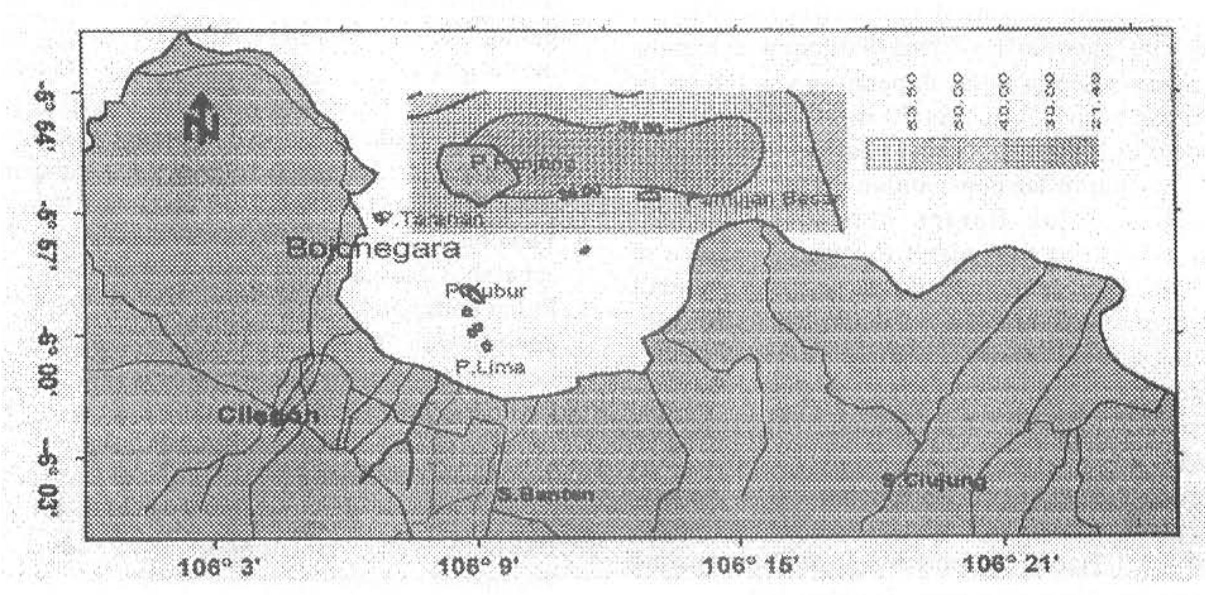


Figure 2.1.2-12 Middle Depth Suspension Distribution (mgr/l) On June 2001

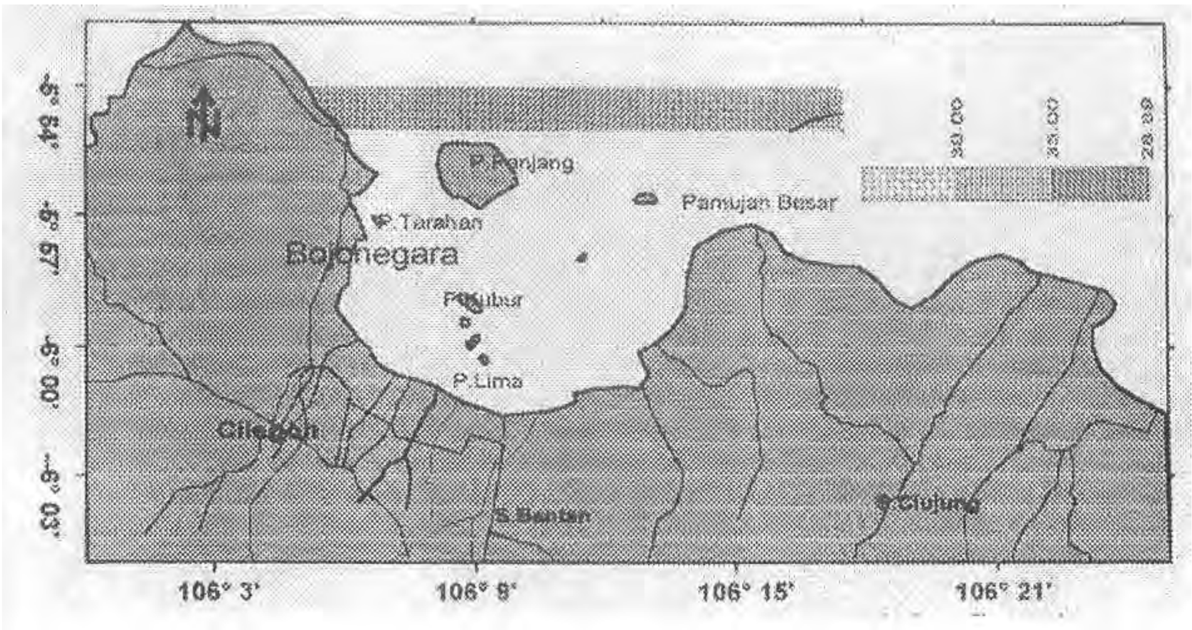


Figure 2.1.2-13 Middle Depth Suspension Distribution (mgr/l) On August 2001

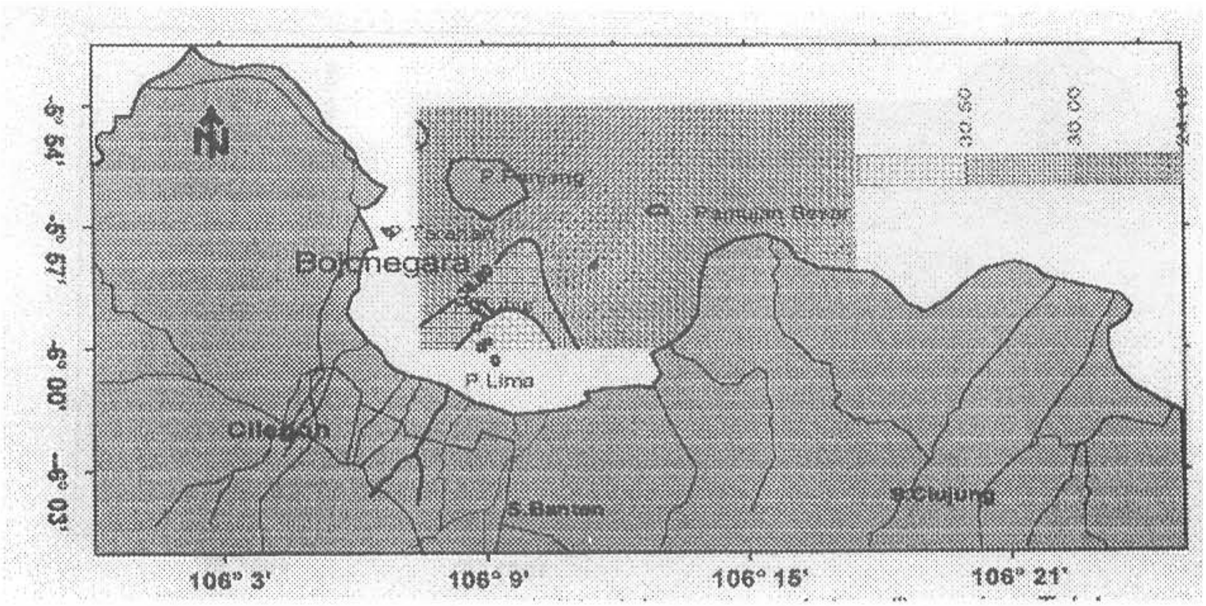


Figure 2.1.2-14 Middle Depth Suspension Distribution (mgr/l) On October 2001