The Socialist Republic of Viet Nam
Ministry of Industry and Trade

Feasibility Study
on
the Coal Transshipment Terminal Project
for
Thermal Power Centers in the Mekong Delta
in
the Socialist Republic of Viet Nam

Final Report

March 2015

Japan International Cooperation Agency (JICA)

Sumitomo Corporation
Nippon Koei Co. Ltd.

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Abbreviation

ASB	Authorized State Body
BOT	Build-Operate-Transfer
CFPP	Coal-Fired Power Plant
CIT	Corporate Income Tax
CTT Project	Coal Transshipment Terminal Project
DONRE	Department of Natural Resources and Environment
DWT	Dead Weight Ton
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EVN	Electricity of Vietnam
FIRR	Financial Internal Rate of Return
F/S	Feasibility Study
GDP	Gross Domestic Product
GGU	Government Guarantees and Undertakings Agreement
HHWL	Highest High Water Level
HWL	High Water Level
IFI	International Financial Institutions
JICA	Japan International Cooperation Agency
LLWL	Lowest Low Water Level
LOA	Length of All
LWL	Low Water Level
MOIT	Ministry of Industry and Trade
MOJ	Ministry of Justice
MONRE	Ministry of Natural Resources and Environment
MPI	Ministry of Planning and Investment
MOT	Ministry of Transport
MOU	Minutes of Understanding
MT	Metric Ton
MWL	Mean Water Level
PPP	Public Private Partnership
PSIF	Private Sector Investment Finance
RAP	Resettlement Action Plan
SPC	Special Purpose Company
THC	Terminal Handling Charge
VCM	Vinacomin (Vietnam National Coal Mineral Industries)

Summary

（Background of the Project）

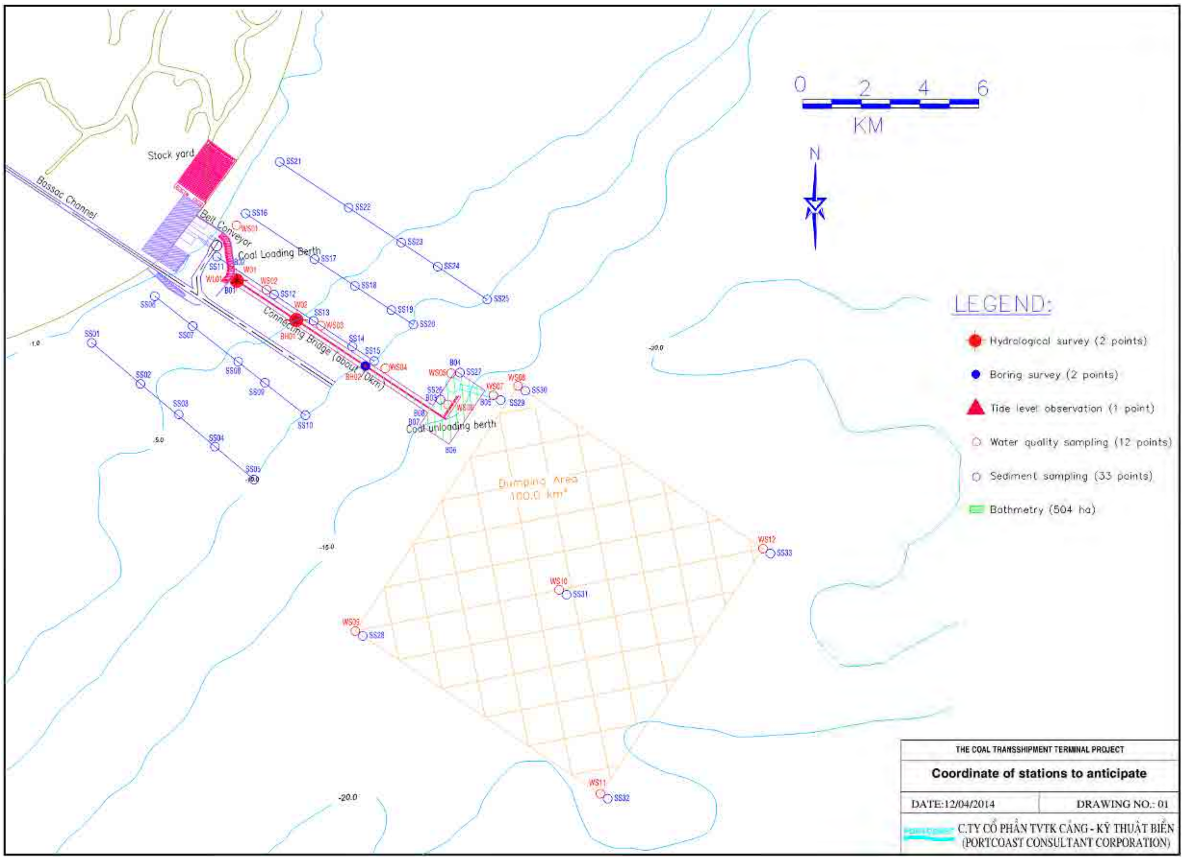
In order to cope with the rapid increase of electric power supply demand based on the high economic growth rate in Vietnam, the 7th National Electric Power Master Plan in Vietnam which was approved in 2011 has been developed and high dependency of Coal Fired Power Plant (CFPP) could be seen in this plan. Most of the coal fired power plant in southern Vietnam were planned to construct by the river and coastal area and the coal were planned to bring in by waterway transportation. However, most of them were located at the Mekong river and its branch river and use of large-scaled coal transport vessel which are commonly used for the international coal transshipment were limited by the shallow water area at the mouth of Mekong river and its branch river. In addition, use of small-size coal transport vessel for coal import is not appropriate by both economic and steady supply reasons. In order to overcome these difficulties, construction of coal transshipment terminal (CTT) fort the import of coal by large-size coal transport vessel and transshipment to smaller-size vessel for secondary transport to power plants are inevitable for the coal fired power plants operation. This study aims to develop the assistant plan assuming the participation of Japanese investor and to develop a CTT project implementation program which will utilize the ODA loan and JICA's overseas investment loan. It is clearly stated in the Assistance Program for Vietnam (2012) that constant and stable supply of resources and energy are the one of the prioritized areas for economic growth and enhancement of competitiveness of Vietnam.and this study accord with this program.

Most of the major ports for general cargos located in Mekong Delta Area are river port and several ports for CFPP such as Long Phu and Soc Tran are said to be constructed along the river side of Hau River in the Development Plan of Vietnam's Seaport System till 2020 and orientation to 2030. Water depth at the river mouth of Hau River is around 5m and becomes the obstacles for the larger ships entering the Hau River. In order to overcome this situation, Vietnam Government decided to construct the bypass channel which accommodate the 10,000DWT and partially loaded 20,000DWT ship to enter the Hau River. Construction of this bypass channel and the improvement of existing channel at the mouth of Hau River are now under construction. EVN planned to construct Duyen Hai CFPP adjacent to the entrance of this bypass channel where CTT was also planned to construct by EPC contract with Chinese enterprise and construction of part of power plants and the port has already started. CTT was planned to construct near Duyen Hai CFPP and use of this port and bypass channel for loading and unloading facilities for coal import and secondary transport of coal. Tra Vinh Province has a plan to construct complex port to handle general cargo, but concrete master plan of this general port has not yet developed.

（Field Survey）

Major civil facilities of CTT consists of coal unloading berths for large coal transport ships , coal storage yard with coal handling facilities such as belt conveyer for steady coal supply and coal loading

berths for secondary coal transport to the CFPP of final consumer of the coal. Coal unloading berths can be located in the harbor where additional dreading for the entrance channel and harbor area are needed or in offshore area where additional dredging are not necessary but the long connecting bridge for coal transport are necessary. Considering these anticipated major civil structure and the availabilities of existing information about the natural conditions, bathymetric survey, boring survey and one month sea state conditions survey including the sampling of sea water and bottom sediments has been done at the locations indicated in Figure @@@ and the results of these surveys were utilized as the basic information for this study.



Source: JICA Study Team

Figure 1 Survey map

(Simulation Study of Channel Deposition)

Because the sea-bottom slope at the front of CFPP is very gentile and enormous amount of periodical maintenance dredging might be unavoidable for the case of additional channel dredging, numerical simulation study of channel sedimentation with a consideration of training dike construction as the countermeasures against sedimentation were done to estimate the amount channel sedimentation volume. No construction of countermeasure is the most cost efficient case by considering the maintenance dredging cost and construction cost of training dike. As a result, annual maintenance dredging cost was added for the estimation of annual CTT operation cost in the feasibility study

（Coal Demand）

Coal demand for coal fired power plants up to 2030 by the Decision dated on 9th of Oct. 2012 by Ministry of Industry and Trade was used as the basic case (Scenario 1).

Table 1 Coal Fired Electric Power Plant which should be considered for CTT and Coal Demand

		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Long Phu Power Center																		
Long Phu Power Plant I	Capacity (MW)					600	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (mil tons)					0.074	1.414	1.786	1.786	1.786	1.786	1.786	2.381	2.381	2.381	2.381	2.381	2.381
Long Phu Power Plant II	Capacity (MW)												1,200	1,200	1,200	1,200	1,200	1,200
	Coal (mil tons)												2.381	2.381	2.381	2.381	2.381	2.381
Long Phu Power Plant III	Capacity (MW)												1,000	2,000	2,000	2,000	2,000	2,000
	Coal (mil tons)												0.118	2.381	2.381	2.381	2.381	3.779
Song Hau Power Center																		
Song Hau Power Plant I	Capacity (MW)				600	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (mil tons)				0.074	1.414	1.885	1.984	1.984	1.984	1.984	1.984	2.381	2.381	2.381	2.381	2.381	2.381
Song Hau Power Plant II	Capacity (MW)																	2,000
	Coal (mil tons)																	3.779
Song Hau Power Plant III	Capacity (MW)																	2,000
	Coal (mil tons)																	2.835
Duyen Hai Power Center																		
Duyen Hai Power Plant II	Capacity (MW)					600	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (mil tons)					0.223	1.563	1.885	1.885	1.885	1.885	1.885	2.381	2.381	2.381	2.381	2.381	2.381
Duyen Hai Power Plant III	Capacity (MW)				600	600	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (mil tons)				1.786	1.984	2.058	2.877	2.877	2.877	2.877	2.877	3.571	3.571	3.571	3.571	3.571	3.571
Long An Power Center																		
	Capacity (MW)												1,200	1,200	1,200	1,200	1,200	1,200
	Coal (mil tons)												1.786	2.381	2.381	2.381	2.381	2.381
Bac Lieu Power Center																		
	Capacity (MW)																	1,200
	Coal (mil tons)																	2.381
An Giang Power Center																		
	Capacity (MW)																	2,000
	Coal (mil tons)																	2.835
TOTAL	Capacity (MW)	0	0	0	1,200	3,000	4,800	4,800	4,800	4,800	4,800	4,800	8,200	9,200	9,200	9,200	9,200	16,400
	Coal (mil tons)	0.00	0.00	0.00	1.86	3.70	6.92	8.53	8.53	8.53	8.53	8.53	15.00	17.86	17.86	17.86	17.86	31.09

Source：Decision No.5964/QD-BCT (9Oct2012)

For the estimation of coal demand, three factors such as coal calories, energy conversion efficiency of the boiler and operation rate of power plant should be considered. JICA Study Team calculated the coal demand based on the more plausible assumptions for above factors upon request from MOIT. Coal demand by JICA study team showed more coal demand shown in Decision No.5964/ QD -BCT(9Oct2012) and was considered additional coal demand case in the study as a Scenario 2.

Table 2 Coal demand calculated by JICA study team by using the plausible assumption

Project Power Plant		**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Long Phu Power Centre												
Long Phu I	Capacity (MW)	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (Mil tons)	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Long Phu II	Capacity (MW)						1,200	1,200	1,200	1,200	1,200	1,200
	Coal (Mil tons)						3.3	3.3	3.3	3.3	3.3	3.3
Long Phu III	Capacity (MW)						1,000	2,000	2,000	2,000	2,000	2,000
	Coal (Mil tons)						2.8	5.6	5.6	5.6	5.6	5.6
Song Hau Power Centre												
Song Hau I	Capacity (MW)	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (Mil tons)	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Song Hau II	Capacity (MW)											2,000
	Coal (Mil tons)											5.6
Song Hau III	Capacity (MW)											2,000
	Coal (Mil tons)											5.6
Duyen Hai Power Centre												
Duyen Hai II	Capacity (MW)	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (Mil tons)	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Duyen Hai III	Capacity (MW)	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (Mil tons)	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Duyen Hai III Expantion	Capacity (MW)											
	Coal (Mil tons)											
Long An Power Centre												
	Capacity (MW)						1,200	1,200	1,200	1,200	1,200	1,200
	Coal (Mil tons)						3.3	3.3	3.3	3.3	3.3	3.3
Bac Lieu Power Centre												
	Capacity (MW)											1,200
	Coal (Mil tons)											3.3
An Giang Power Centre												
	Capacity (MW)											2,000
	Coal (Mil tons)											5.6
Capacity/year	(MW)	4,800	4,800	4,800	4,800	4,800	8,200	9,200	9,200	9,200	9,200	16,400
Coal demand/year	**(Mil tons)**	**13.38**	**13.38**	**13.38**	**13.38**	**13.38**	**22.85**	**25.64**	**25.64**	**25.64**	**25.64**	**45.71**

Source：JICA study team

（Phased Development Plan）

Although the coal demand is increasing yearly, construction of CTT facilities at the beginning phase which accommodate the coal demand at 2030 was not practical. With that introduction of phased development plan of CTT facilities are considered. Considering the increase of coal demand, start of 1st phase at the year of 2020, 2nd phase at the year of 2025 and 3rd phase at the year of 2030 were considered for the phased development plan. Because the coal transfer to the Duyen Hai CFPP are done by belt conveyer, amount of coal supply to the consumer CFPP was obtained by excluding the coal demand by Duyen Hai CFPP.

（Coal Logistics）

It is assumed to procure coal from Australia and Indonesia in CTT Project, although procurement plan of coal for Coal Fired Power Plant in Southern part of Vietnam has not been decided and loading ports have not been specified yet. Australia and Indonesia are main supplying countries of coal and distances from Australia and Indonesia are more efficient than other coal producing countries. Transit time from Australian coal loading ports to Duyen Hai is 11 to 12 days, and transit time from Indonesian loading ports is 4 to 5 days.

From the view point of loading operation and chartering vessels, vessel size for imported coal will be Panamax size in the 1st phase, over- Panamax size in the 2nd phase and Cape size in the 3rd phase.

Considering the current conditions of Hau River and bypass canal under construction, secondary transport vessels of 5,000DWT to 10,000DWT vessels are considered.

(Port Layout Plan)

Above mentioned coal import ships and secondary transport ships are considered for the determination of port plan. Survey results of existing facilities and dimensions of coal transport ships were considered for the determination of capacity of coal unloader and two continuous coal unloader of 2,500 tons/hour per berth with unloading efficiency of 75% were selected. Based on the similar study, one loader of 1,500 tons/hour per berth with loading efficiency of 90% were selected. Considering the existing CTT, annual operation days of 350 days and working hours of 18 hours were considered

Advisable berth occupancy ratios shown in "Port Development – A handbook for planner in developing countries -) issued by UNCTAD as well as above mentioned conditions were considered for the determination of the required number if coal unloading berths. Average waiting time of vessels computed by a queuing theory and other factors were also referred for the determination of required number of unloading berths.

The approach channel is to be developed as a one-way channel because the number of calling vessels is limited and for the economic efficiency of the CTT project and the width of the approach channel is set at least five times of the beam of the design vessel based on the report by UNCTAD and the Japanese technical standard for determination of the depth of the approach channel, tidal differences of around 3.13m were utilized by referring the idea employed by many bulk terminals worldwide.

(Selection of the Site of the Coal Storage Yard)

Five candidate locations shown in Figure 2 were selected by considering the closeness of the coal storage yard to the unloading and loading berths. The closeness to the unloading and loading berths, capability of expansion, impacts on the surrounding environment, construction cost, construction work effect and others were considered fort the determination of the location of coal storage yard for the two coal demand scenario case. As a result, candidate locations of (c) and (d) were selected.

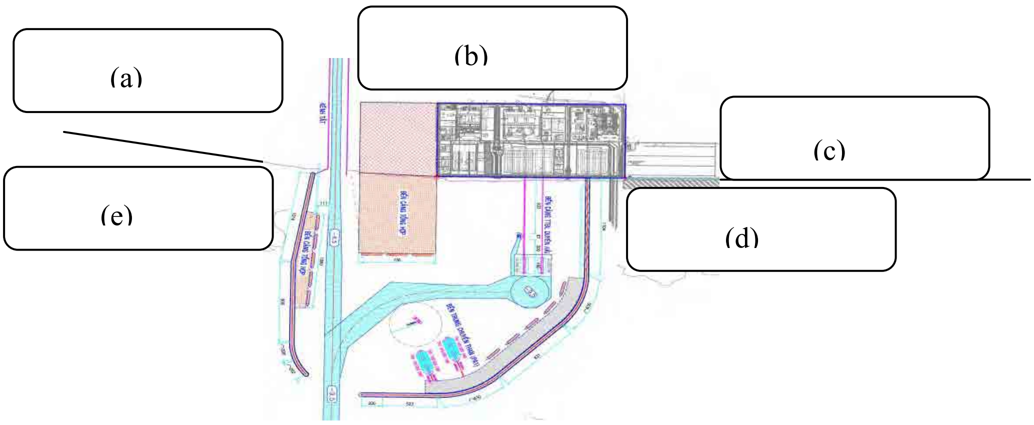


Figure 2 Candidate Site for Coal Stock Yard

Location (a) and (e) had disadvantage about the coal transportation from unloading and loading berths to the candidate site due to the long distance transportation and necessity of crossing the channel and had low evaluation in coal storage site selection although other factors showed appropriate as shown above. Because the request by local government should be appreciated, site (a) and (e) were also considered as the candidate of coal storage yard by employing the idea of construction new port and secondary coal transport to Duyen Hai CFPP as well and the results of the feasibility study were given as an Appendix.

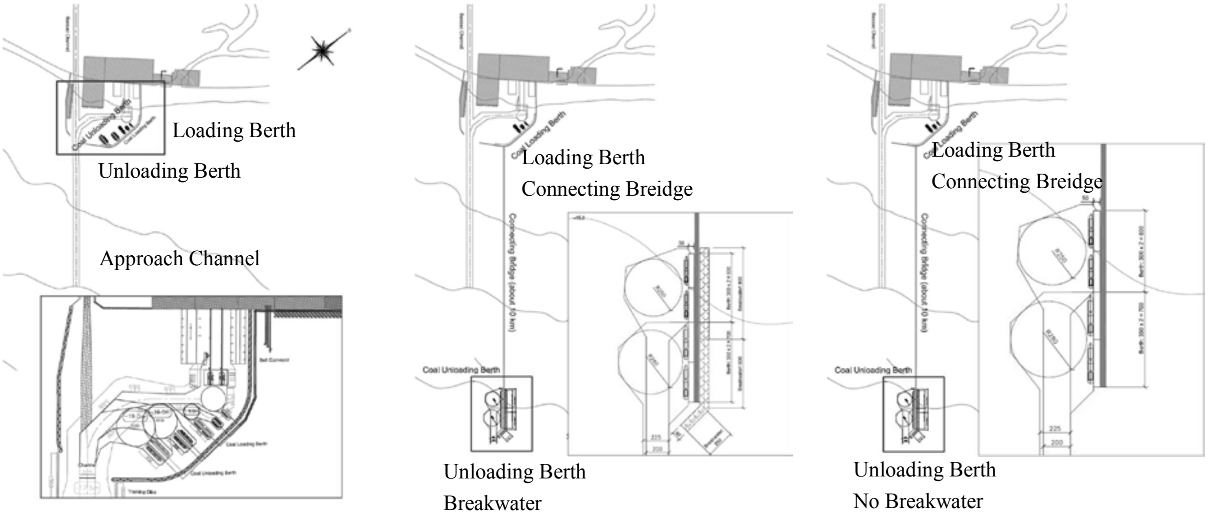
(Coal Storage Yard)

As a general operation in CFPP, CFPP requires 1 to 2 month's coal stock in stockyard of CFPP.
In this study, planning total coal stock amount is 1.5 months stock as a total volume in both stockyard of CFPP and CTT. Minimum required stock amount in stockyard of CFPP is set as 0.5 month, and in stockyard of CTT is set as 1.0 month in this study. This is to be determined in detail by discussion with each CFPP utilizing CTT. Effect of rough wave conditions during the monsoon season on berth working ratio were considered in determining the necessary coal stock yard area for the case of offshore unloading berths without breakwater. Forecasting wave records during Jan. 2000 to Dec. 2010 were used for this purpose to determine the necessary amount of coal stock.

(Selection of Port and Terminal Layout)

Following (a) to (c) three alternative layout plans of coal unloading berths were considered for the selection. Steady operation of coal unloading and loading can be expected for the alternative (a) because of the expected calmness of the harbor, huge amount of deep channel dredging and maintenance dredging are necessary for the entry of large import coal transport vessels. On the other hand, no necessity of additional channel dredging, long connecting bridge for conveying the import coal from unloading berths to coal storage yard by belt conveyer. Alternative case (a) was selected as the most cost efficient case from the comparative study by considering the above mentioned merits and demerits, conceptual design results based on the natural conditions and easiness of construction and construction cost.

(a) In harbor type | (b) Offshore type with breakwater | (c) Offshore type without breakwater



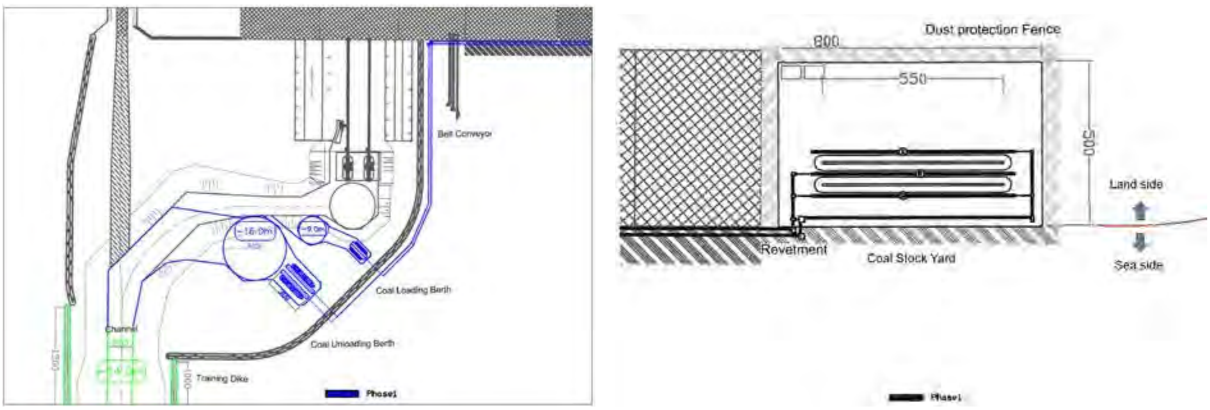
Source: JICA Study Team

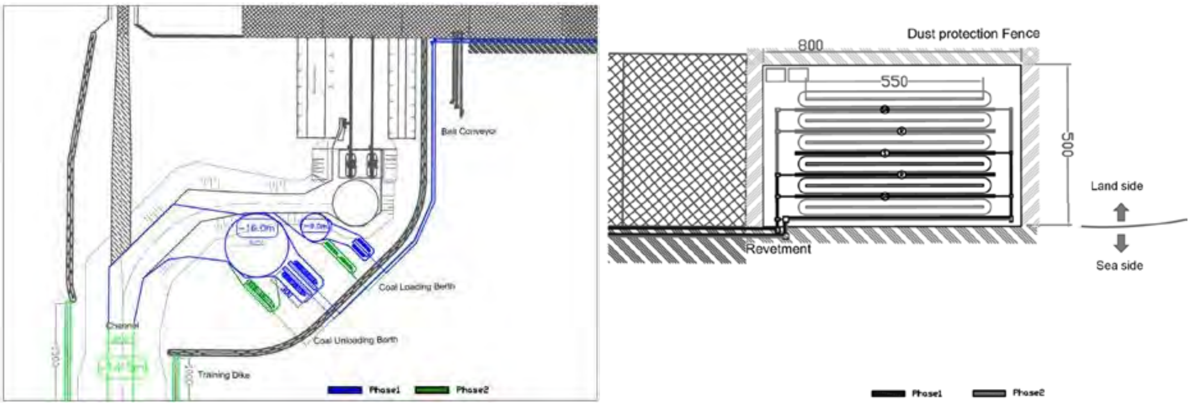
Figure 3 Candidates of the type of the terminal

As requested by VINACOMIN, additional candidate of case for the use of crane barge for coal transfer at offshore will be evaluated and cost advantages of the above alternative case (a) was confirmed.

(Proposed Phased Development Plan)

Three phased development plan for port and terminal layout plan for two coal demand scenario case were shown below.



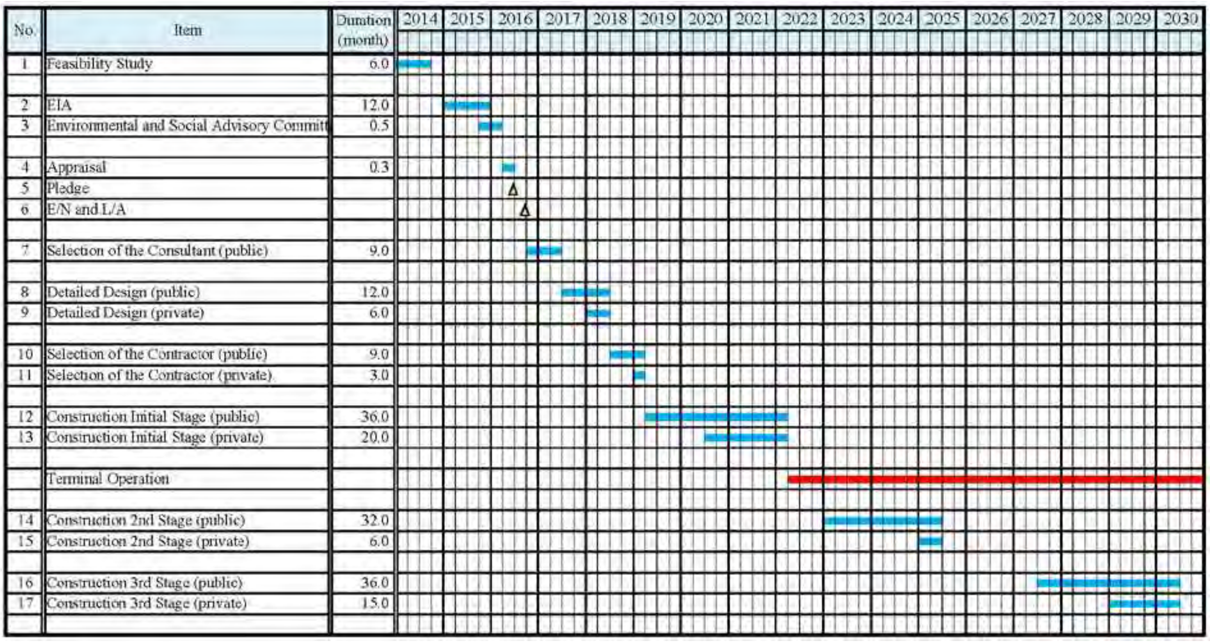


Source: JICA Study Team

Figure 4 Phased Development Plan of Port and Terminal

(Outline of Execution Plan and Schedule for Construction Works)

Outline of execution plan for construction works were prepared based on the proposed phased development plan of this project. Outline of construction schedule was prepared based on the conceptual design for each development phase as well as the above mentioned execution plan. Tentative overall project schedule was also presented based on the phased development plan and outline of execution plan and schedule for construction works.

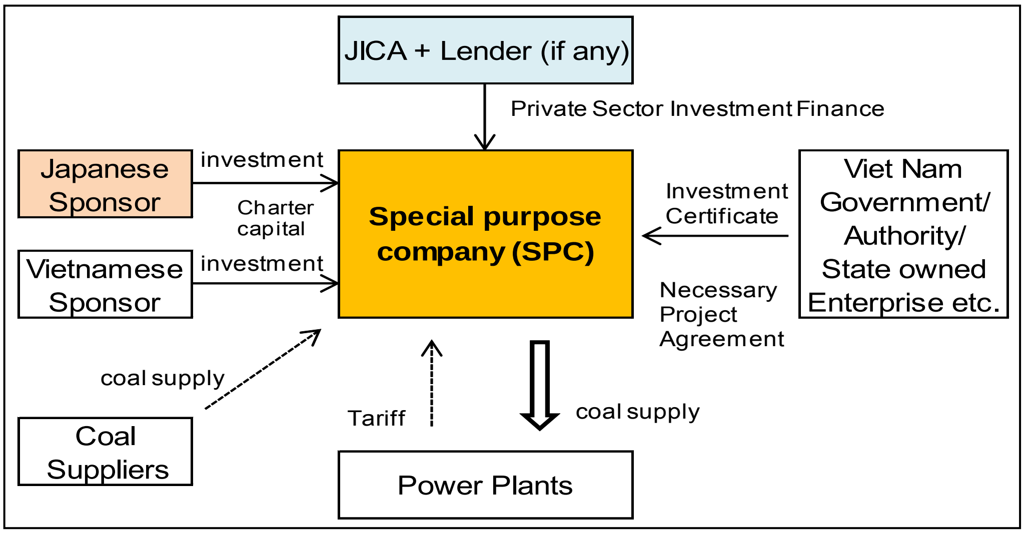


Source：JICA study team

Figure 5 Tentative Overall Project Schedule

(Terminal Management)

In order to make the project successful, it is important to obtain the project risk assignment of government and private sector certainly. For this reason, it is expected that about lower part of infrastructure for unloading berth, loading berth and coal stock yard etc., the application of Japanese ODA which the Vietnam government manages is made, and that for CTT (Coal Transshipment Terminal) project including the investment of upper part of infrastructure, private sector by both Japanese and Vietnamese firms set up SPC and invests and operates the terminal. About the performance of each work, it is expected that the companies which are reliable will be selected for each work and the work will be performed under subcontract arrangement. For the organization of SPC, the following scheme is investigated.



Source: JICA Study Team

Figure 6 Relation of SPC and other related organization and firms

Running cost of CTT operation was obtained from personnel expenses, utilities expenses, water charge, depreciation cost, maintenance cost of coal handling equipment, insurance cost, land usage fee, maintenance cost for the lower infrastructure and other necessary expenses of which were obtained by considering the anticipated project scheme and dimension of those organization and port and terminal. The lower infrastructure is the asset of Vietnam government, and will have economic value after the project term. Therefore, necessary fund, which we assume to use JICA ODA loan, for the lower infrastructure should basically be prepared and born by Vietnam government. However, we assumed in this study that SPC will bear 50% of funding cost, which is principal and interest of ODA loan, for the lower infrastructure as "Land Usage Fee" to Vietnam government. Lower infrastructure is supposed to be owned by Vietnam government, however, Study team assumed that 100% of the maintenance cost during the project term is born by SPC, instead of Vietnamese government.

(Financial Analysis)

Construction cost, maintenance cost and operation cost for each phase has been obtained and financial and economic analysis has been done. Several general conditions such as application of normal market price at the project site, negligence of price fluctuation and interest of rent money, inclusion of consultant fee for Detailed Design and Supervision of construction works were applied for obtaining the construction cost .Estimation of terminal operation cost was shown above.

Feasibility is evaluated by calculating Terminal Handling Charge (THC) per ton which fulfills Equity IRR of the SPC required by public investor. It is common to calculate a minimum rate of return on a capital investment project (Hurdle Rate) for investment by "capital cost plus spread between domestic and overseas interest rates". Study team set Hurdle Rate as 17.2% by calculating weighted average cost of capital (WACC) and spread between Vietnamese and Japanese interest rate of 5 years average. This ratio is on the assumption that other risks of SPC mentioned later in later are properly minimized.

Term of the project is from 2020 to 2049, 30 years and financial analysis was considered from the commencement of construction work. 30% of total project cost was assumed to be financed by the investors equity from both Japan and Vietnam and the rest of the project cost was assumed to loan from project finance by JICA "Private Sector Investment Finance (PSIF)"

Terminal Handling Charge (THC) is assumed to be based on Take or Pay mechanism, which consist of Capacity charge (Fixed charge for installed capacity of CFPP) and Variable charge. Fluctuation of Capacity charge which cost of compensation for the financing cost, its interest and capital cost including dividend and tax cost, and compensation for the fixed O&M cost such as labor cost and periodic maintenance during the project period was considered based on the idea that phased development was employed in accordance with the increase of the coal demand. Terminal Handling Charge based on the assumption that the capacity charge guarantees the agreed income amount of SPC as long as CTT maintains a capability of its performance which is mutually agreed in advance. In other word, the prices in each phase were obtained by the assumption that coal demands of each phase will not be increased during the project term.

（Economic Analysis）

In the "With-project Case", port facilities such as coal unloading berths, coal loading berths, and coal unloading machine will be installed in front of Duyen Hai CFPP, which are prepared for larger vessels, and the CTT will be also installed and operated adjacent to the power plant. In the "Without-project Case", the above-mentioned facilities will not be developed. Therefore, in the case of coals from Indonesia, coals will be imported by 30,000 DWT vessels for Duyen Hai CFPP on the assumption of usage of power plant accompanying port facilities, and be imported by vessels up to 10,000 DWT for other CFPPs due to the limitations of the Hau River Bypass Canal. The benefit is quantified by Cost reduction of coal transport by larger vessels which will be enabled by the construction CTT facilities.

The EIRR of 17.4%, was obtained from this economic analysis which is larger than the social discount rate (SDR) of 12 % which is employed with similar study in Vietnam indicates that the project will be feasible from the perspective of the national economy.

（PPP project plan）

Neither the BOT nor the PPP investment form can currently be relied upon and plausible alternative is to develop the CTT Project by a JV scheme under the Investment Law which have the prior case in the similar business scale that have received the Government Guarantees and Undertakings Agreement (GGU)

BOT/PPPs will have Government support, or at least protection against certain risks that are outside of the Project Company's control. In order to put a JV project in the same position, the JV project would request Government support. Risks such as country and political risks, natural conditions risks, legal risks, commercial risk should be considered.

（Feasibility of the Project）

In southern part of Vietnam there are a lot of CFPP being constructed and plans of construction of CFPP. It is not efficient in economy that each IPP investors construct huge CTT disorderly and go ahead with dredge project disorderly. Economic IRR of the project is more than social discount rate in all demand scenarios, the project can contributes to Vietnamese economy as CTT users can import coal through the CTT cheaper than not through the CTT even if CTT users bear the terminal handling charge estimated in this report.

As the project needs huge lower infrastructure investment for land, stock yard and pier for transshipment, it is essential that the project utilize ODA for below infrastructure and investment by the private sector for upper infrastructure so that the private sector can secure feasibility of the Project. Investment by the public sector to the project and profitability of the project can be worked out by utilizing JICA PSIF long-term and low interest loan and cannot be realized without stable profit support by the government and others as well as the precise coal demand forecast.

As current terminal handling charge is estimated with conservative assumption in estimating the project cost as an F/S level, there is a more room for reduction of the project cost. As the CTT project is high public nature port infrastructure, the enterprising body in Vietnam is required operation ability of smooth communication with the government of Vietnam, ASB, customers including CFPP and others. In the light of securing stable profitability, it is an option to invite business operators of CFPP directly to the CTT project.

The private sector is required to provide know-how of management and operation of the CTT utilizing its experience on managing and operating the CTT in Japan. The Improving profitability and quality of service in the CTT project is required by utilizing Japanese company who has high technology and competition in design, construction, procurement, maintenance and management.

（Environmental and Social Considerations）

Proposed Project area is used for a prosperous fishery and agriculture, though recent large-scale project is changing the local economy drastically. Vast reclamation work is conducted near the project area in Duyên Hải, and previous lakes and marshes have been changed to serve as yards for construction of factories.

The Project area is located at the neighboring area of power plant which is under construction. In this area, there are villages where fishermen and farmers reside. It is estimated that approximately 20 households are required to be resettled from the area when the final stage (Phase 3), which is 72ha of the project area. No preserved zone or conservation areas for biodiversity regulated by the international treaties or national laws are present in the proposed Project area. There is no endangered species (IUCN) to be protected in this area as well. Many mangrove forests seen on the coastline of Duyên Hải district were planted in order to prevent soil erosion of seashore.

There are ponds with middle and small scale rivers in the proposed Project area, and fishery is being conducted using fish pond. It is necessary to conduct land reclamation, as such; there is a possibility that changes in the geographical features will occur if large scale land reclamation is carried out in coastal area. The turbidity of coastal area (shallows) is high but no marine ecology was observed in the proposed coal stock yard. Fishermen who live in the proposed coal stock yard have been conducting fishing operation by using small boat in coastal area. However they have no water right or access and the fishermen utilize the existing river as fish pond for aquiculture. It is necessary adequate compensation be provided to them.

Construction work includes dredging in the port and access channels, and soil and earth of the seabed will be disturbed as a result of such activity. However, due to the muddy conditions of the seawater, the water has low transparency and very low visibility. It is expected that the impact of water pollution by dredging work is limited. Impact might still be reduced by study of dredging method and monitoring. Disposal site for dredged soils need to be approved by the related authority in advance.

Massive amount of coal will be imported, during the coal operation (loading and unloading, storage and delivering) in the dry season; fine particles of coal may cause air pollution, so the countermeasures shall be planned accordingly. Coal particle collecting system such as a settling basin is planned to prevent discharge of coal into the sea with surface drainage which includes small particles of coal. As for the living waste water discharged from the facility, it is treated before discharge, so the impact to water quality is estimated to be small

PART 0. Common Contents

Chapter 1. Introduction

1.1. Background of the Project

Recently, the average economic growth rate of Vietnam was achieved with a high growth rate of around 5%. Accordingly, the annual average growth rate of electric power demand from 2006 to 2012 was achieved with a high growth rate of around 10%. In order to cope with the rapidly increasing electric power demand, construction of a new electric power plant with a total power supply of 50,000 MW from 2011 to 2020 is planned in the 7^{th} National Electric Power Master Plan in Vietnam, which was approved in 2011. Among the electric power plant development plans prepared, the electric power supply of 36,000 MW or 47% of total electricity supply in 2020 produced from a coal-fired power plant (CFPP) is considered. However, the progress of this electric power development plan was behind schedule due to shortage of investment funds and for other reasons. Therefore, Vietnam suffered the shortage of power supply especially in 2009 and 2010, when the amount of precipitation was small and the electric power supply from hydraulic power stations dropped significantly and planned blackout in Hanoi and Ho Chi Minh City were done. This shortage of power supply has created negative impact on the economic and social activities in Vietnam.

In Southern Vietnam, many CFPPs are in the planning stage and some of them are under construction stage. Now, coal used for the CFPPs is supplied by a domestic coal mine in the northern part of Vietnam. Future demand in 2010 for coal in Vietnam is considered to be from 26 million t to 67 million t. On the other hand, expected total amount of domestic coal supply will remain up to 58 million t that means domestic coal supply is not sufficient to cover the coal demand. Given this situation, necessity of coal imports from 2015 was stated in the 7^{th} National Electric Power Master Plan in Vietnam to cope with the rapid increase in electric power demand. In addition, importing coal, which is preferable for an efficient electric generation by CFPP boost its necessity. Recently, in southern part of Vietnam, several CFPPs such as Song Hau, Duyen Hau, and Long Phu are under construction stage or planning stage to cope with the rapid increase in electric power demand. On the other hand, coal supply for power plants depends on the domestic coal production in Quan Ninh Province, north of Vietnam. There is a high possibility that domestic coal production will be insufficient to meet the coal demand of coal-fired plants in Vietnam. Thus, the necessity to use imported coal will continue to increase rapidly.

Most of the CFPPs in Southern Vietnam are planned to be constructed along the river and coastal area and t of coal are planned to be brought by waterway transportation. However, most of the CFPPs located along the Mekong River and its branch river using large-scaled coal transport vessels, which is commonly used for international coal transshipment, are limited due to the shallow water area at the mouth of the Mekong River and its branch river. Under the present situation, it is economically inefficient to deepen the current navigational channel for the large-scale coal transport vessels to enter the river because it entails an enormous amount of maintenance dredging effort to be done in order to maintain the shallow current water depth for navigational channel. In addition, use of small-size coal transport vessel for coal import is inappropriate both for economic and safety reasons. In order to overcome these difficulties, construction of coal transshipment terminal (CTT) for the import of coal by large-size coal transport vessel and transshipment to smaller-size vessel for secondary transport to power plants are inevitable for the CFPPs' operation.

Import of relatively low price coal encourages the export of high quality domestic anthracite coal instead of using it for domestic coal-fired electric power plant, thus this will contribute in the improvement of trade balance. It reduces the dependence rate of domestic CFPPs on a high quality domestic anthracite coal and dispersion and reduction of risk of coal procurement can be achieved by further diversifying the sources of import coal.

It is clearly stated in the Assistance Program for Vietnam (2012) that constant and stable supply of resources and energy are the one of the prioritized areas for economic growth and enhancement of competitiveness of Vietnam. This project corresponds to this Assistance Program. Based on the above Assistance Program, the Japan International Cooperation Agency (JICA) expressed its interest in building up of electric power supply capacity, which is one of the four major prioritized assistant areas.

1.2. Objectives of the Study

This study aims to develop the assistance plan assuming the participation of the Japanese investor and to develop a project implementation program which will utilize the official development assistance (ODA) loan and JICA's overseas investment loan. This study also aims to improve the electricity supply capacity by constructing the CTT as a common infrastructure for Southern Vietnam where many CFPPs are planned to be constructed in order to contribute in the economic growth, promotion and strengthening of international competitiveness in this region. For this reasons, this study will focus on the following two issues:

(1) Develop a coal logistic system to satisfy the imported coal supply demand for planned CFPPs.
(2) Secure the return of investment in the construction of CTT and to draft a CTT plan in order to make it a meaningful investment.

Based on the study results of the "Preparatory Survey for Song Hau 1 Coal-Fired Power Plant Project and Its Related Common Infrastructures (PPP Infrastructure Project)", which has been done as "Phase 1" project for this CTT Project, Duyen Hai Distsrict in Tra Vinh Province was selected as the construction location of CTT by the Government Decision No.3491/VPCP-KTN. Figure 1.2.1 shows the location of the construction site of CTT. Concrete site location of CTT was done in this study as part of the Feasibility Study (F/S).

Source: JICA Study Team

Figure 1.2.1 Location of the Construction Site of CTT

In order to achieve the abovementioned objectives, this study was done as an F/S based on the conceptual design of CTT facilities with limited information about the natural conditions such as subsurface soil conditions and topographical survey data. Further information by supplemental survey should be obtained at the following detailed design (DD) study stage.

The prospective CFPP as a coal consumer from CTT were determined by Decision No.5964/ QD-BCT (9 Oct. 2012). Two scenarios of coal demand by Decision No.5964/ QD-BCT (9 Oct. 2012) and the JICA Study Team estimates upon the request of the Ministry of Industry and Trade (MOIT) were used in this study. As the coal demand will prominently increase year after year, phased development plans were studied and proposed to be employed.

Function of CTT is one of the study issues of this F/S, but basic ideas on the function of CTT are to supply coal handling facilities and coal storage yard and to realize the stable supply of coal to the prospective consumer. Although this study assumed that the procurement and transportation of import coal will belong to the prospective consumer of CFPP, the most appropriate coal supply source and coal transporting vessels were studied in determining the scale of the CTT facilities as well as to compute the total project cost.

To ensure the feasibility of the CTT, terminal handling charge (THC) was determined by setting the minimum equity internal rate of return (IRR) at 17.2% and necessary contractual conditions such as government support and investment scheme of a Special Purpose Company (SPC) and other necessary issues were also studied. Tentative project overall schedule is also presented in this report.

Chapter 2. Current Status of the Region

2.1. Natural Conditions of the Region

(Topographical features)

Tra Vinh Province is located in the Mekong Delta area facing the South China Sea at the east end. The terrain is mostly flat ground with 1 m to 3 m above sea level. Coastline mostly consists of sand beach, but shore erosion is evidently seen in the north of the construction site of Duyen Hai CFPP (See photos 2.1.1 and 2.1.2). Sea-bottom slope in front of CFPP is around 1/1000 slope, thus is a very gentle slope.

Photo 2.1.1 Current beach conditions about 1 km north of the Duyen Hai CFPP (wooden piles seemingly for beach erosion protection are placed in front of the house. Photo by the JICA Study Team)

Photo 2.1.2 Current beach condition about 3 km north of the Duyen Hai CFPP (quarry path for beach erosion protection placed in front of the house. Photo taken by the JICA Study Team)

(1) Temperature

Yearly average:	26.6 ºC
Maximum:	35.8 ºC
Minimum:	18.5 ºC

(2) Rain fall

Rainfall from the months of May to October accounts approximately 90% of annual rainfall. Rainy days in a year vary from 137 to 178 days.

Yearly average rainfall:	2,106 mm
Yearly maximum rainfall:	2,391 mm
Yearly minimum rainfall:	1,821 mm

(3) Humidity

Yearly average humidity is 83% and the maximum humidity is 95%.

(4) Fog

Foggy days rarely occur in this area.

(5) Wind

Main results of wind observation from May 2007 to April 2008 are shown below.

Prevailing wind direction:	Southeasterly 12.1%, northeasterly 11%, southwesterly 10.6%
Yearly average wind speed:	6.79 m/s
Maximum wind speed:	25.7 m/s

According to offshore wind data from 1999 to 2008, there were strong winds of more than 9~12 m/s blow in 85 days (23.4%).

2.2. Socio-Economic Conditions of the Region

(1) Population

The rate of natural population growth in 2012 was 1.1%. Distributions of population in the city/districts are shown in Table 2.2.1 and Table 2.2.2.

Table 2.2.1 Population of Tra Vinh Province

Year	2009	2010	2011	2012	2013
Population (x 1,000)	1,003	1,006	1,012	1,015	1,027

Source: General Statistics Bureau of Vietnam

Table 2.2.2 Population of City/Districts in Tra Vinh Province (2009)

No.	City/District	Population	Percentage (%)
1	Trà Vinh	98,699	9.8
2	Càng Long	143,389	14.3
3	Cầu Kè	109,592	10.9
4	Tiểu Cần	109,122	10.9
5	Châu Thành	136,786	13.6
6	Cầu Ngang	130,608	13.0
7	Trà Cú	176,121	17.6
8	Duyên Hải	98,695	9.8
	Total	1,003,012	100

Source: 2009 Vietnam Population and Housing Census: Completed Results

(2) Industry

Craft industry has been well developed in some business sectors. Products include textiles, mats for export, coconut shell charcoal, and related machineries. The province has 8,520 industrial manufacturing firms and handicraft industries. Share of the industry in gross domestic product (GDP) has increased from 14.52% in 2005 to 18.35% in 2010. Share of the industry in GDP has slightly changed from 18.38% in 2008 to 16.09% in 2012. So far, the province has 1,037 enterprises, with total registered capital of VND 8,050 billion. In 2010, industrial production value was estimated to reach VND 3,580 billion, which is twice higher than in 2005.

(3) Economy

The provincial economy continues to grow at a fair rate and investment in all economic sectors inside and outside the province have been mobilized more than the values in 2001-2005. However, Tra Vinh is still in a less developed state compared with other provinces in the region. The following are Tra Vinh's situations in terms of its economy:

- Economic restructuring and investment mobilization is still slow;
- Planning of agricultural production is not good;
- Non-uniform investment in business sectors;
- Lack of uniform application of technical progress;
- Expansion of cost-effective model is limited; and
- Fisheries development is not commensurate with its potentials and advantages.

The Dinh An Economic Zone is planned to develop about 39,000 ha, which is located in Tra Cu and Duyen Hai districts, until 2030. The economic zone is expected to attract investments in the fields of industry, seaport, trade, tourism, and new urban area to speed up the province's socioeconomic development.

(4) Tourism

Surrounded by two rivers, Tien and Hau, with long coastlines, Tra Vinh's economy depends on agriculture, aquaculture, and fish and shrimp breeding. The province is covered by verdant plants in the garden village along its riverbank. Some of its interesting places to visit include Ba Dong Beach, Ba Om Lake, and many Kinh, Hoa, and Khmer pagodas. Ba Dong Beach coast is lined with white sand for tens of kilometers where air is clear and fresh. Tra Vinh Tourism Office also plans to renovate and exploit the Ba Dong Seaside Resort, and turns it into an attractive tourist site in the Cuu Long River Delta. There are 140 Khmer pagodas, 50 Viet (Kinh) pagodas, and five Hoa pagodas. According to the development plan set by the Tra Vinh government, the number of tourists who visited Tra Vinh in 2010 was over 300,000. Revenue from tourism will reach over USD 27 million.

(5) Fishing

The estimated output of aquatic products in 2010 has reached 157,000 t, up by 2.44% over 2005. Aquaculture development is practiced in saltwater, brackish water, and freshwater, in addition to breeding of shrimps, crabs, clams, fish, and other aquatic products with high economic values.The inland fish stocks estimated in Tra Vinh is 3,000-4,000 t, with operators regularly harvesting at 2,000-2,500 t. Fishery resources of coastal areas of Tra Vinh include estuaries, mangroves, and coastal waters with a depth of 30-40 m of water to the shore.

2.3. Transportation System of the Region

(1) Port and Inland Waterway

The Vietnam Maritime Administration (VINAMARINE) prepared the Development Plan of Vietnam's Seaport System till 2020 and orientation to 2030. Most of the major ports located in Mekong Delta area are river ports. Several ports for CFPP such as Lon Phu and Soc Tran are said to be constructed along the river side of the Hau River.

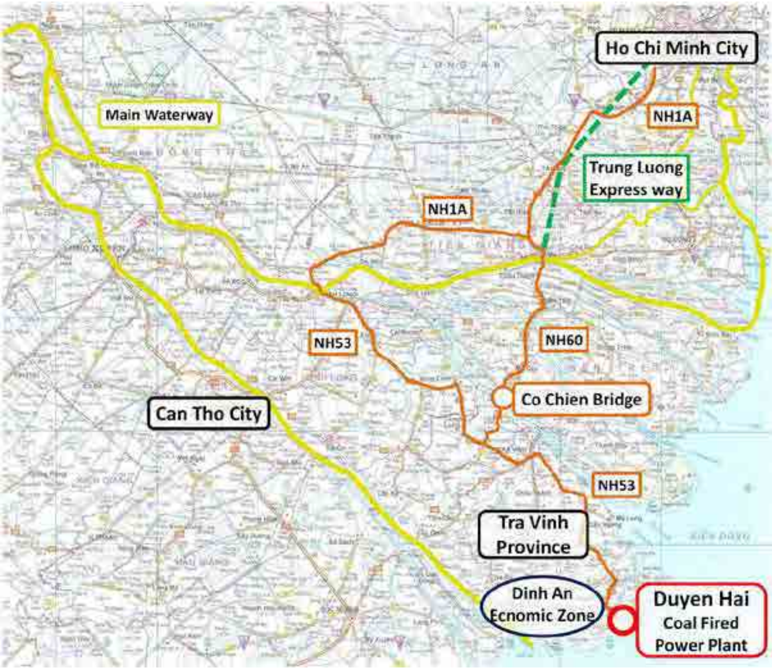
Water depth at the river mouth of the Hau River is around 5 m, which becomes the obstacle for larger ships entering the Hau River. In order to overcome this situation, the Vietnamese government decided to construct a bypass channel which can accommodate 10,000 DWT and partially loaded 20,000 DWT ships to enter the Hau River. Construction of this bypass channel and the improvement of the existing channel at the mouth of the Hau River are primary projects in the master plan. Although the construction of the new canal was stopped until 2013 due to financial difficulties of the Vietnamese government, it will be started again in 2014 using their own fund.

Figure 2.3.1 Duyen Hai Coal-Fired Power Plant and Hau River Bypass Canal (Planned)

(2) Road

There are three main national highways, i.e., 53, 54, and 60, which are upgraded to grade 3 delta road, and connect Tra Vinh with Ho Chi Minh City and other provinces in the Mekong River Delta. The road is 130 km from Tra Vinh to Ho Chi Minh City along National Highway 60 and crossing Trung Luong controlled-access highway. It is 200 km from Tra Vinh to Ho Chi Minh City and 100 km from Tra Vinh to Can Tho City along National Highway 53 and crossing National Highway 1A.

The Co Chien Bridge is planned to be built on National Highway 60, which connects Ben Tre and Tra Vinh Province. After the completion of this project, it is expected that accessibility to National Highway 60 and crossing Trung Luong controlled-access highway will be improved. It is also expected that part of the heavy traffic from National Highway 1A will be reduced, thus will help in the development of Dinh An Economic Zone. The construction of the project has begun in 2011 in the form of a build-operate-transfer (BOT) scheme. It is 2.6 km long and is 16 m wide, with four lanes of vehicles. The completion of this project is estimated in early 2016.



Source: JICA Study Team

Figure 2.3.2 Road System of South Vietnam

2.4. Current Status of the Candidate Site of CTT

Most of the candidate sites for the CTT are used as fish ponds located along the coastline as well as rice paddy on the inland side. The construction of the Duyen Hai CFPP is done on a reclamation site formerly used as a fishpond.

The following are the construction plans for the Duyen Hai CFPPs.

- Duyen Hai I.1 (2014): 600 MW (domestic coal to be used)
- Duyen Hai I.2 (2015): 600 MW (domestic coal to be used)
- Duyen Hai II.1 (2018): 600 MW (imported coal to be used)
- Duyen Hai II.2 (2019): 600 MW (imported coal to be used)
- Duyen Hai III.1 (2015): 600 MW (imported coal to be used)
- Duyen Hai III.2 (2016): 600 MW (imported coal to be used)
- Duyen Hai III.3 (2019): 600 MW (imported coal to be used)

A port receiving 30,000 DWT coal carrier is planned to receive imported coal under Phase II of Duyen Hai. The northern breakwater is planned to be 3.9 km, and that of southern breakwater is 2.5 km. Channel depth is 9.5 m. Yearly coal handling volume is estimated at 12 million t.

Currently, EVN has started constructing CFPPs in 2010. In 2014, part of the smock stack and building of Duyen Hai I Power Plant are under construction. The eastern part of breakwater and trestle of port for coal transshipment is also under construction. The western part of breakwater is planned for construction through MOT fund, but has not started yet. Tra Vinh Province plan to construct complex port to handle not only coal but also general cargo.

Photo 2.4.1 Duyen Hai CFPP under Construction (March 2014, Photo taken by the JICA Study Team)

Photo 2.4.2. East Breakwater and Trestle for Coal Transshipment (March 2014 by the JICA Study Team)

Chapter 3. Field Survey of the Natural Conditions and Environmental Survey

3.1. Bathymetric Survey

Bathymetric survey at the Project site of imported CTT was carried out in May 2014. The survey area is in green hatching as shown in Figure 3.1.1 below.

The survey area consists of unloading berth area at offshore and connecting bridge for belt conveyor with the area of 504 ha in total. The survey area control points were named B1-B8 as shown in Figure 3.1.1. The standard and method of this survey are shown in Appendix B.

Source: JICA Study Team

Figure 3.1.1 Survey Points Map

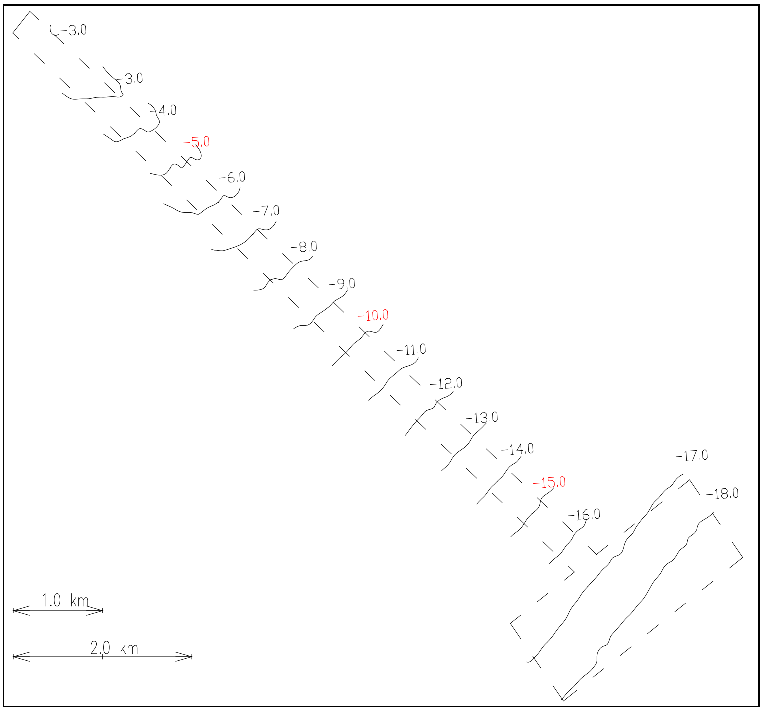
Table 3.1.1 Coordinates of Control Points

Stt	Point	VN2000 Coordinate		WGS84 Coordinate	
		N	E	N	E
1	B 1	1057841.227	614201.970	1057617.574	669246.820
2	B 2	1058091.289	614367.707	1057867.849	669412.179
3	B 3	1053618.377	621116.407	1053405.168	676166.658
4	B 4	1054789.504	621892.608	1054577.301	676941.091
5	B 5	1054126.557	622892.858	1053915.863	677942.203
6	B 6	1052292.764	621677.455	1052080.493	676729.567
7	B 7	1052955.712	620677.204	1052741.933	675728.457
8	B 8	1053368.315	620950.670	1053154.891	676001.300

Source: JICA Study Team

※VN2000 Coordinate System

The topographic drawing with 1.0 m contour line of the Project area is shown in Figure 3.1.2. For the seabed slope is quite shallow, the effect of waves is considered limited.



Source: JICA Study Team

Figure 3.1.2 Topographic Map

3.2. Boring Survey

It is very important to implement a boring survey and obtain the geo-information of the soil layers below and awareness of distribution of each underground layer. Therefore, in this investigation, a boring survey with two-holes along the connecting bridge (belt conveyor) was implemented. The boring hole's positions are shown in Figure 3.2.1.

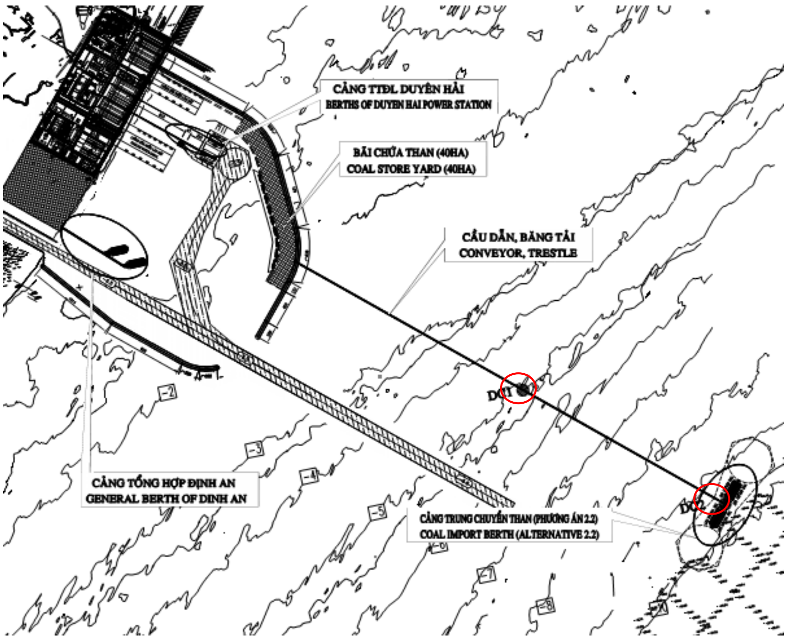


Figure 3.2.1 Boring Hole Positions

Coordinates of the boring holes are listed in Table 3.2.1 below.

Table 3.2.1 Boring Hole Coordinates

No	Borehole No.	Actual Coordinate		Ground Elevation (m)
		N (m)	E (m)	
1	BH1	1055594	616846	-6.0
2	BH2	1053862	618805	-11.0

Source: JICA Study Team

Table 3.2.2 shows the depth for each boring hole and numbers of obtained samples for laboratory test.

Table 3.2.2 Boring Depth and Number of Test Samples

No	Borehole .No	Depth (m)		Sample		SPT test	Remark
		Soil (m)	Total (m)	U	D		
1	BH1	50.0	50.0	23	2	25	Offshore
2	BH2	50.0	50.0	25	0	25	Offshore
Total		**100.0**	**100.0**	**48**	**2**	**50**	

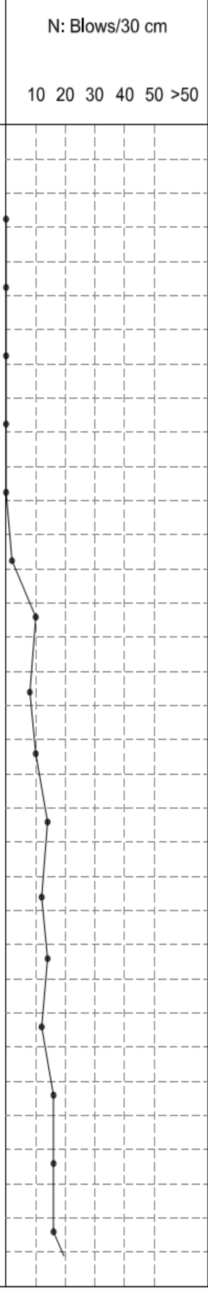
Source: JICA Study Team

After acquisition, the boring samples were sealed and loaded carefully into the laboratory to examine the physical and chemical characteristics. The boring log and longitudinal section of two boring holes are shown in Figures 3.2.2 to 3.2.6. The laboratory test results for each soil sample are also listed in Appendix B.

Co-ord (m): N = 1055594.0 | Sheet: 1 / 2
E = 616846.0 | Location: Offshore
Ground elevation (m): -6.00 | Date commenced: 17/4/2014
Depth (m): 50.0m | Date completed: 18/4/2014

Layer	Elevation (m):	Depth (m)	Thickness (m)	Lithological symbol	SOIL AND ROCK DESCRIPTION	SPT test Depth (m)	Blows/15cm N_0	N_1	N_2	N	Sample No. / Depth of the sample (m)
1	-6.30	0.30	0.30		Medium dense, grey, poorly graded sand (SP)						
2			13.30		Very soft, brownish grey, grey, Fat clay (CH)	2.75	0	0	0	0	U1 2.00 - 2.60
						4.75	0	0	1	1	U2 4.00 - 4.60
						6.75	0	0	1	1	U3 6.00 - 6.60
						8.75	0	0	1	1	U4 8.00 - 8.50
						10.75	0	0	1	1	U5 10.00 - 10.60
	-19.60	13.60				12.75	0	1	1	2	U6 12.00 - 12.60
3	-21.00	15.00	1.40		Medium dense, Brownish grey, grey, poorly graded sand (SP)	14.4	3	4	6	10	U7 14.00 - 14.40
4			12.00		Stiff, brownish grey, yellowish grey, lean clay with sand (CL)	16.6	3	4	5	9	U8 16.00 - 16.50
						18.4	3	5	6	11	U9 18.00 - 18.40
						20.4	5	7	8	15	U10 20.00 - 20.40
						22.6	5	6	7	13	U11 22.00 - 22.40
						24.4	4	7	7	14	U12 24.00 - 24.40
	-33.00	27.00				26.4	5	7	6	13	U13 26.00 - 26.40
6			11.40		Very stiff, bluish grey, brownish grey, Fat clay (CH)	28.4	5	7	10	17	U14 28.00 - 28.40
						30.4	6	6	10	16	U15 30.00 - 30.40
						32.4	5	8	9	17	U16 32.00 - 32.40

SPT chart



Source: JICA Study Team

Figure 3.2.2 Boring Log at BH1 (0~33 m depth)

Co-ord (m): N = 1055594.0 Sheet: 2 / 2

E = 616846.0 Location: Offshore

Ground elevation (m): -6.00 Date commenced: 17/4/2014

Depth (m): 50.0m Date completed: 18/4/2014

Layer	Elevation (m):	Depth (m)	Thickness (m)	Lithological symbol	SOIL AND ROCK DESCRIPTION	SPT test Depth (m)	Blows/15cm N_0	N_1	N_2	N	SPT chart N: Blows/30 cm (10 20 30 40 50 >50)	Sample No. / Depth of the sample (m)
6			11.40		Very stiff, bluish grey, brownish grey, Fat clay (CH)	34.6	6	8	10	18		U17 34.00 - 34.60
						36.5	5	7	10	17		U18 36.00 - 36.50
	-44.40	38.40				38.4	13	25	40	65		U19 38.00 - 38.40
7			4.40		Very dense, grey, yellowish grey, Poorly graded sand with silty clay (SP-SC)	40.0	11	25	50	75		D20 40.00 - 40.45
						42.0	13	27	54	81		D21 42.00 - 42.45
	-48.80	42.80										
8			4.00		Very stiff, grey, bluish grey, brownish grey, Sandy Lean clay (CL)	44.4	8	11	12	23		U22 44.00 - 44.40
						46.3	8	10	11	21		U23 46.00 - 46.25
	-52.80	46.80										
10			3.20		Midium dense, bluish grey, Clayey sand (SC)	48.4	6	8	10	18		U24 48.00 - 48.40
	-56.00	50.00				50.0	5	9	11	20		U25 49.60 - 50.00

Source: JICA Study Team

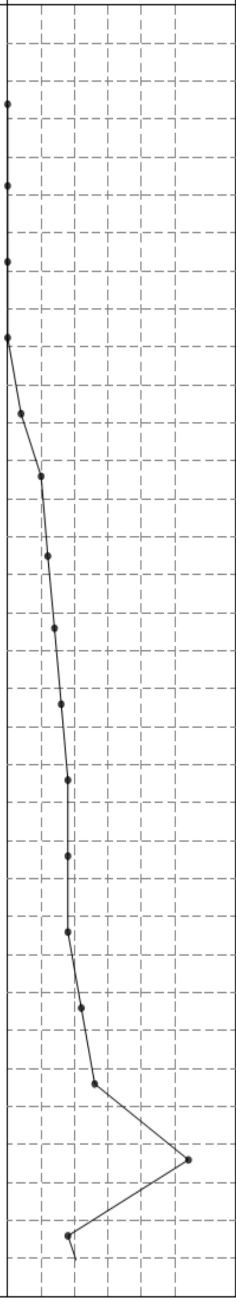
Figure 3.2.3 Boring Log at BH1 (33~50 m depth)

Co-ord (m): N = 1053862.0
E = 618805.0
Ground elevation (m): -11.00
Depth (m): 50.0m

Sheet: 1 / 2
Location: Offshore
Date commenced: 19/4/2014
Date completed: 20/4/2014

Layer	Elevation (m)	Depth (m)	Thickness (m)	SOIL AND ROCK DESCRIPTION	SPT Depth (m)	N_0	N_1	N_2	N	Sample No. / Depth of the sample (m)
1			11.00	Very soft, brownish grey, grey, Fat clay (CH)	2.6	0	0	0	0	U1 2.00 - 2.50
					4.75	0	0	1	1	U2 4.00 - 4.70
					6.75	0	0	1	1	U3 6.00 - 6.70
					8.75	0	0	1	1	U4 8.00 - 8.70
					10.75	0	1	3	4	U5 10.00 - 10.70
3	-22.00	11.00	2.50	Medium dense, bluish grey ,grey, Clayey sand with gravel (SC)	12.4	4	5	6	11	U6 12.00 - 12.40
4	-24.50	13.50	9.70	Stiff, brownish grey, yellowish grey, Lean clay with sand (CL)	14.5	4	6	7	13	U7 14.00 - 14.50
					16.4	5	7	7	14	U8 16.00 - 16.40
					18.4	6	8	9	17	U9 18.00 - 18.40
					20.4	15	9	10	19	U10 20.00 - 20.40
					22.4	7	8	10	18	U11 22.00 - 22.40
TK1	-34.20	23.20	0.80	Very hard, Yellowish grey, brownish grey, Lean clay with fragment (CL)	24.4	8	9	10	19	U12 24.00 - 24.40
5	-35.00	24.00	8.00	Medium dense, yellowish grey, brownish grey, Clayey sand (SC)	26.4	9	10	12	22	U13 26.00 - 26.40
					28.4	10	12	14	26	U14 28.00 - 28.40
					30.4	15	20	34	54	U15 30.00 - 30.40
	-43.00	32.00		Very stiff, bluish grey, brownish grey, Fat clay (CH)	32.4	6	8	10	18	U16 32.00 - 32.40

SPT chart (N: Blows/30 cm):

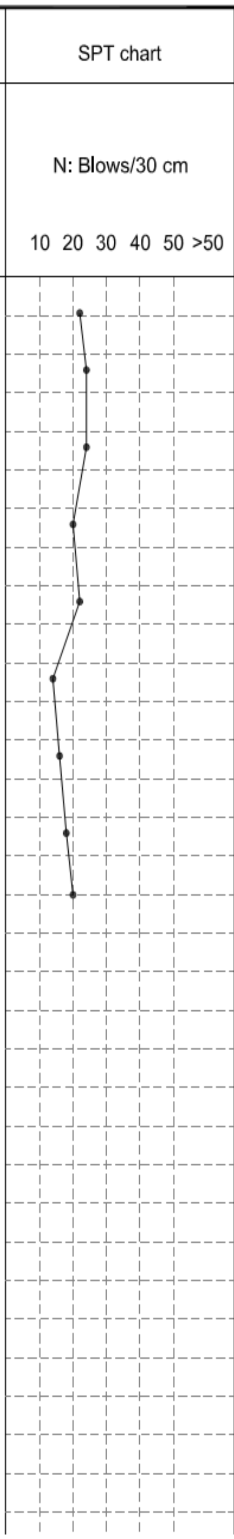


Source: JICA Study Team

Figure 3.2.4 Boring Log at BH2 (0~33 m depth)

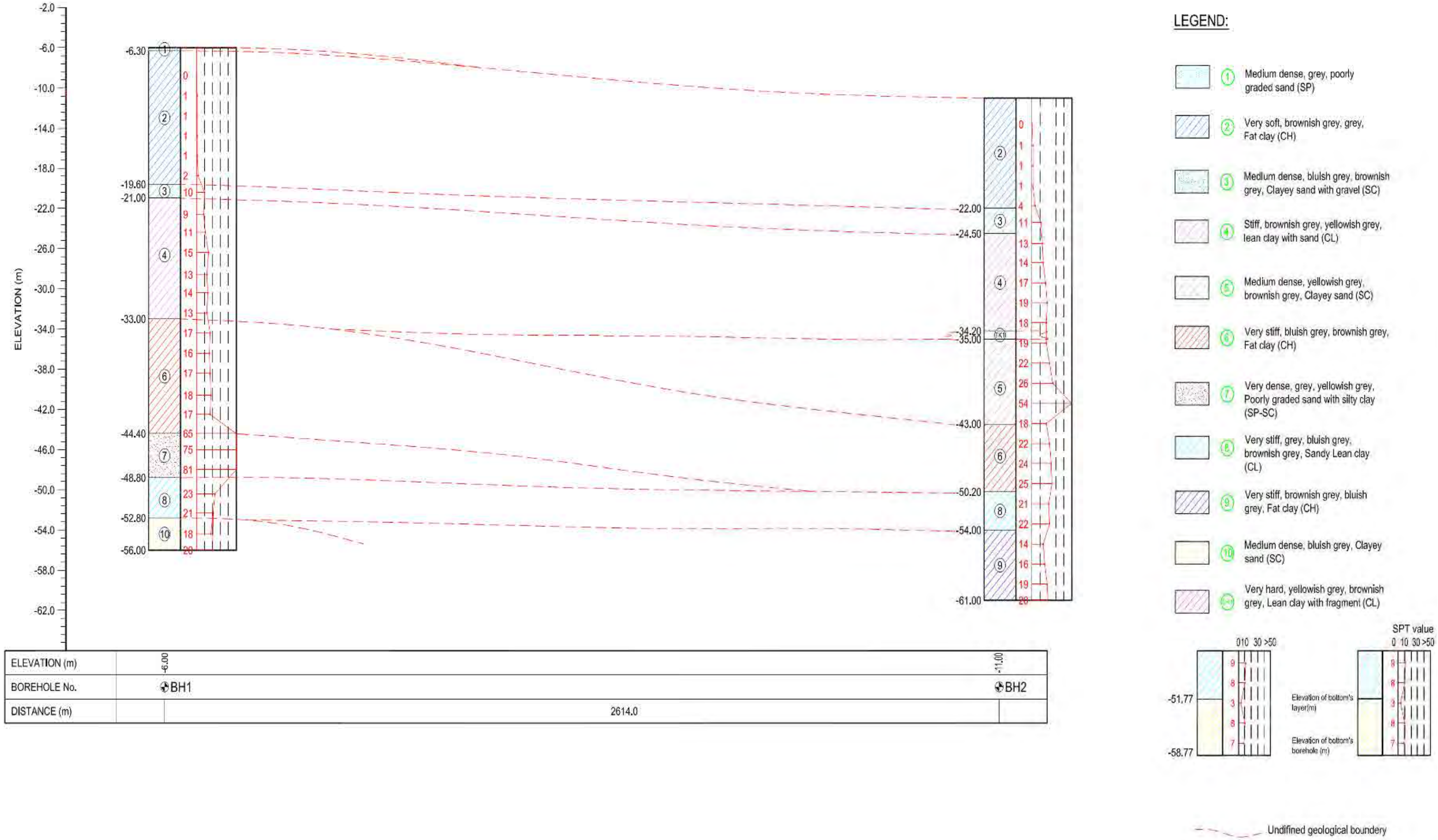
Co-ord (m): N = 1053862.0 | Sheet: 2 / 2
E = 618805.0 | Location: Offshore
Ground elevation (m): -11.00 | Date commenced: 19/4/2014
Depth (m): 50.0m | Date completed: 20/4/2014

Layer	Elevation (m):	Depth (m)	Thickness (m)	Lithological symbol	SOIL AND ROCK DESCRIPTION	SPT test Depth (m)	Blows/15cm N_0	Blows/15cm N_1	Blows/15cm N_2	N	Sample No. Depth of the sample (m)
6			7.20		Very stiff, bluish grey, brownish grey, Fat clay (CH)	34.4	8	10	12	22	U17 34.00 - 34.40
						36.4	9	11	13	24	U18 36.00 - 36.40
	-50.20	39.20				38.4	8	12	13	25	U19 38.00 - 38.40
8			3.80		Very stiff, brownish grey, Silty clay with sand (CL-ML)	40.4	7	10	11	21	U20 40.00 - 40.40
	-54.00	43.00				42.4	8	10	12	22	U21 42.00 - 42.40
9			7.00		Very stiff, brownish grey, bluish grey, Fat clay (CH)	44.4	4	6	8	14	U22 44.00 - 44.40
						46.4	5	8	8	16	U23 46.00 - 46.40
						48.4	7	9	10	19	U24 48.00 - 48.40
	-61.00	50.00				50.0	9	10	10	20	U25 49.60 - 50.00



Source: JICA Study Team

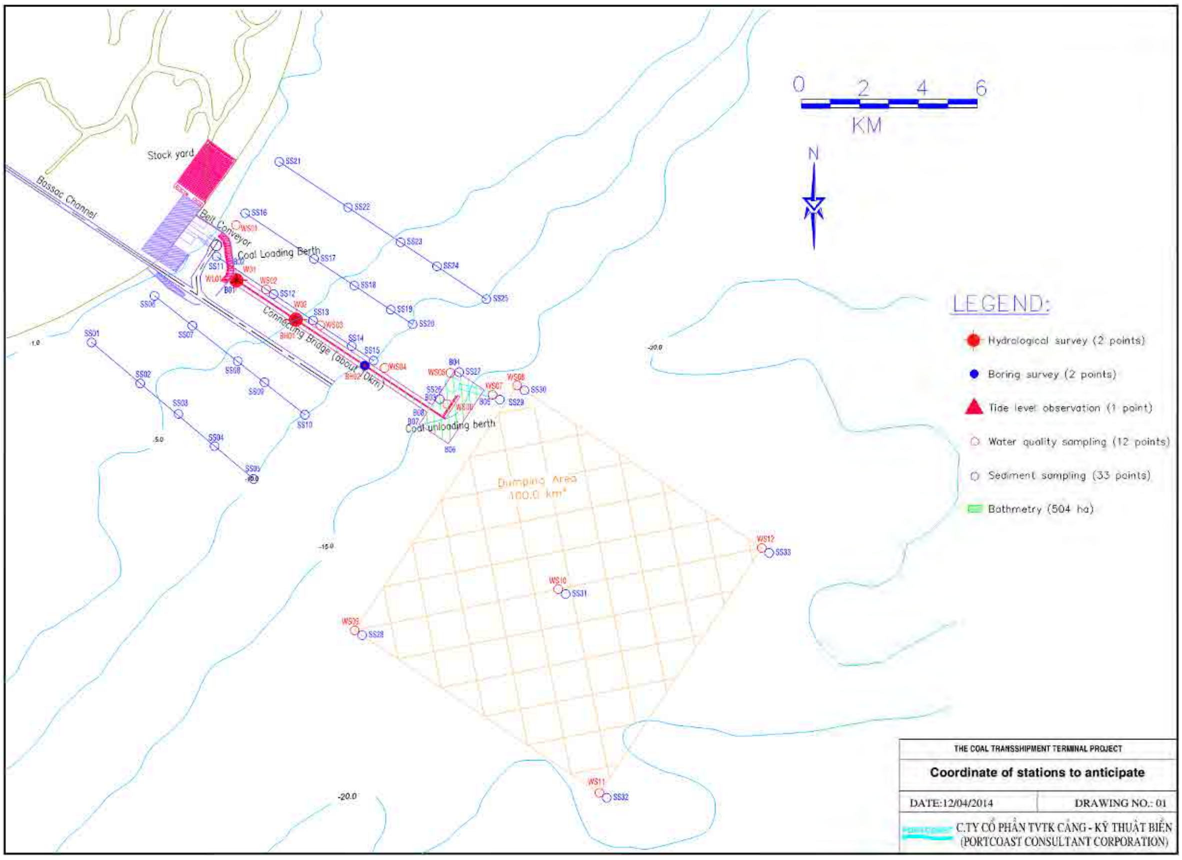
Figure 3.2.5 Boring Log at BH2 (33~50 m depth)



Source: JICA Study Team

Figure 3.2.6 Longitudinal Section of Two Boring Holes

3.3. Sea State Condition Survey



Source: JICA Study Team

Figure 3.3.1 Survey Points Location Map

Figure 3.3.1 shows the sea state condition survey point's location. This survey was implemented for a period of one month (from 15 April to 15 May 2014). Aside from the investigation for wave observation, tide observation and flow observation, 12 water samples and 33 seabed samples were collected for physical and chemical characteristics laboratory test. The tests for pH, salinity, turbidity, etc., were implemented for water samples and the tests for particle size distribution, density, and the like were implemented for seabed soil samples.

(1) Water Sample and Seabed Soil Sample

The test results for water samples and seabed soil samples are listed in Table 3.3.1 and Table 3.3.2.

Table 3.3.1(a) Test Results of Water Samples for pH, Tempurature, Salinity Test

BẢNG KẾT QUẢ ĐO pH - NHIỆT ĐỘ - ĐỘ MẶN MẪU NƯỚC (TABLE OF pH - TEMPERATURE - SALINITY TEST RESULT)							
STT (No.)	Ngày (Date)	Giờ (h)	Tầng (Layer)	Giá trị			Ghi chú (Notes)
				pH	Độ mặn (Salimity) (%o)	Nhiệt độ (Temperature) (^{0}C)	
1	19/4/2014	15	0.2H	7.5	24.5	33.0	WS01-1
			0.5H	7.5	24.9	32.4	WS01-2
			0.8H	7.5	25.4	32.0	WS01-3
2	18/4/2014	9	0.2H	7.5	24.5	32.0	WS02-1
3	18/4/2014	11	0.2H	7.5	25.0	32.0	WS03-1
4	18/4/2014	11	0.2H	7.5	24.4	31.8	WS04-1
			0.5H	7.5	26.3	31.0	WS04-2
			0.8H	7.5	29.4	31.0	WS04-3
5	18/4/2014	12	0.2H	7.5	26.0	32.0	WS05-1
6	18/4/2014	12	0.2H	7.5	26.0	32.0	WS06-1
			0.5H	7.5	29.8	30.3	WS06-2
			0.8H	7.5	29.8	30.0	WS06-3
7	18/4/2014	13	0.2H	7.5	25.5	31.9	WS07-1
8	18/4/2014	13	0.2H	7.5	25.6	31.7	WS08-1
9	19/4/2014	13	0.2H	7.6	27.1	32.5	WS09-1
10	19/4/2014	9	0.2H	7.6	26.1	31.0	WS010-1
			0.5H	7.6	29.6	30.0	WS010-2
			0.8H	7.6	29.9	30.0	WS010-3
11	11/4/2014	12	0.2H	7.6	26.7	32.0	WS11-1
12	19/4/2014	10	0.2H	7.6	26.1	31.0	WS12-1

Source: JICA Study Team

Table 3.3.1 (b) Test Results of Water Samples for Turbidity Test

BẢNG KẾT QUẢ PHÂN TÍCH MẪU BÙN CÁT LƠ LỮNG
TABLE OF SUSPENDED SEDIMENT TEST RESULT

Ngày/Tháng/ Năm [Date/month/ year]	Giờ-HOUR	Tầng-LAYER	Ký Hiệu Mẫu-SAMPLE	Weight			Dung tích-Water sample volume (ml)	Hàm Lượng Bùn Cát-Suspended sediment concentration (g/l)	Ghi Chú-Notes
				Giấy Lọc Sấy Khô-Dry filter-paper (mg)	Mẫu Lọc Sấy Khô-Dry sample (mg)	Bùn Cát-Dry suspended sediment (mg)			
19/4/2014	15	0.2H	WS01-1	1969	2290	321	850	0.378	
		0.5H	WS01-2	1973	2320	347	820	0.423	
		0.8H	WS01-3	1988	2380	392	820	0.478	
18/4/2014	9	0.2H	WS02-1	1980	2310	330	820	0.402	
18/4/2014	11	0.2H	WS03-1	1962	2271	309	840	0.368	
18/4/2014	11	0.2H	WS04-1	1962	2340	378	820	0.461	
		0.5H	WS04-2	1968	2430	462	800	0.578	
		0.8H	WS04-3	1992	2410	418	820	0.510	
18/4/2014	12	0.2H	WS05-1	1975	2360	385	840	0.458	
18/4/2014	12	0.2H	WS06-1	2015	2270	255	840	0.304	
		0.5H	WS06-2	1991	2270	279	820	0.340	
		0.8H	WS06-3	1992	2350	358	820	0.437	
18/4/2014	13	0.2H	WS07-1	1979	2290	311	820	0.379	
18/4/2014	13	0.2H	WS08-1	1999	2270	271	820	0.330	
19/4/2014	13	0.2H	WS09-1	2038	2340	302	820	0.368	
19/4/2014	9	0.2H	WS010-1	1979	2243	264	840	0.314	
		0.5H	WS010-2	2003	2350	347	820	0.423	
		0.8H	WS010-3	2000	2310	310	840	0.369	
11/4/2014	12	0.2H	WS11-1	2047	2350	303	840	0.361	
19/4/2014	10	0.2H	WS12-1	1949	2230	281	840	0.335	

Source: JICA Study Team

Table 3.3.2(a) Test Results of Seabed Soil Samples

KẾT QUẢ THÍ NGHIỆM CÁC CHỈ TIÊU HÓA LÝ CỦA MẪU ĐẤT
(PHYSICAL AND CHEMICAL PROPERTIES TEST RESULTS)

Số thứ tự - **No.**	Số hiệu mẫu **Sample No.**	Thành phần hạt - **Grain Size Distribution**, %								Tính chất vật lý **Physical Properties**		Kết quả hóa nước **Result of Chemical Testing**					
		Sạn - **Gravel**		Cát - **Sand**			Bụi-**Silt**	Sét - **Clay**						Cl^-		SO_3	
		19.0 - 75	4.75 - 19	2.0 - 4.75	0.425 - 2.0	0.075 - 0.425	0.005 - 0.075	0.002 - 0.005	<0.002	Độ ẩm - **Moisture Cont.**,%	Tỷ trọng - **Specific Gravity**	**CO_3^{-2} %**	**pH**	**(mg/l)**	**%**	**(g/l)**	**%**
1	SS01					88.7	7.7	1.2	2.4	34.0	2.681	2.38	7.540	0.012	0.249	0.274	0.055
2	SS02					67.5	26.2	1.3	5.1	29.2	2.680	2.02	7.540	0.012	0.234	0.206	0.041
3	SS03					33.9	50.8	3.4	11.9	71.4	2.682	3.17	7.650	0.016	0.327	0.521	0.104
4	SS04					8.5	49.9	14.4	27.2	71.4	2.691	3.17	7.130	0.023	0.458	1.358	0.272
5	SS05					5.1	49.8	10.8	34.3	84.1	2.691	3.87	7.620	0.034	0.685	0.960	0.192
6	SS06					74.9	19.4	0.0	5.7	34.0	2.682	2.38	7.870	0.010	0.206	0.741	0.148
7	SS07					88.4	6.7	1.2	3.7	35.7	2.680	2.55	7.760	0.007	0.142	0.247	0.049
8	SS08					81.2	13.2	1.2	4.4	34.2	2.681	2.55	7.360	0.012	0.238	0.672	0.134
9	SS09					39.1	35.0	5.9	19.9	47.6	2.691	3.08	7.850	0.020	0.408	0.480	0.096
10	SS10					14.7	41.5	10.9	32.8	76.2	2.692	3.34	7.770	0.028	0.568	1.482	0.296
11	SS11					81.1	13.2	1.9	3.8	28.1	2.680	2.55	7.530	0.011	0.213	0.700	0.140
12	SS12					91.9	5.1	0.6	2.4	41.3	2.683	2.64	7.950	0.014	0.280	0.343	0.069
13	SS13					67.9	24.4	1.3	6.4	41.6	2.688	2.82	7.410	0.016	0.316	1.070	0.214
14	SS14					32.9	42.3	3.2	21.6	48.5	2.697	2.73	8.020	0.016	0.316	0.741	0.148
15	SS15					46.0	33.2	2.8	17.9	52.3	2.698	2.99	8.020	0.023	0.458	0.988	0.198
16	SS16					79.3	16.3	1.3	3.1	35.4	2.684	2.38	8.110	0.012	0.238	1.043	0.209
17	SS17					90.9	5.4	0.6	3.1	36.4	2.685	2.38	7.990	0.009	0.178	1.317	0.263
18	SS18					8.8	46.8	11.3	33.1	53.7	2.685	3.52	7.950	0.025	0.493	0.466	0.093
19	SS19					75.1	18.5	1.3	5.1	30.7	2.682	2.46	8.040	0.012	0.249	0.329	0.066
20	SS20					77.7	16.6	0.6	5.1	35.9	2.684	2.46	7.970	0.014	0.277	0.288	0.058
21	SS21					88.9	7.4	0.6	3.1	31.5	2.683	2.20	7.930	0.010	0.206	0.302	0.060

Source: JICA Study Team

Table 3.3.2 (b) Test Results of Seabed Soil Samples

KẾT QUẢ THÍ NGHIỆM CÁC CHỈ TIÊU HÓA LÝ CỦA MẪU ĐẤT
(PHYSICAL AND CHEMICAL PROPERTIES TEST RESULTS)

Số thứ tự - No.	Số hiệu mẫu Sample No.	Thành phần hạt - Grain Size Distribution, % — Sạn - Gravel		Cát - Sand			Bụi-Silt	Sét - Clay		Tính chất vật lý Physical Properties		Kết quả hóa nước Result of Chemical Testing		Cl⁻		SO_3	
		19.0 - 75	4.75 - 19	2.0 - 4.75	0.425 - 2.0	0.075 - 0.425	0.005 - 0.075	0.002 - 0.005	<0.002	Độ ẩm - Moisture Cont.,%	Tỷ trọng - Specific Gravity	CO_3^{-2} %	pH	(mg/l)	%	(g/l)	%
22	SS22					94.9	2.1	0.6	2.4	30.8	2.681	2.46	7.870	0.011	0.224	1.262	0.252
23	SS23					92.8	4.0	0.6	2.6	35.3	2.682	2.20	7.910	0.010	0.209	0.906	0.181
24	SS24					84.8	9.1	0.6	5.4	31.0	2.680	2.55	7.910	0.013	0.256	0.823	0.165
25	SS25					34.1	32.5	5.4	28.1	51.2	2.690	3.78	7.930	0.027	0.540	0.906	0.181
26	SS26					2.2	43.2	11.4	43.2	86.1	2.695	4.31	7.840	0.039	0.774	2.127	0.425
27	SS27					3.7	42.7	11.3	42.3	81.5	2.696	4.49	8.020	0.040	0.809	1.468	0.294
28	SS28					16.5	32.8	11.7	38.9	78.1	2.694	6.07	8.070	0.042	0.848	2.785	0.557
29	SS29				0.4	3.6	41.2	13.4	41.3	89.9	2.694	4.49	7.970	0.049	0.983	2.346	0.469
30	SS30					7.3	42.0	10.5	40.3	103.5	2.693	5.54	7.980	0.057	1.136	2.181	0.436
31	SS31					83.6	6.5	2.0	7.9	33.2	2.682	4.40	8.190	0.013	0.263	1.729	0.346
32	SS32					89.5	4.0	1.3	5.2	30.6	2.681	4.40	8.000	0.014	0.284	0.631	0.126
33	SS33				5.8	79.9	6.5	1.3	6.6	27.2	2.687	4.22	8.290	0.011	0.217	1.468	0.294

Source: JICA Study Team

(2) Wave Observation

The wave observation machines were set up offshore at the Project site (Figure 3.3.1), and the survey was implemented for one month (15 April to 15 May 2014). During this period, in order to keep the accuracy from deposition of shells, cleaning and re-installation of measuring instruments were made with a frequency of once in four days.

Data on the average, maximum, and minimum wave heights, turbidity, water temperature, and salinity are shown in Table 3.3.3.

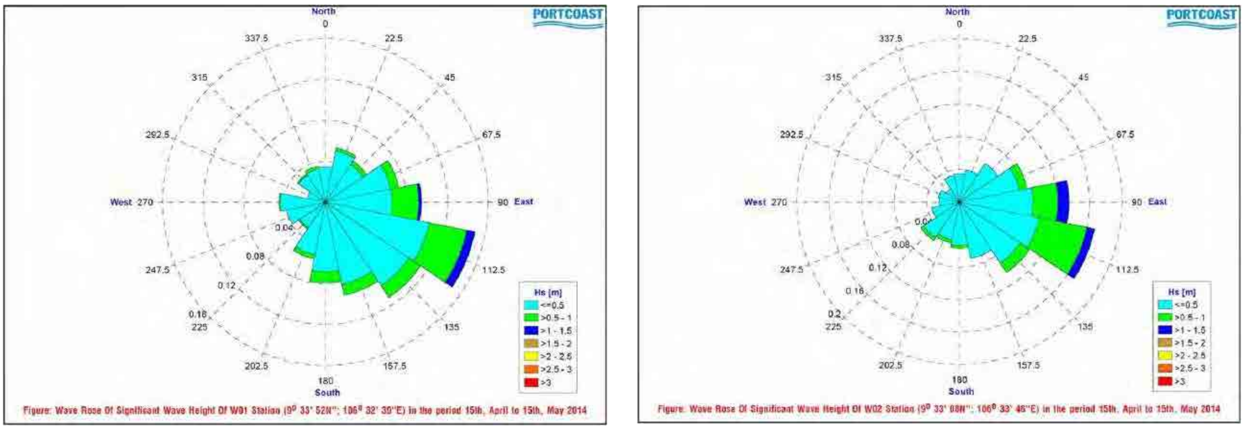
Figure 3.3.2 to Figure 3.3.3 show the results of wave observation.

Table 3.3.3 Wave Height

Items	Station	Average	Max	Min
Wave Height (Hs)	W01	31.04cm	129.70cm	11.50cm
	W02	29.0cm	144.0cm	6.90cm
Suspended sediment concentration	W01	0.221g/l	0.787g/l	0.160g/l
	W02	0.214g/l	0.492g/l	0.080g/l
Water Tempurature	W01	30.74℃	32.85℃	27.26℃
	W02	30.33℃	31.30℃	29.04℃
Sadinity	W01	30.14psu	33.54psu	21.10psu
	W02	30.63psu	34.16psu	21.32psu

Source: JICA Study Team

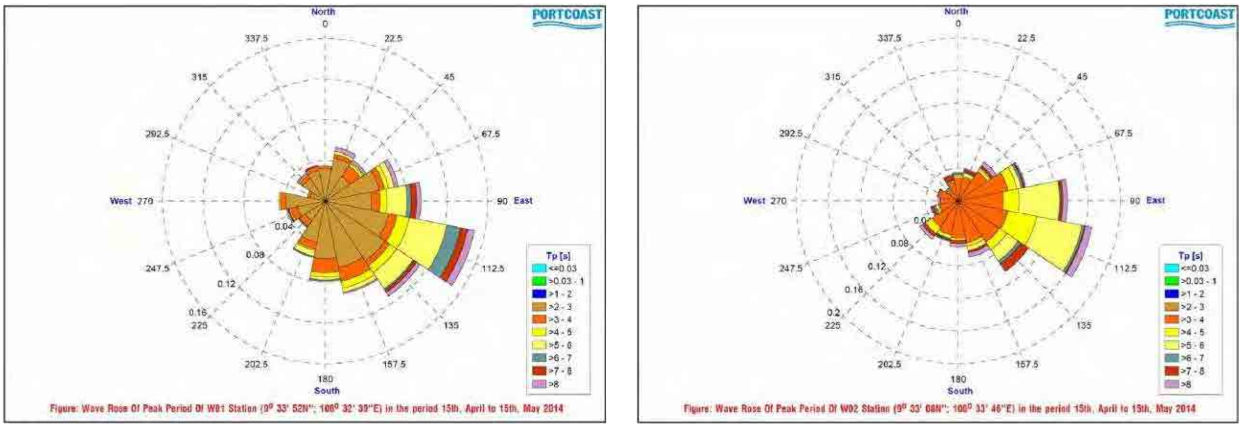
a) Observation Station W01 b) Observation Station W02



Source: JICA Study Team

Figure 3.3.2 Wave Rose of Significant Wave Height and Wave Direction

a) Observation Station W01 b) Observation Station W02



Source: JICA Study Team

Figure 3.3.3 Wave Rose of Peak Period and Wave Direction

(3) Flow Observation

The measuring machines were set up at abovementioned W01, W02; the average flow velocity in 2 minutes was measured in 20 minutes, and considered as instantaneous flow velocity. The average, maximum, and minimum flow velocities are shown in Table 3.3.4. For each observation station, the average, maximum, minimum flow velocities were approximately recorded at 0.3 m/s, 0.85 m/s, and 0.05 m/s, respectively, which showed confirmation of gentle streams.

The variations of wave velocity, wave direction, and water pressure are shown in Appendix B.

Table 3.3.4 Average Flow Velocity (m/s)

Station	Location	Average current velocity [m/s]		
		Average	Max	Min
W01	Sea	0.266	0.830	0.088
W02	Sea	0.318	0.866	0.037

Source: JICA Study Team

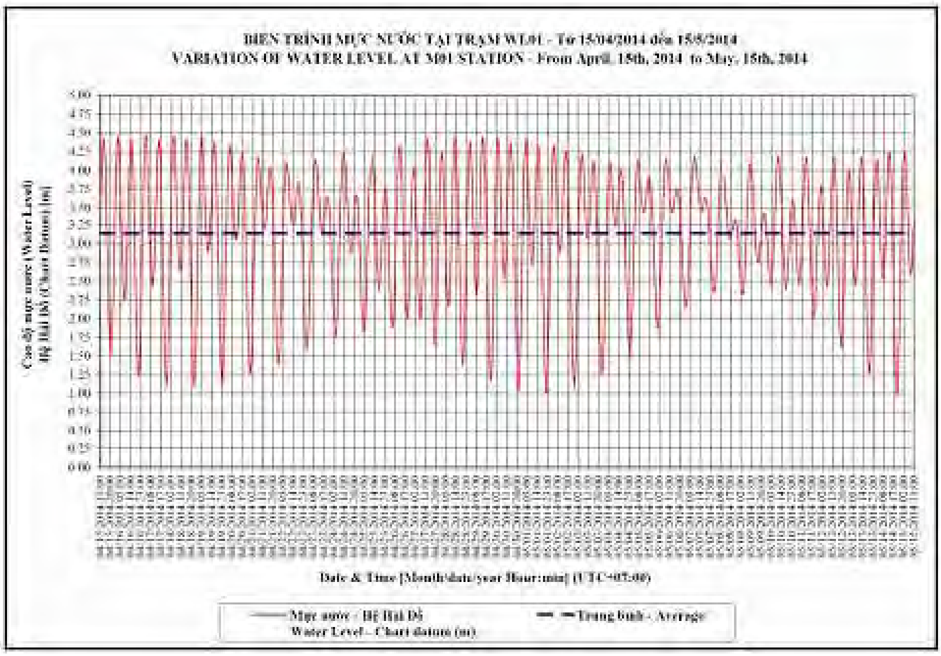
(4) Tide Level Measurement

The average, maximum, and minimum tide levels during measurement period are shown in Table 3.3.5 and the variation of tide level is shown in Figure 3.3.4. It could be said that the tide level frequency is an irregular half-day period. The ebb and flow of tide level vary twice a day and the tide level difference is about 3.50 m.

Table 3.3.5 Tide Observation

Station	Location	Water level [m] – Chart Datum		
		Average	Max	Min
WL01	Sea	3.136	4.479	0.978

Source: JICA Study Team



Source: JICA Study Team

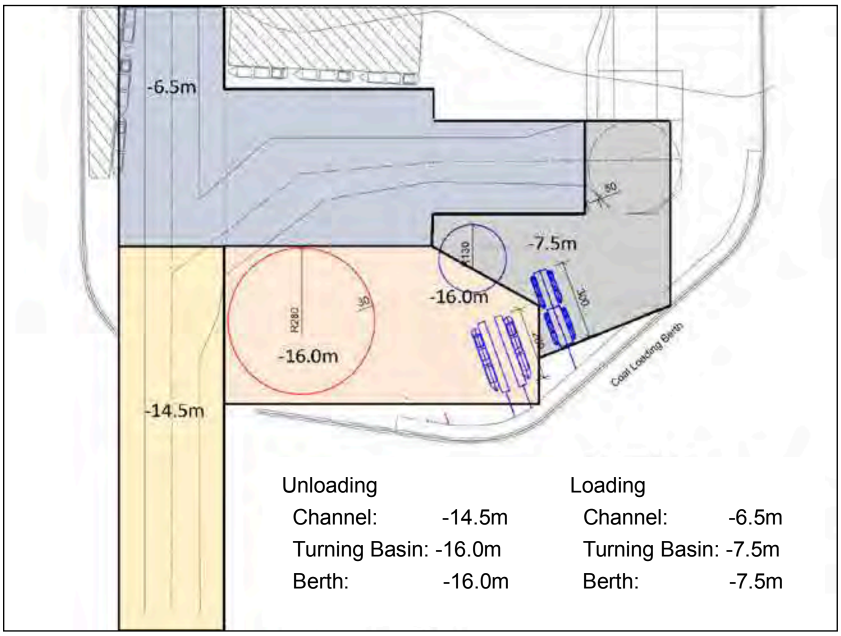
Figure 3.3.4 Variation of Tide Level

Chapter 4. Simulation Study of Channel Deposition

4.1. General Conditions

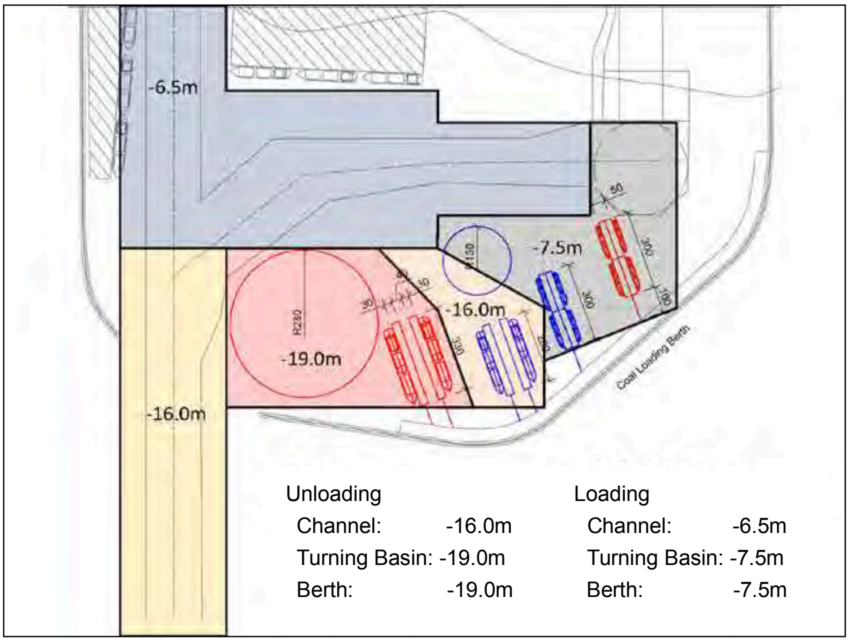
4.1.1. Water Depth of Channel and Basis

Figures 4.1.1 and 4.1.2 show the water depth of channel and port area for the 1st Phase (referred in this section as the 1st and 2nd Phases) and the 3rd Phase (referred in this section as the 3rd Phase), respectively.



Source: JICA Study Team

Figure 4.1.1Water Depth of Channel and Port Basin for the 1st Phase

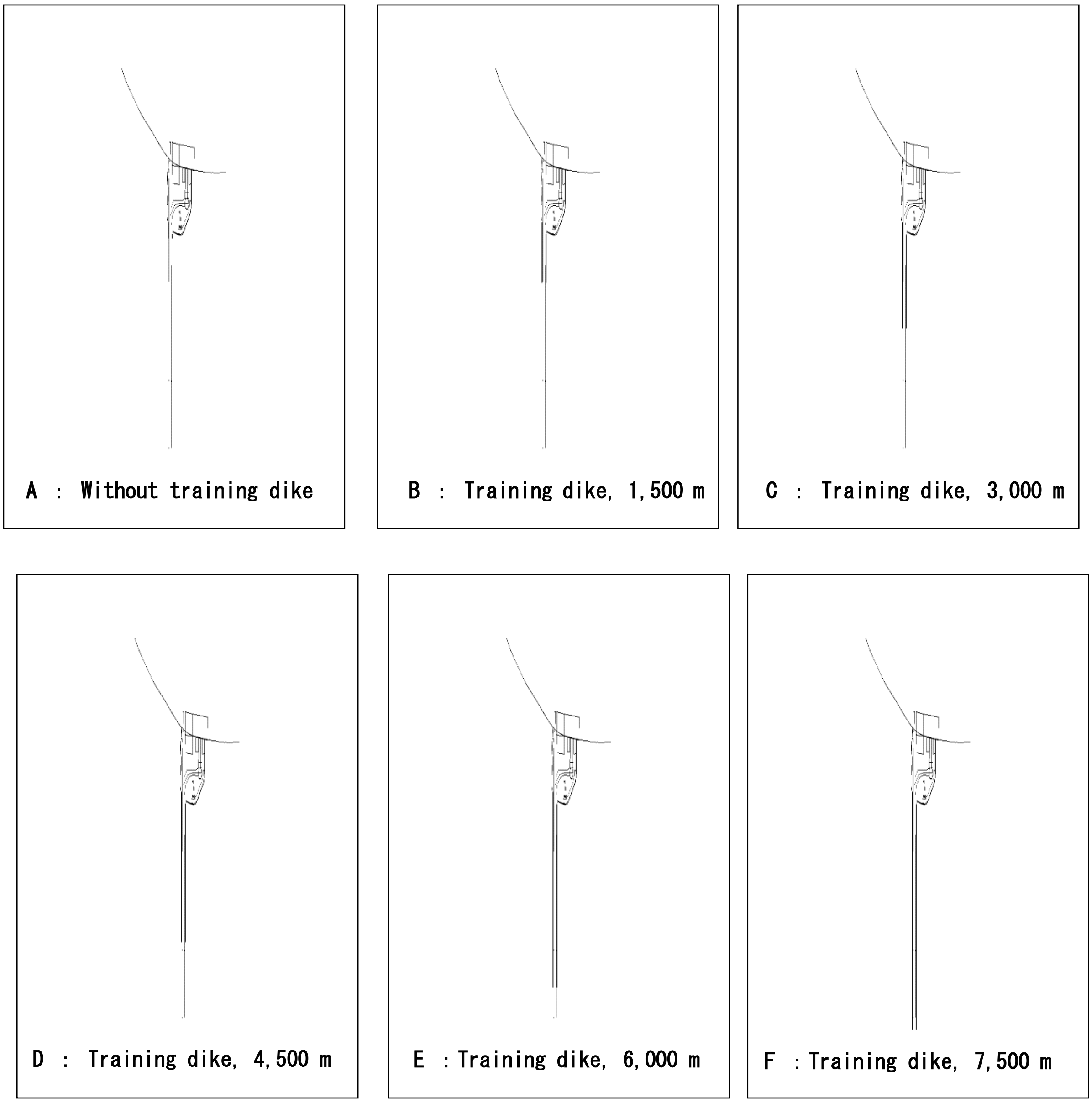


Source: JICA Study Team

Figure 4.1.2 Water Depth of Channel and Port Basin for the 3rd Phase

4.1.2. Port Layout

Figure 4.1.3 shows the layout of the port facilities including the training dike as a countermeasure against channel and basin sedimentation. Five different lengths of training dike were considered.



Source: JICA Study Team

Figure 4.1.3 Layout of Port Facilities for the Simulation

4.1.3. Summary of Simulation Cases

Table 4.1.1 summarizes the cases of simulation. Two different water depths and six different lengths of training dike as countermeasures against sedimentation were considered. Accordingly, 12 different conditions were considered for the simulation of channel and basin sedimentation. Three different wave conditions which were discussed in the later section were considered, thus the simulation were done on the whole for 36 cases.

Table 4.1.1 Summary of Simulated Case (Water Depth and Training Dike Conditions)

		Length of Training Dike					
		A (Without)	B (1,500 m)	C (3,000 m)	D (4,500 m)	E (6,000 m)	F (7,500 m)
Water depth	1st Phase	1st Phase -A	1st Phase -B	1st Phase -C	1st Phase -D	1st Phase -E	1st Phase -F
	3rd Phase	3rd Phase-A	3rd Phase-B	3rd Phase-C	3rd Phase-D	3rd Phase-E	3rd Phase-F

Source: JICA Study Team

Table 4.1.2 shows the collected data of water depth at the site for the simulation. Chart data were scanned and digitized. Several computational domains for the simulation were employed and a smaller grid interval was used for the smaller computational domain near the site.

Table 4.1.2 Collected Data of Water Depth for the Simulation

Area	Referred Material	Reference
Broad area	ETOPO1 (1'Mesh data)	http://www.ngdc.noaa.gov/mgg/global/global.html
Near the site	Chart data (HON KHOAI to MUI KE GA)	British Admiralty Nautical Chart 3986

Source: JICA Study Team

4.2. Wave Conditions

4.2.1. Determination of Representative Waves for the Simulation

(1) Employed Wave Data

Wave hindcasting data by the United Kingdom (UK) Met Office from 22 May 1999 to 31 December 2010 were used for the determination of representative wave conditions for the simulation. Table 4.2.1 shows the location and duration of obtained wave hindcasting data. Figure 4.2.3 shows the wave hindcasting location.

Table 4.2.1 Summary of the Location and Duration of Obtained Data

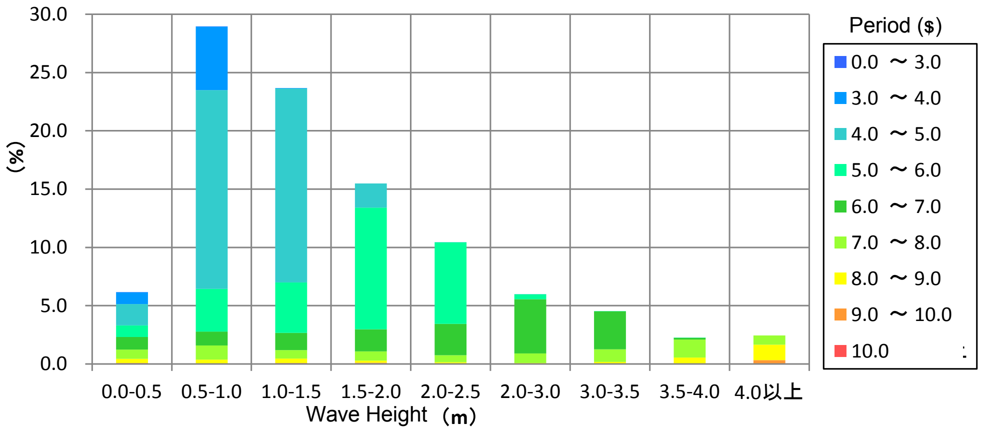
Model	Start	End	dt	Latitude	Longtude	Depth
2nd generation Hindcast	1999/05/28	2002/09/13	6 hr	8.05 N	107.91 E	78 m
2nd generation Hindcast	2002/09/01	2008/11/24	3 hr	8.05 N	107.91 E	78 m
3rd generation Hindcast	2008/11/24	2010/12/31	3 hr	8.05 N	107.91 E	68 m

Source: JICA Study Team

(2) Wave Statistics at the Wave Simulated Site

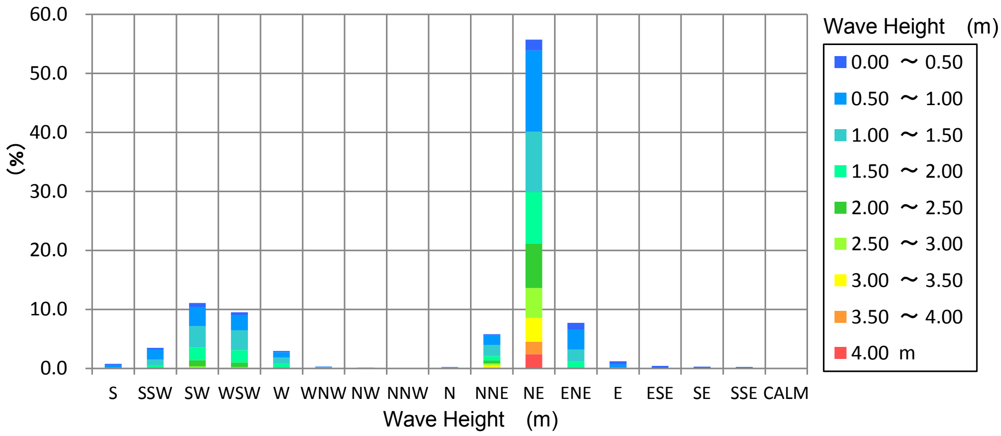
Wave statistics at the simulated location were obtained by using the wave data of every three hours from 2003 to 2008. Figure 4.2.1 shows the occurrence of wave height and wave frequency while

Figure 4.2.2 shows the occurrence of wave height and wave direction. Most frequent occurrence of wave direction is from the northeast (NE) and wave height of more than 3 m had occurred.



Source: JICA Study Team

Figure 4.2.1 Histogram of Wave Height and Period



Source: JICA Study Team

Figure 4.2.2 Histogram of Wave Height and Wave Direction

(3) Determination of Representative Wave

The following three scenarios for the determination of representative waves were considered:

- Ordinal wave conditions: Energy average wave of wave height under 3 m
- High wave conditions: Representative wave of wave height more than 3 m
- Extreme wave conditions: Extreme wave conditions expected occurrence is once in a decade

1) Ordinal Wave Conditions

Representative waves for ordinal wave conditions were obtained by energy average waves by using the every three hours wave data from 2003 to 2010 as shown below.

$$H_e = \sqrt{\frac{\overline{H^2 T}}{T_e}} \text{、} \quad T_e = \overline{T}$$

As a result, the average wave height H_e of 1.97 m and average wave period T_e of 5.36 sec were obtained. The most frequent wave direction of NE is used for representative wave direction.

2) High Wave Conditions

Table 4.2.2 shows the annual maximum wave height for ten years from 2001 to 2010. Lowest annual maximum wave height for ten years of 3.90 m with wave period of 7.2 sec and wave direction of NE is used as the representative of high wave condition.

3) Extreme Wave Conditions

Maximum annual maximum wave height for ten years of 5.91 m with wave period of 9.0 sec and wave direction of NE is used as the representative wave condition.

Table 4.2.2 Annual Maximum Wave Height for Ten Years(8.05 N, 107.91 E)

Year	Date	Time	Hs	Tm	Dir	Remarks
2001	02/10	18:00	5.40	8.40	NE	
2002	01/22	12:00	3.90	7.20	NE	Minimum
2003	12/20	00:00	5.19	8.25	NE	
2004	12/31	21:00	5.09	8.25	NE	
2005	12/22	09:00	5.91	9.00	NE	Maximum
2006	12/21	12:00	5.47	8.50	NE	
2007	01/28	15:00	4.69	8.00	NE	
2008	01/01	09:00	5.09	8.25	NE	
2009	01/10	12:00	5.41	9.55	NE	
2010	12/17	15:00	5.02	9.16	NE	

Source: JICA Study Team

4.2.2. Wave Deformation Analysis

Wave deformation analyses by SWAN* were done for each representative wave condition.
*http://www.swan.tudelft.nl/

(1) Representative Waves

Table 4.2.3 shows the summary of representative wave conditions.

Table 4.2.3 Representative Wave Conditions

	Hs	Tm	Dir	Smax	Remarks
Ordinal wave	1.97 m	5.36 sec	NE	10	Energy average wave

High wave	3.90 m	7.20 sec	NE	10	Occurrence of this wave is more than once a year
Extreme wave	5.91 m	9.00 sec	NE	10	Occurrence of this wave is more than once a decade

Source: JICA Study Team

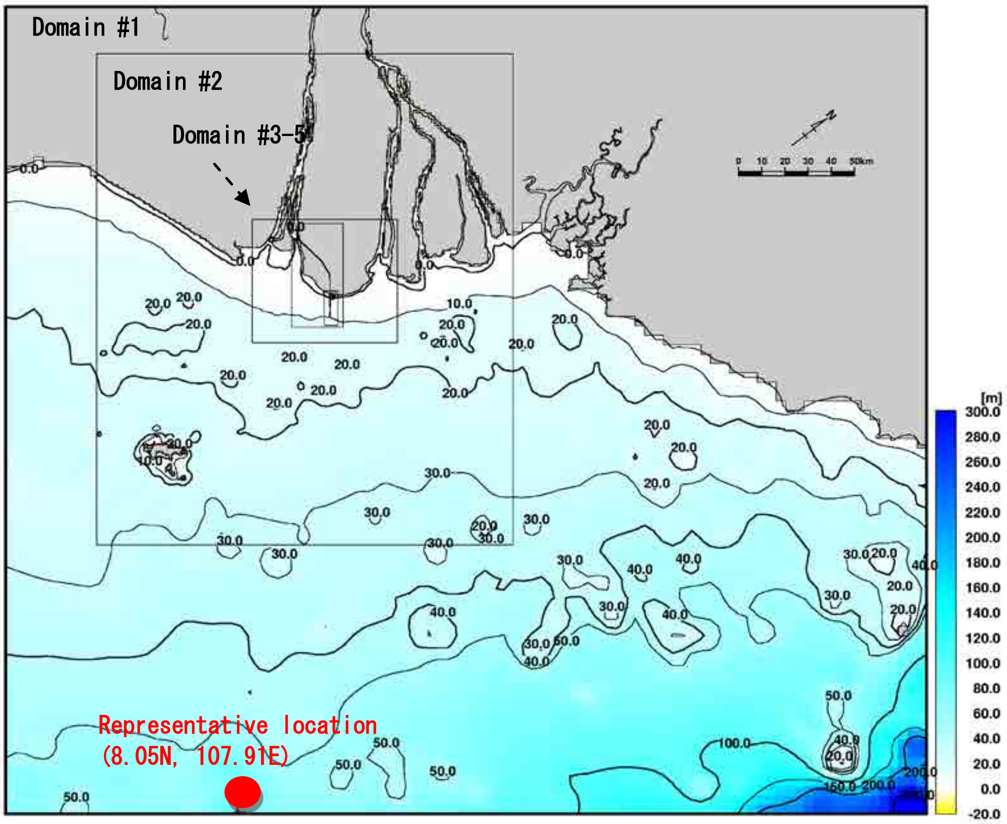
(2) Simulated area for wave deformation analysis

Five different areas of computational domains were considered as presented in Table 4.2.4. The table shows the simulated area and numerical simulation interval for each calculated condition while Figure 4.2.3 shows the simulated area.

Table 4.2.4 Simulated Area and Computational Grid for Wave Deformation Analysis

	Number of Computational Grid	Computational Grid Interval	Simulated Area
Domain #1	100 mesh× 88 mesh	4,050 m	405.00 km×356.50 km
Domain #2	136 mesh×160 mesh	1,350 m	183.60 km×216.00 km
Domain #3	142 mesh×121 mesh	450 m	63.90 km× 54.45 km
Domain #4	151 mesh×301 mesh	150 m	22.65 km× 45.15 km
Domain #5	121 mesh×301 mesh	50 m	6.05 km× 15.05 km

Source: JICA Study Team



Source: JICA Study Team

Figure 4.2.3 Simulated Area and Water Depth for Wave Deformation Analysis (Reference :CDL)

(3) Major Conditions for Computation

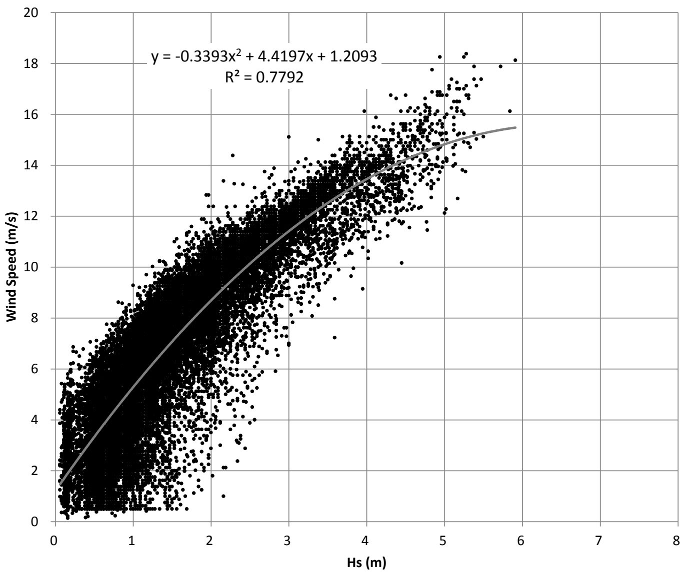
Table 4.2.5 shows the major computational conditions. The incident wave conditions at the boundary were obtained by checking the calculated wave conditions at the reference points for representative wave conditions that will coincide with the considered representative wave condition.

Wind effects in the computational domain were also considered by taking into consideration the obtained field observation results of waves height at the site. The relation between the wind and wave hindcasting data were summarized in Figure 4.2.4 and wind velocity at each representative wave height was determined by the regression expression and constant wind velocity in the computational domain was assumed.

Table 4.2.5 Major Computational Conditions for Wave Deformation Analysis

Items	Description	Remarks
Water depth data	Broad area：ETOPO1 data Narrow area：chart data (HON KHOAI to MUI KE GA)	Representative value for each one arc-minute mesh data was used. ETOPO1 data was provided by NOAA (http://www.ngdc.noaa.gov/mgg/global/global.html)
Tide data	M.S.L.=D.L.+3.13 m	Meal Sea Level
Training dike	Linier boundary	Impermeable dike conditions were assumed.
Wind velocity	Regression expression shown in Figure 4.2.4 was used	Wave generation in the computational domain was considered.

Source: JICA Study Team

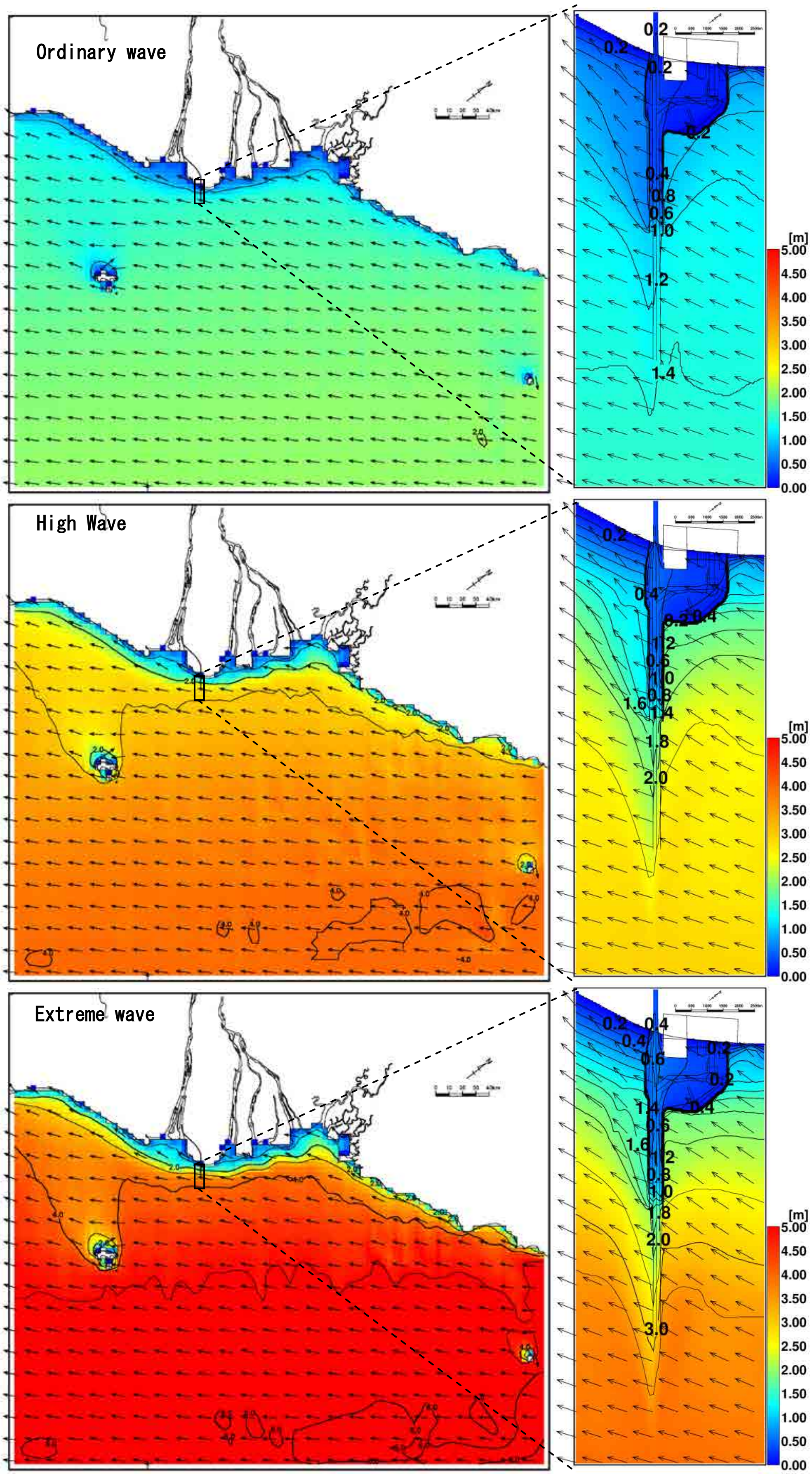


Source: JICA Study Team

Figure 4.2.4 Relation between Wave Height and Wind Velocity at the Hindcasting Location

(4) Results of Wave Deformation Analysis

Figure 4.2.5 shows the example of simulated wave field of 3rd -C for ordinal wave, high wave, and extreme wave conditions by SWAN.



Source: JICA Study Team

Figure 4.2.5 Example of Simulated Wave Height and Direction for 3rd Phase-C

4.3. Current Field by Numerical Analysis

4.3.1. Computational Method

The Finite Difference Method is employed for the calculation of current field, which is expressed by the combination of continuity equation and momentum equation. Basic equations are shown below.

＜Continuity Equation＞

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0 \tag{1}$$

＜Momentum Equations＞

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}-fv=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\frac{\partial}{\partial z}\left(K_M\frac{\partial u}{\partial z}\right)+\frac{\partial}{\partial x}\left[A_M\frac{\partial u}{\partial x}\right]+\frac{\partial}{\partial y}\left[A_M\frac{\partial u}{\partial y}\right] \tag{2}$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}+fu=-\frac{1}{\rho}\frac{\partial p}{\partial y}+\frac{\partial}{\partial z}\left(K_M\frac{\partial v}{\partial z}\right)+\frac{\partial}{\partial y}\left[A_M\frac{\partial v}{\partial y}\right]+\frac{\partial}{\partial x}\left[A_M\frac{\partial v}{\partial x}\right] \tag{3}$$

$$\rho g=-\frac{\partial p}{\partial z} \tag{4}$$

Where,

x, y, z :right hand cartesian coordinate system, plus for upward diretion
u, v, w :flow velocities for *x, y, z* direction
p : pressure
f : Coriolis parameter
ρ : density of seawater
K_M : vertical eddy viscosity
A_M : horizontal eddy viscosity
g : acceleration of grabity
t : time

Boundary conditions at these surfaces are shown below.

$$w=\frac{\partial \eta}{\partial t}+u\frac{\partial \eta}{\partial x}+v\frac{\partial \eta}{\partial y} \tag{5}$$

$$\rho K_M\left(\frac{\partial u}{\partial z},\frac{\partial v}{\partial z}\right)=(\tau_{sx},\tau_{sy}) \tag{6}$$

$$\vec{\tau}_s = (\tau_{sx}, \tau_{sy}) = \rho_a C_a \vec{\mathbf{W}} \left| \vec{\mathbf{W}} \right|$$
$$\vec{\mathbf{W}} = (W_x, W_y), \left| \vec{\mathbf{W}} \right| = \sqrt{W_x^2 + W_y^2} \qquad (7)$$

Where,

η	: elevation of sea surface
C_a	: friction coefficient
ρ_a	: density of atmosphere
W_x, W_y	: flow velocities of *x, y* direction

Boundary conditions at the sea bottom are defined by the following equations:

$$w_b = -u_b \frac{\partial h}{\partial x} - v_b \frac{\partial h}{\partial y} \qquad (8)$$

$$\rho K_M \left(\frac{\partial u}{\partial z}, \frac{\partial v}{\partial z} \right) = (\tau_{bx}, \tau_{by}) \qquad (9)$$

$$\vec{\tau}_b = (\tau_{bx}, \tau_{by}) = \rho C_D \left| \vec{\mathbf{V}}_\mathbf{b} \right| \vec{\mathbf{V}} \qquad (10)$$

$$\vec{\mathbf{V}}_\mathbf{b} = (u_b, v_b), \left| \vec{\mathbf{V}}_\mathbf{b} \right| = \sqrt{u_b^2 + v_b^2} \qquad (11)$$

$$C_D = \left[\frac{1}{\kappa} \ln \frac{h + z_b}{z_0} \right]^{-2} \qquad (12)$$

Where,

u_b, v_b	: flow velocities for *x, y* direction at the sea bottom
h	: water depth
z_b	: vertical coordinates at the bottom where bottom flow velocities are defined (0 at the sea surface)
z_0	: roughness height (=1.0cm)
κ	: Karman constant (=0.4)

4.3.2. Conditions for Simulation

(1) Computational Area

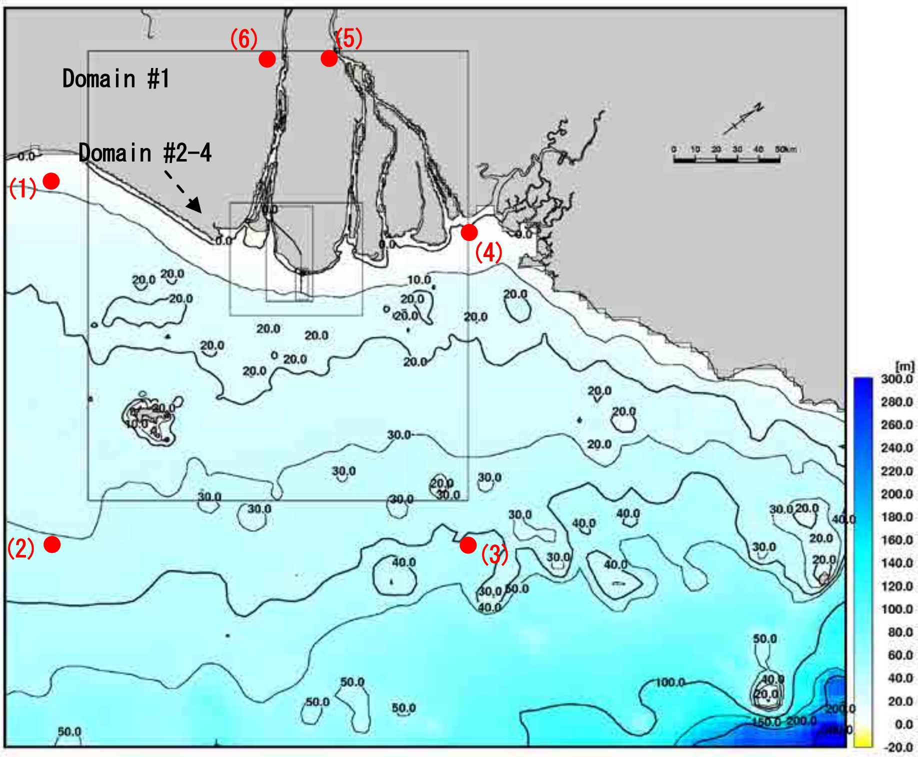
Table 4.3.1 and Figure 4.3.1 show the four computational domains that coincide with domains #2 to #5 of wave deformation analysis.

Table 4.3.1 Simulated Area and Computational Grid for Current Analysis

	Number of Computational Grid	Computational Grid Interval	Simulated Area

Domain #1	136 mesh×160 mesh	1,350 m	183.60 km×216.00 km
Domain #2	142 mesh×121 mesh	450 m	63.90 km× 54.45 km
Domain #3	151 mesh×301 mesh	150 m	22.65 km× 45.15 km
Domain #4	121 mesh×301 mesh	50 m	6.05 km× 15.05 km

Source: JICA Study Team



Source: JICA Study Team

Figure 4.3.1 Simulated Area and Water Depth for Current Analysis (Reference Level: CDL)

(2) Tidal Conditions

Boundary conditions at locations (1) to (4) in Figure 4.3.1 are given, and interpolated values at boundaries of (1) to (2), (2) to (3), and (3) to (4) were used for the simulation. For obtaining the tide level, average spring tide condition was considered and K1 component (lumi-solar diurnal tide) with a period of 24 hours and M2 component (principal lunar semi-diurnal tide) were assumed.

Tidal model with spatial resolution of 0.5 degree by Masumoto, *et al.* (2000) was basically used to obtain the tidal parameter. The latest amplitude data was used to determine the amplitude at each boundary location. Phase difference between each boundary location by latest data was calculated and adjusted at each location. Table 4.3.2 shows the boundary conditions for tidal simulation.

Table 4.3.2 Boundary Conditions for Tide Simulation

Boundary Location	K1 Component (Period by 24 hours)	M2 Component (Period by 12 hours)

	Amplitude	Phase Difference	Amplitude	Phase Difference
(1)	62.2 cm	228.49 deg	86.3 cm	233.91 deg
(2)	54.9 cm	218.20 deg	54.4 cm	220.30 deg
(3)	50.5 cm	201.71 deg	48.2 cm	194.41 deg
(4)	57.0 cm	202.55 deg	74.8 cm	202.35 deg

Source: JICA Study Team

(3) River Discharge

Average river discharges of the Mekong and Hau rivers by Global Runoff Data Center (http://www.bafg.de/GRDC/EN/Home/homepage_node.html) were used to determine the boundary conditions at the mouth of the river. Table 4.3.3 shows the river discharge conditions at locations of (5) and (6) in Figure 4.3.1.

Table 4.3.3 Boundary Conditions for River Discharge

Boundary Location	River	Location	River Discharge
(5)	Mekong	My Thuan	8,433 m^3/sec
(6)	Bassac	Chau Doc	2,766 m^3/sec

Source: JICA Study Team

(4) Major Conditions for Simulation

Table 4.3.4 shows the major conditions for simulation of tidal current flow. Eight divisions of vertical layers were considered by referring to the maximum water depth at the channel and port basin.

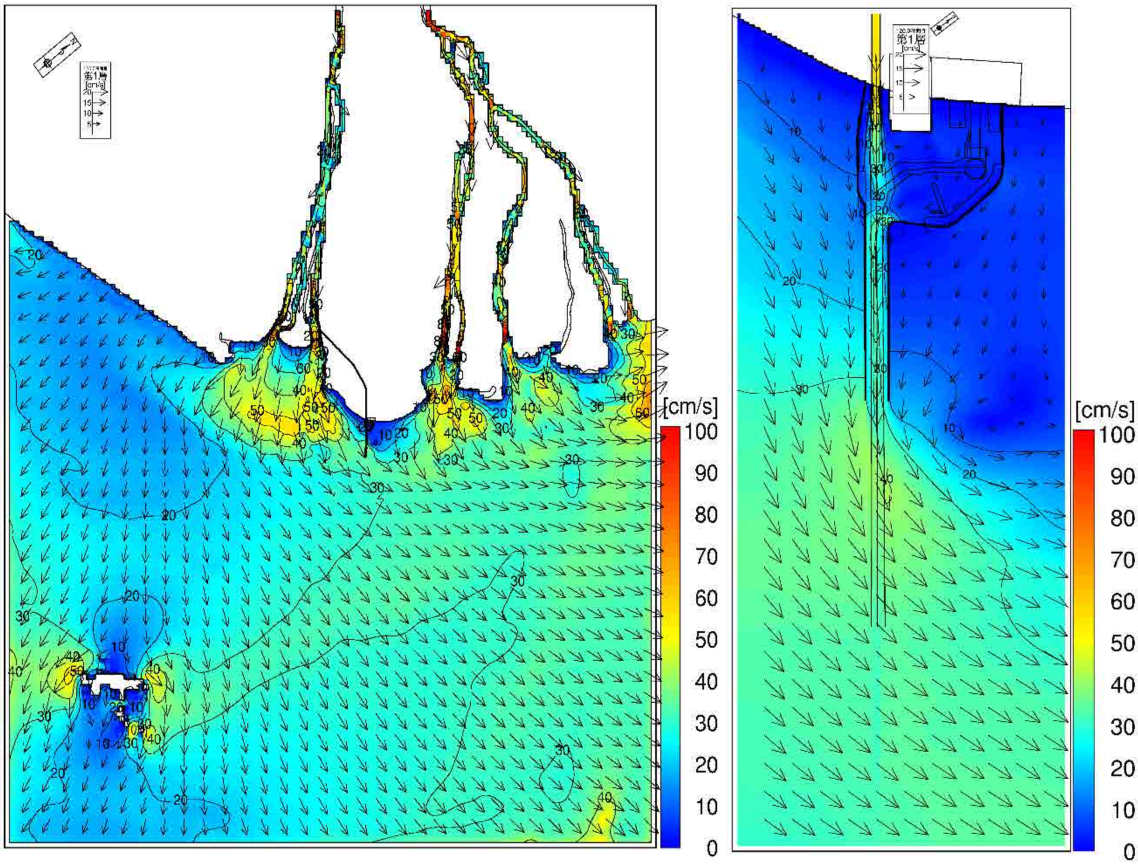
Table 4.3.4 Major Conditions for Simulation of Tidal Current

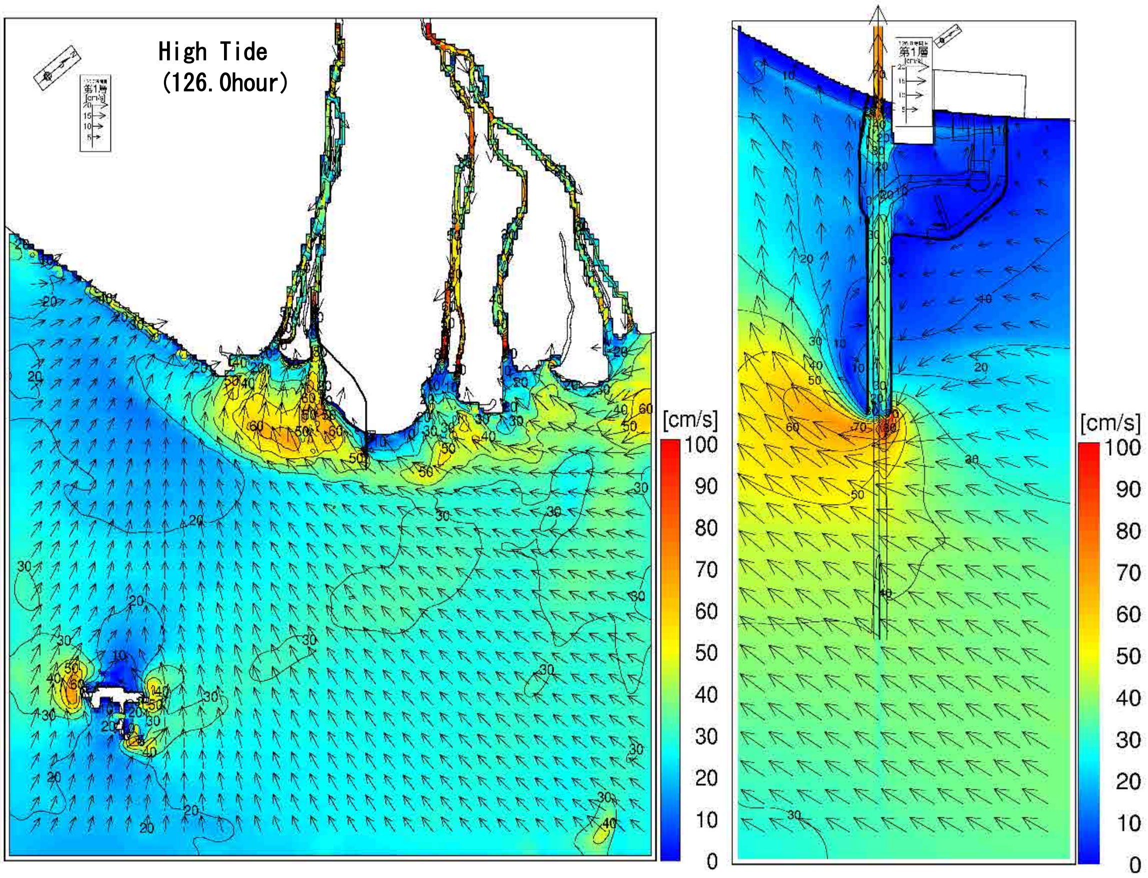
Item	Description	Remarks
Time increment	Domain #1 : 24.0 sec Domain #2 : 12.0 sec Domain #3 : 6.0 sec Domain #4 : 2.0 sec	
Depth of each layer	0.0 m, 3.0 m, 6.0 m, 9.0 m 12.0 m,15.0 m,18.0 m	8 layers from bottom to surface Reference level by CDL
Simulated duration	240 hours	10 days
Roughness coefficient	0.0026	Manning's roughness coefficient
Training dike	Linear element	Impermeable structure

Source: JICA Study Team

4.3.3. Simulated Results

Figure 4.3.2 shows an example of a tidal current at the web tide (120 hours) and flood tide (126 hours) for 3rd Phase-C.





Source: JICA Study Team

Figure 4.3.2 Example of Tidal Current Velocity and Direction of Uppermost Layer for 3rd Phase-C

4.4. Prediction of Channel and Harbor Depositions

4.4.1. Numerical Model

(1) Basic Equations

Following advection-diffusion equations considering the suspension and settlement process of sea bottom materials by conservative system were used for the numerical simulation of channel and harbor deposition.

$$\frac{\partial S}{\partial t}+u\frac{\partial S}{\partial x}+v\frac{\partial S}{\partial y}+\left(w-W_S\right)\frac{\partial S}{\partial z}=\frac{\partial}{\partial x}\left(K_x\frac{\partial S}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_y\frac{\partial S}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_z\frac{\partial S}{\partial z}\right)+q \qquad (13)$$

Where,

S	:	Concentration of SS (mg/L)
x,y,z	:	right hand cartesian coordinate system, plus for upward direction
u,v,w	:	flow velocities of *x,y,z* direction (cm/s)
t	:	time (s)
Kx,Ky	:	horizontal eddy viscosity (cm^2/s)
Kz	:	vertical eddy viscosity (cm^2/s)

q : amount of loading (mg/L/s)

W_s : settlement velocity (cm/s)

(2) Suspension and Settlement

The amounts of suspension E and settlement D were obtained by using the following equations:

$$\begin{cases} E = P_m M \left(\dfrac{\tau_b}{\tau_{ec}} - 1 \right)^n, \tau_b \geq \tau_{ec} \\ E = 0, \tau_b < \tau_{ec} \end{cases} \quad (14)$$

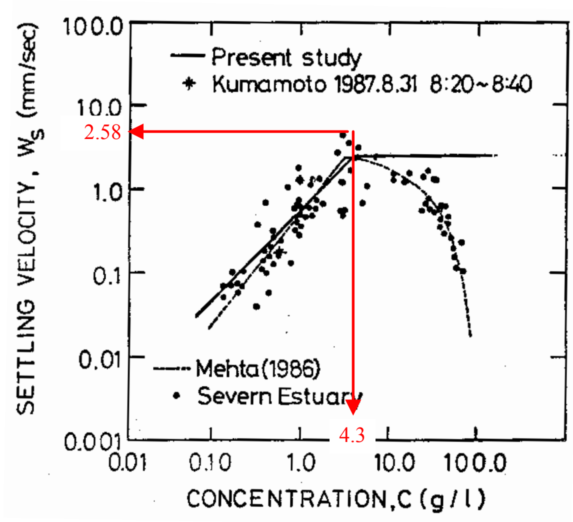
$$\begin{cases} D = W_s (1 - \tau_b / \tau_{dc}) C_{bed}, \tau_b \leq \tau_{dc} \\ D = 0, \tau_b > \tau_{dc} \end{cases} \quad (15)$$

Where, P_m is ratio of the contents of silty material in the sea bottom materials (mud contents), M and n are coefficients of suspension, τ_b is shear stress at the sea bottom, τ_{ec} is the critical shear stress for suspension, τ_{dc} is the critical shear stress for settlement W_s is the velocity of settlement, C_{bed} concentration of SS at the bottom layer.

(3) Settling Velocity

Following the consideration by Tsuruya, *et al.*(Refer to Figure 4.4.1), concentration of suspended sediment were used to evaluate the effect of flocculation of smaller particles on settling velocity of suspended material by employing the following equations as a function of concentration C. Stokes equation for single particle was used for the evaluation of lowest settling velocity.

$$\begin{aligned} & w_S = A_1 C^{B_1} \ldots (C < C_H) \\ & w_S = const. \quad \ldots (C \geq C_H) \\ & A_1 = 0.6 \times 10^{-3} m^4 / kg / s \\ & B_1 = 1 \\ & C_H = 4.3 kg / m^3 \end{aligned} \quad (16)$$



Source : Added to the Figure by Tsuruya *et al.* (1989)

Figure 4.4.1 Relation between SS Concentration and Settling Velocity

(4) Evaluation of Thickness of Deposition and Erosion

In the numerical simulation, deposition and erosion were evaluated by the material weight. Necessary information were obtained to evaluate the thickness of deposition and erosion. Deposited and eroded material weights G were converted to thickness D of deposition and erosion by the using the following equations:

Deposited and eroded material dry weight $G\left[\frac{kg}{m^2}\right]$

Dry density of the material $\rho\left[\frac{kg}{m^3}\right]=\frac{\rho_s V_s}{V_w+V_s}$

Thickness of deposition and erosion $D=G/\rho\left[\frac{kg}{m^2}\right]\left[\frac{m^3}{kg}\right]=[m]$

Where, ρ_w : density of seawater ρ_s : density of the sediment particle, V_w : volume of seawater in the unit volume, V_s : volume of sediment material in the unit volume.

Water contents $W=\frac{W_w}{W_s}=\frac{\rho_w V_w}{\rho_s V_s} \rightarrow \frac{V_w}{V_s}=W\frac{\rho_s}{\rho_w}$

Thus,

$$\frac{1}{\rho}=\frac{1}{\rho_s}+\frac{V_w}{\rho_s V_s}=\frac{1}{\rho_s}+\frac{W}{\rho_w}$$

$$D = G\left(\frac{1}{\rho_s} + \frac{W}{\rho_w}\right) \qquad (17)$$

4.4.2. Conditions for Computation

(1) Wave Conditions

The following three scenarios for the determination of representative waves were considered for the evaluation of sedimentation volume:

- Energy average wave of wave height under 3 m;
- High wave condition: representative wave of wave height more than 3 m; and
- Extreme wave condition: Extreme wave conditions expected occurrence of once in a decade.

Ordinal wave condition and high wave condition were used to evaluate the annual sedimentation volume while the extreme wave condition was used to confirm the sedimentation volume at a very extreme condition. Table 4.4.1 shows the representative wave conditions of abovementioned three different conditions. Sinusoidal functional time series of incident wave amplitude of 48 hours was considered. Maximum wave height will appear at the time of 60 hours from the beginning

Table 4.4.1 Representative Wave Conditions

	Significant Wave Height	Significant Wave Period	Wave Direction	Remarks
Ordinal wave	1.97 m	5.36 sec	NE	Energy average wave
High wave	3.90 m	7.20 sec	NE	Once a year occurrence
Extreme wave	5.91 m	9.00 sec	NE	Extreme wave every ten years occurrence

Source: JICA Study Team

In this analysis, numerical simulation for two days by two representative waves of ordinal wave case and high wave case were done to obtain the channel and basin deposition volume in two days. Annual deposition volume was obtained by multiplying the number of attacks of representative waves.

Ordinal wave condition represents the significant waves lower than 3.0 m and the number of attack by ordinal wave is 196.2 days according to the wave statistics at the offshore of the site. As sinusoidal functional time series of 48 hours was employed for the incident wave with peak value by representative wave height of 1.97 m, thus the incident ordinal wave of one day was considered for the simulation and accordingly the number of attack became 196.2 times.

High wave condition represents the significant waves higher than 3.0 m and the number of occurrence is 31.7 times by wave statistic at the offshore of the site. Incident high wave of one day was considered in this analysis and number of wave attack of this high wave condition became 31.7 times.

Table 4.4.2 Number of Wave Attack Considered for the Estimation of Annual Sedimentation Volume

	Number of Wave Attack in the Simulation	Annual Number of Wave Attack	Annual Nnumber of Wave Attack
Ordinal wave	1.0	196.2	196.2
High wave	1.0	31.7	31.7

Source: JICA Study Team

(2) Major Computational Conditions

Table 4.4.3 shows the major computational conditions.

Table 4.4.3 Major Computational Conditions

Item		Description	Remarks
Basic condition	Simulated area Numerical grid Time interval Division of vertical layer	Identical with current simulation	Basic condition
Integration period	Simulated period	120 hour	Integration period
	Incident wave duration	From 36 hour to 84 hour From 36 hour to 84 hour	
	Duration of deposition	36 hour to 120 hour	
SS	Initial SS concentration	200 mg/L	SS
	Concentration in river	200 mg/L	
Difusion factor	Horizontal value	5.0×10^4 cm^2/sec	Difusion factor
	Vertical value	5.0 cm^2/sec	
Bottom sediment	Mud content	50%	Bottom sediment
	Water content	150%	
	Diameter	0.01 mm	
Suspension and settling coefficient	Suspension coefficient	0.0002 kg/m^2/min	Suspension and settling coefficient
	Maximum shear stress against suspension	0.1 Pa	
	Minimum shear stress	0.3 Pa	

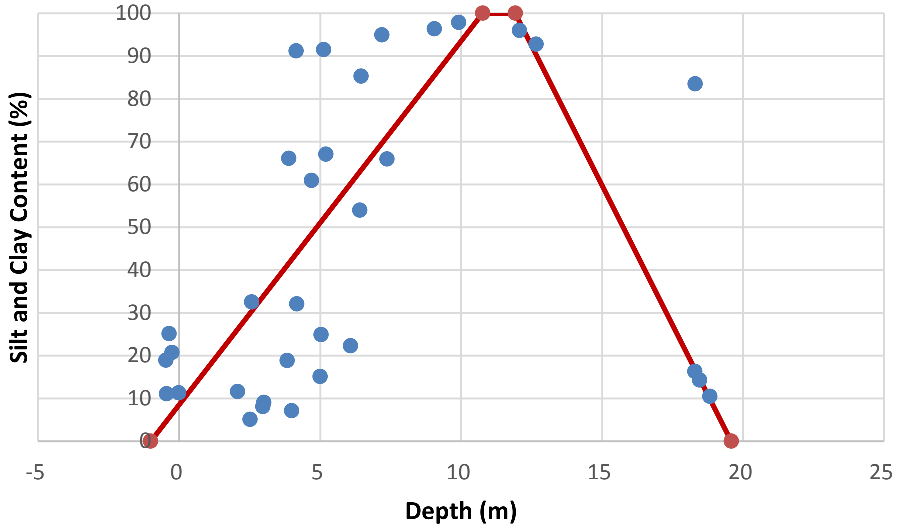
	against settling		

Source: JICA Study Team

4.5. Bottom Sediment Data

4.5.1. Mud Contents

Figure 4.5.1 shows the relationship between water depth and mud contents of bottom sediment sampling survey results. High mud contents can be seen at the water depth between 5 m and 10 m. In the simulation, approximate linear relationship between water depth and mud content shown in Figure 4.5.1 was used for the simulation (See equation (14)).

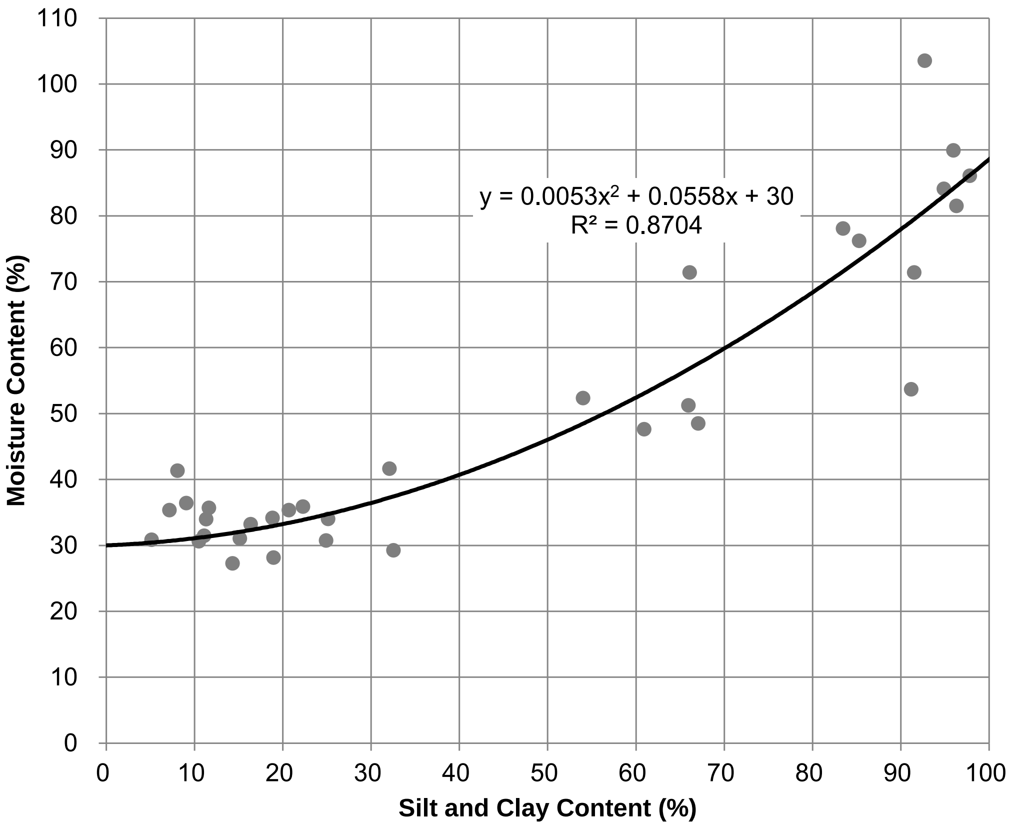


Source: JICA Study Team

Figure 4.5.1 Relationship between Water Depth and Mud Contents

4.5.2. Water Contents

Figure 4.5.2 shows the relationship between mud and water contents of the bottom sediment sampling data same as above. Water content of mud was assumed to be 88% for obtaining the estimation of the deposition layer thickness by using the equation (17).



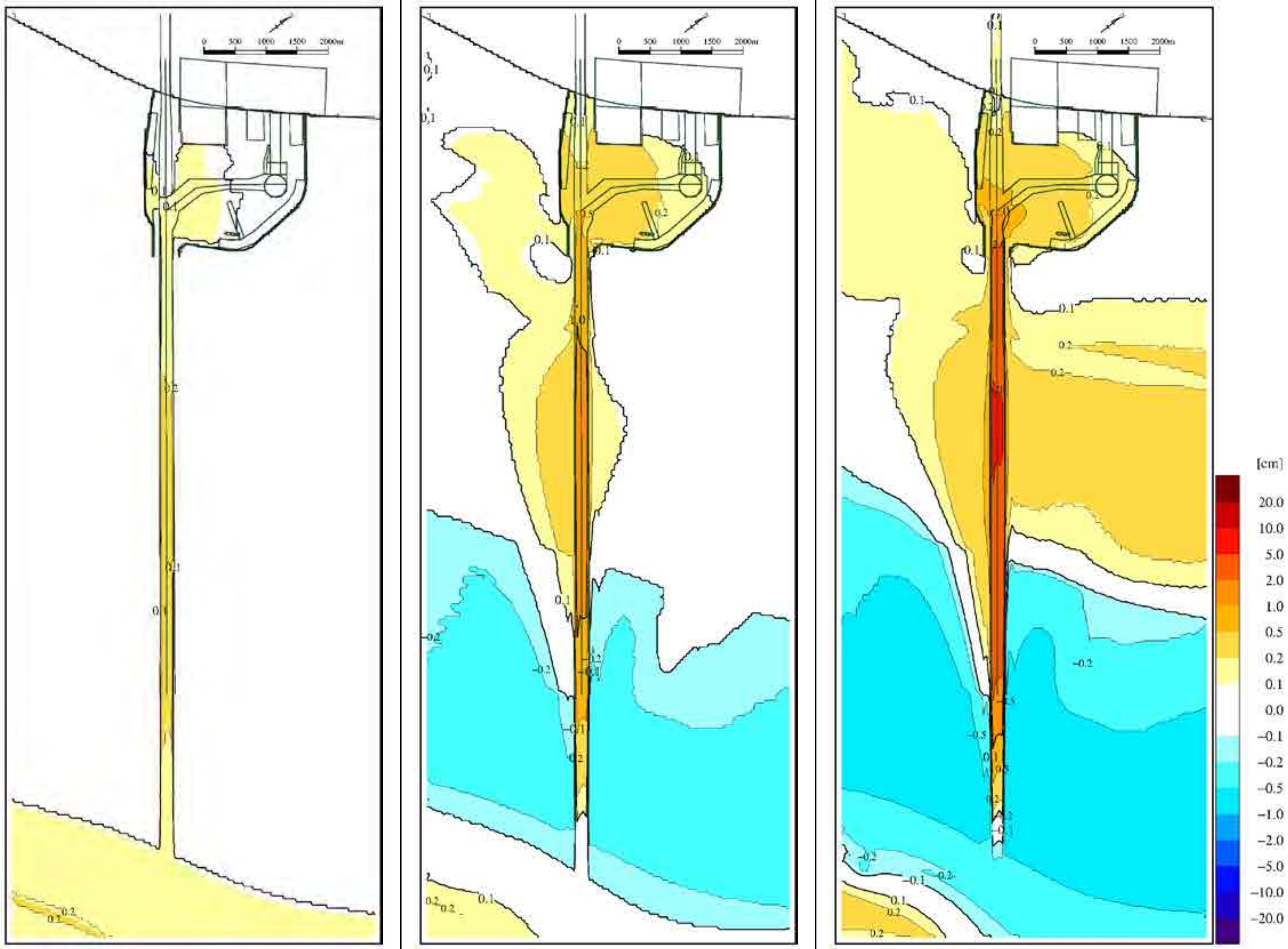
Source: JICA Study Team

Figure 4.5.2 Relationship between Mud Contents and Water Contents

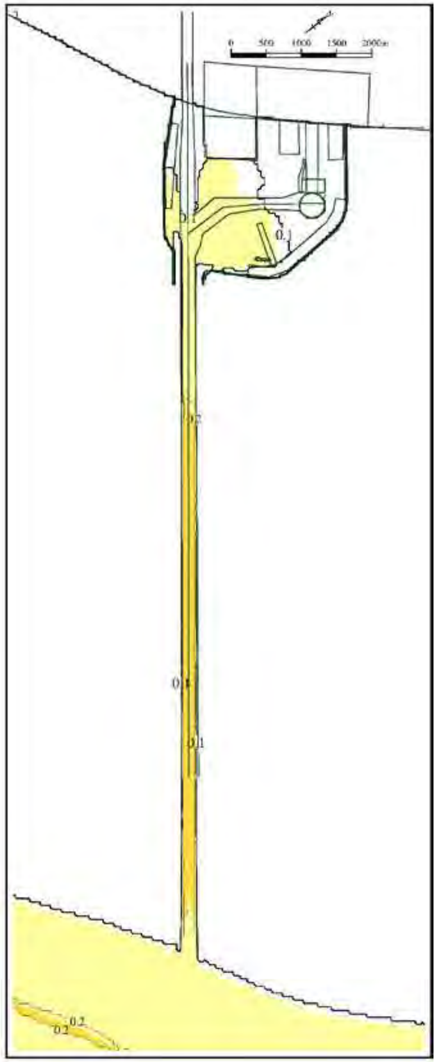
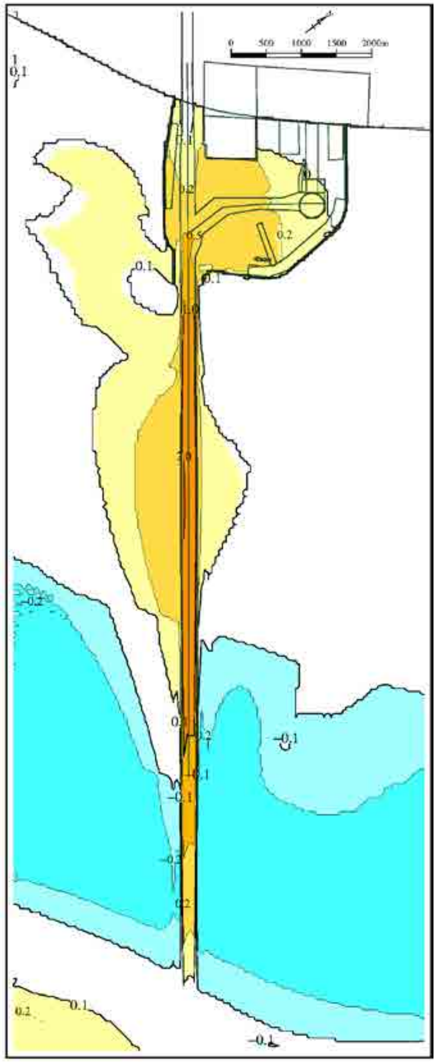
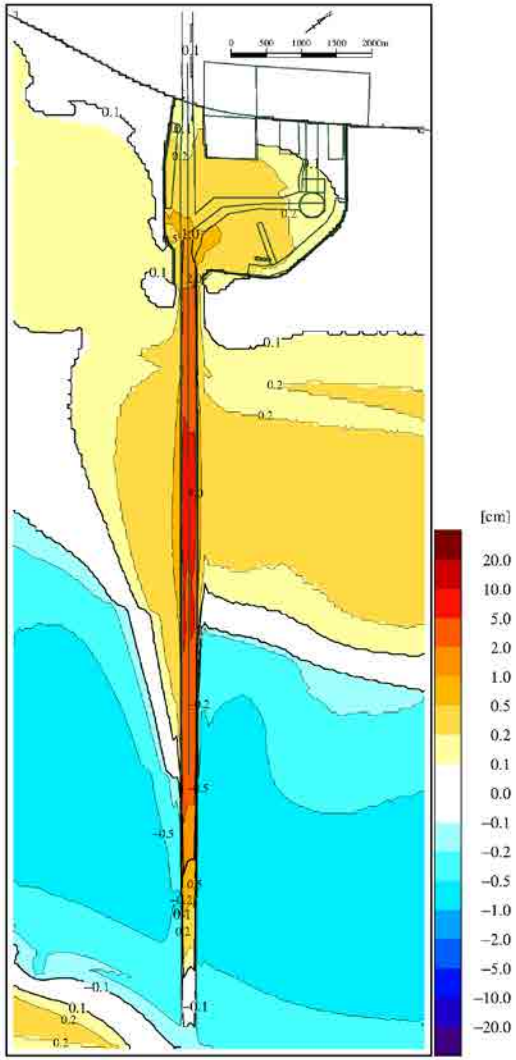
4.6. Results of Numerical Simulation of Channel and Harbor Sedimentation

Figures 4.6.1 to 4.6.6 show the calculated results of sedimentation per single wave attack for each representative wave condition (ordinal wave, high wave, and extreme wave conditions). In the basin area, sedimentation becomes less as the training dike becomes longer. Similar results were obtained for channel sedimentation as a whole, but on the contrary, maximum sedimentation thickness becomes bigger as the training dike becomes longer. Consideration of the results and the annual sedimentation volume were discussed in the next section.

Ordinal Wave (per day)	High Wave (per day)	Extreme Wave (per day)

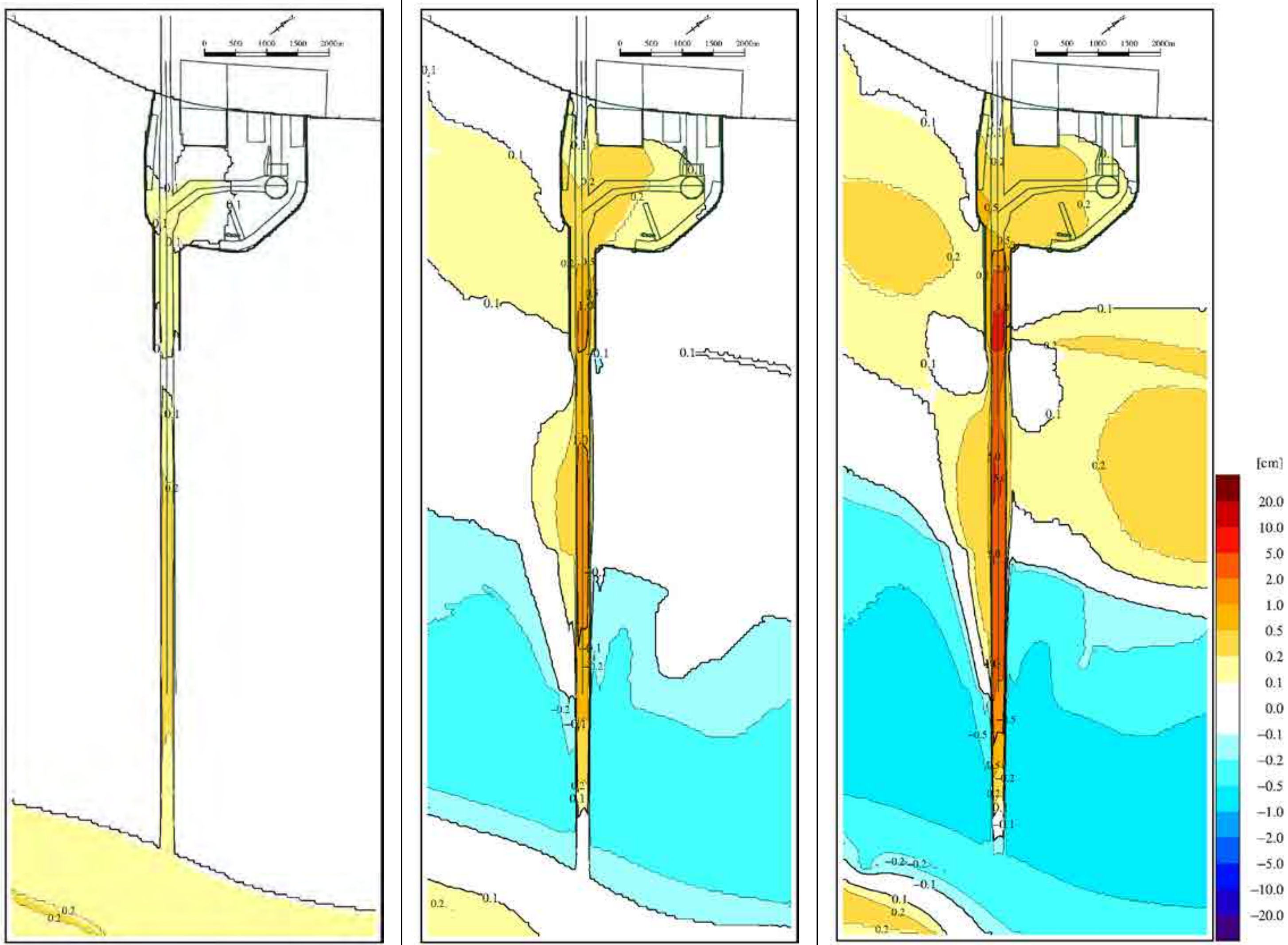


Source: JICA Study Team Figure 4.6.1 (1) Thickness of Sedimentation (1st Phase-A : Without Training Dike)

Ordinal Wave (per day)	High Wave (per day)	Extreme Wave (per day)
		

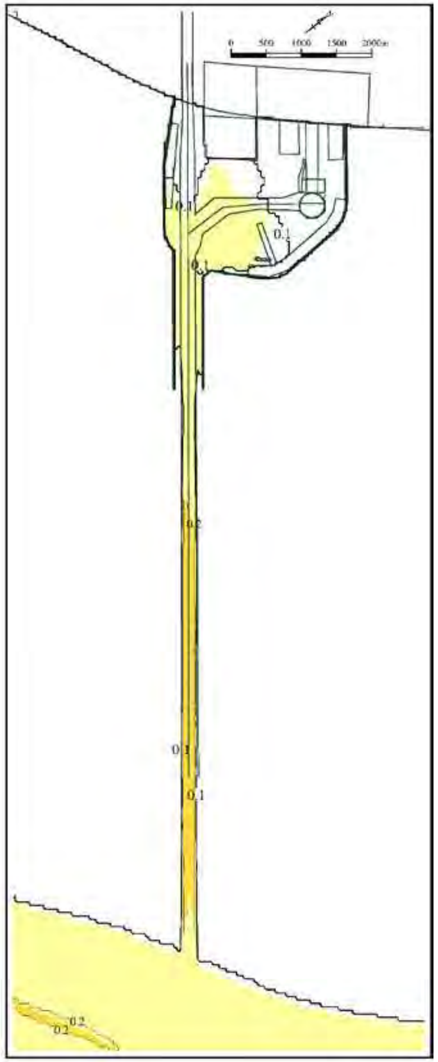
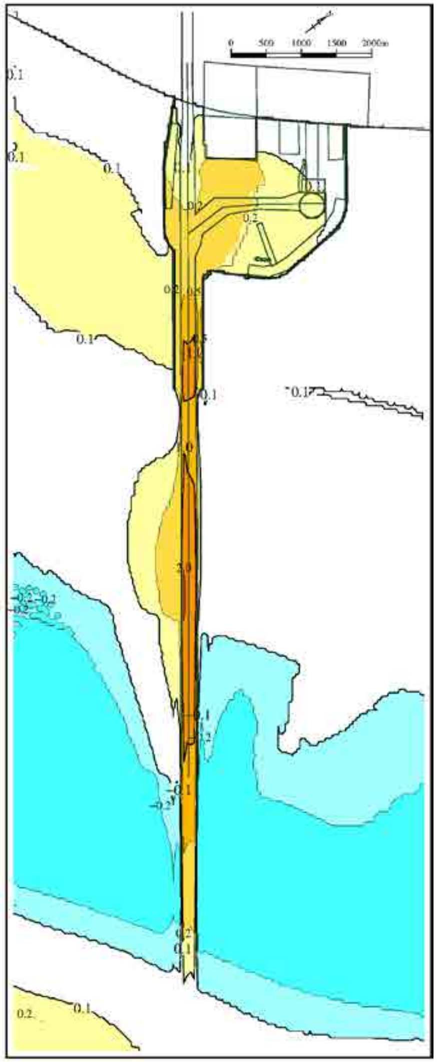
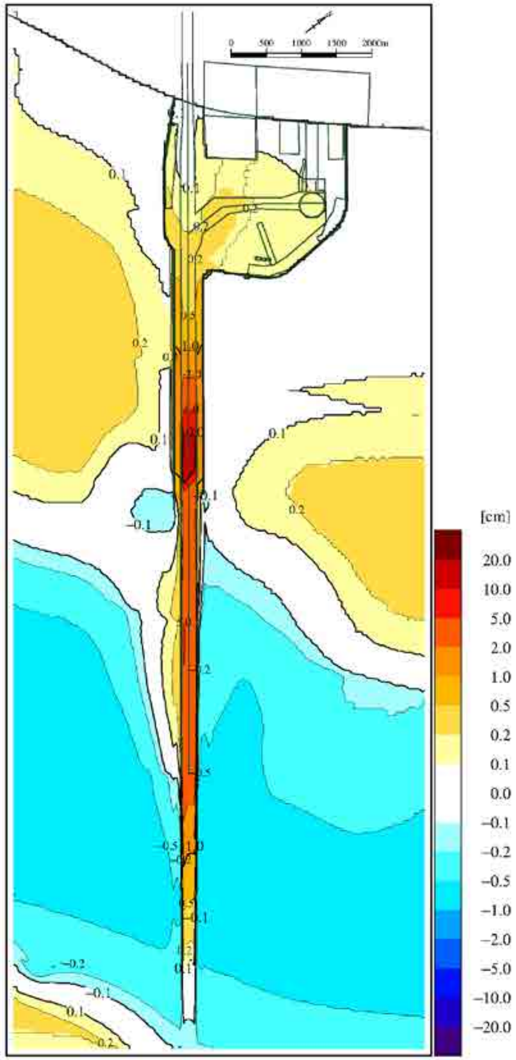
Source: JICA Study Team Figure 4.6.1(2) Thickness of Sedimentation (3rd Phase -A：Without Training Dike)

Ordinal Wave (per day)	High Wave (per day)	Extreme Wave (per day)



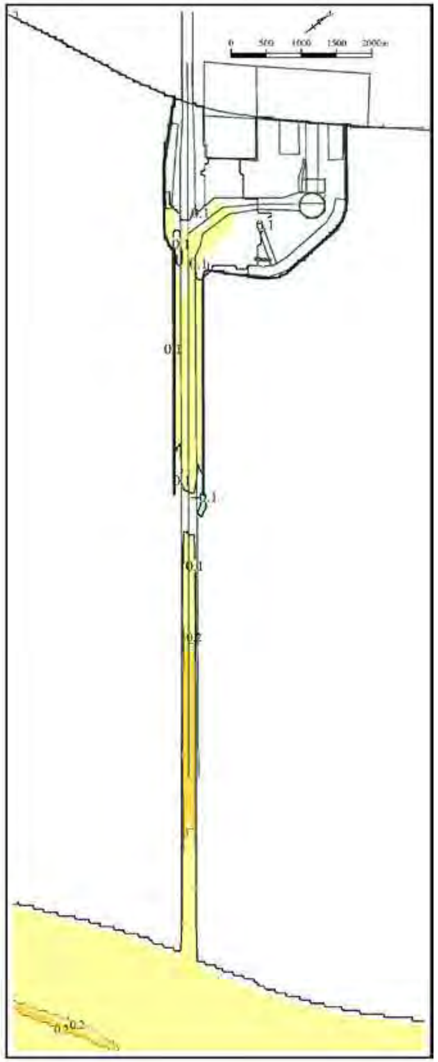
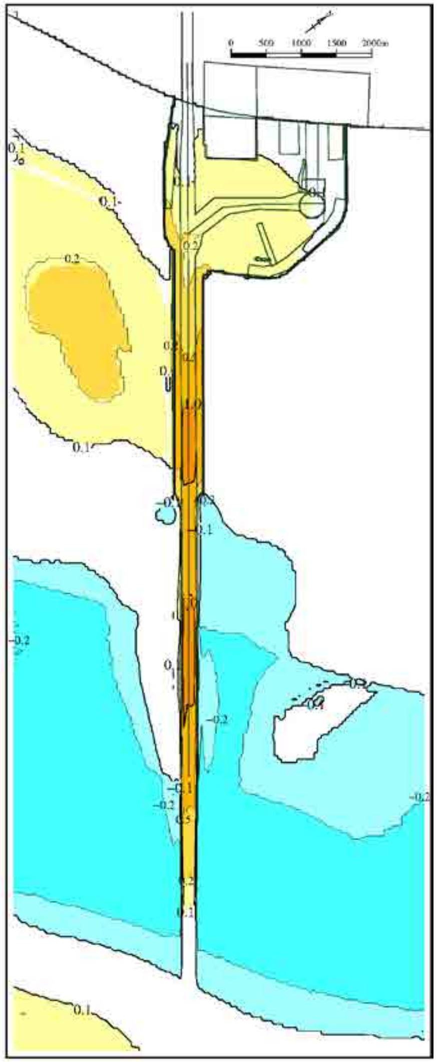
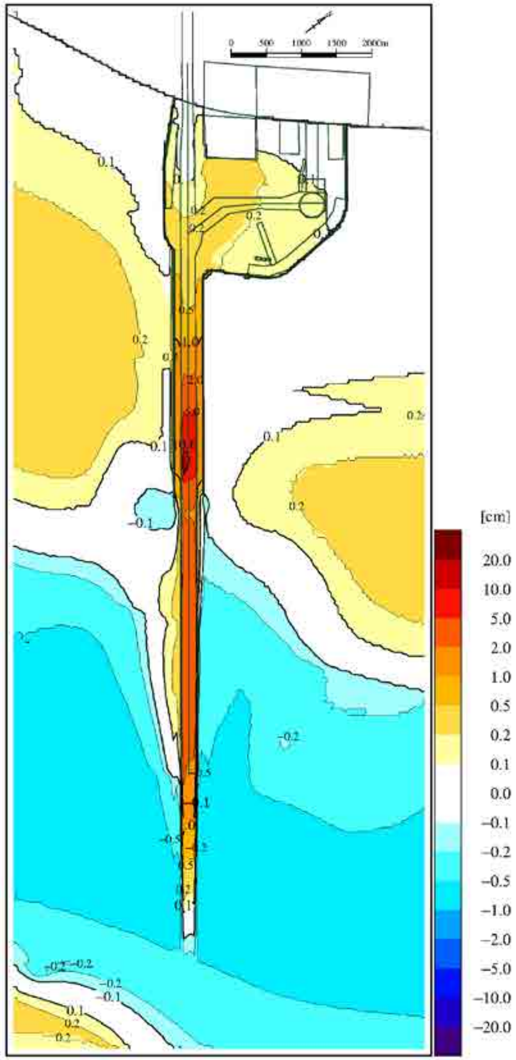
Source: JICA Study Team

Figure 4.6.2 (1) Thickness of Sedimentation (1st Phase -B：Training Dike 1,500 m)

Ordinal Wave (per day)	High Wave (per day)	Extreme Wave (per day)
		

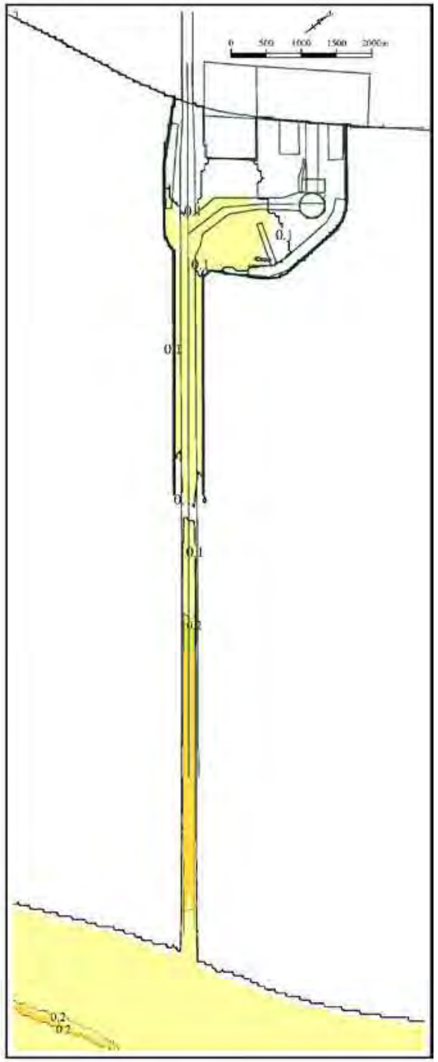
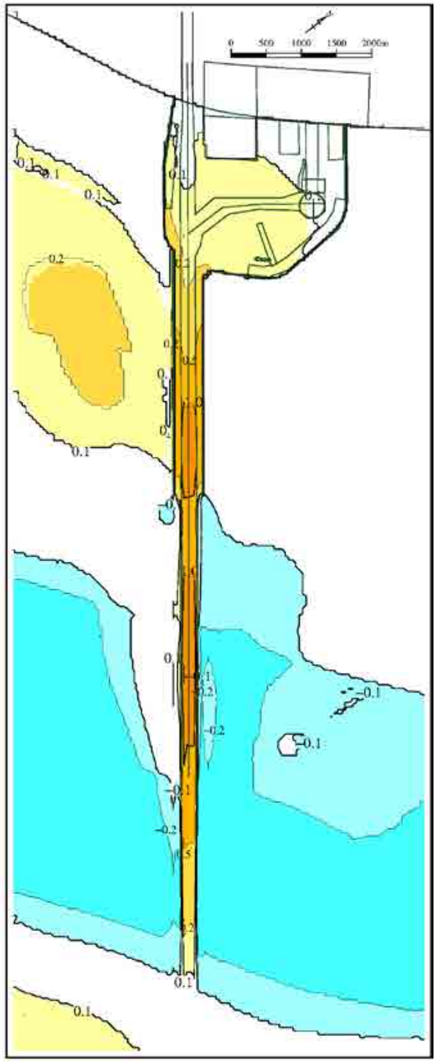
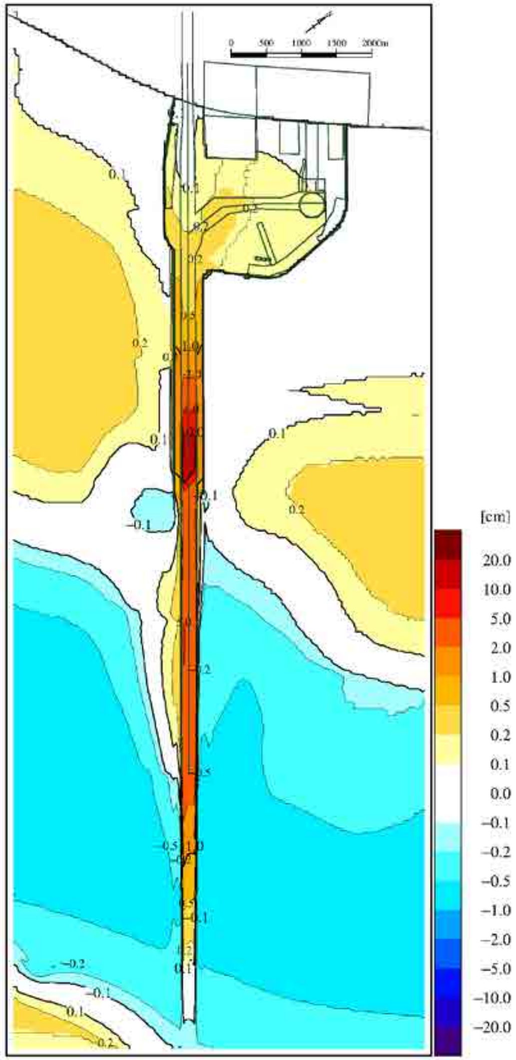
Source: JICA Study Team

Figure 4.6.2 (2) Thickness of Sedimentation (3rd Phase -B：Training Dike 1,500 m)

Ordinal Wave (per day)	High Wave (per day)	Extreme Wave (per day)
		

Source: JICA Study Team

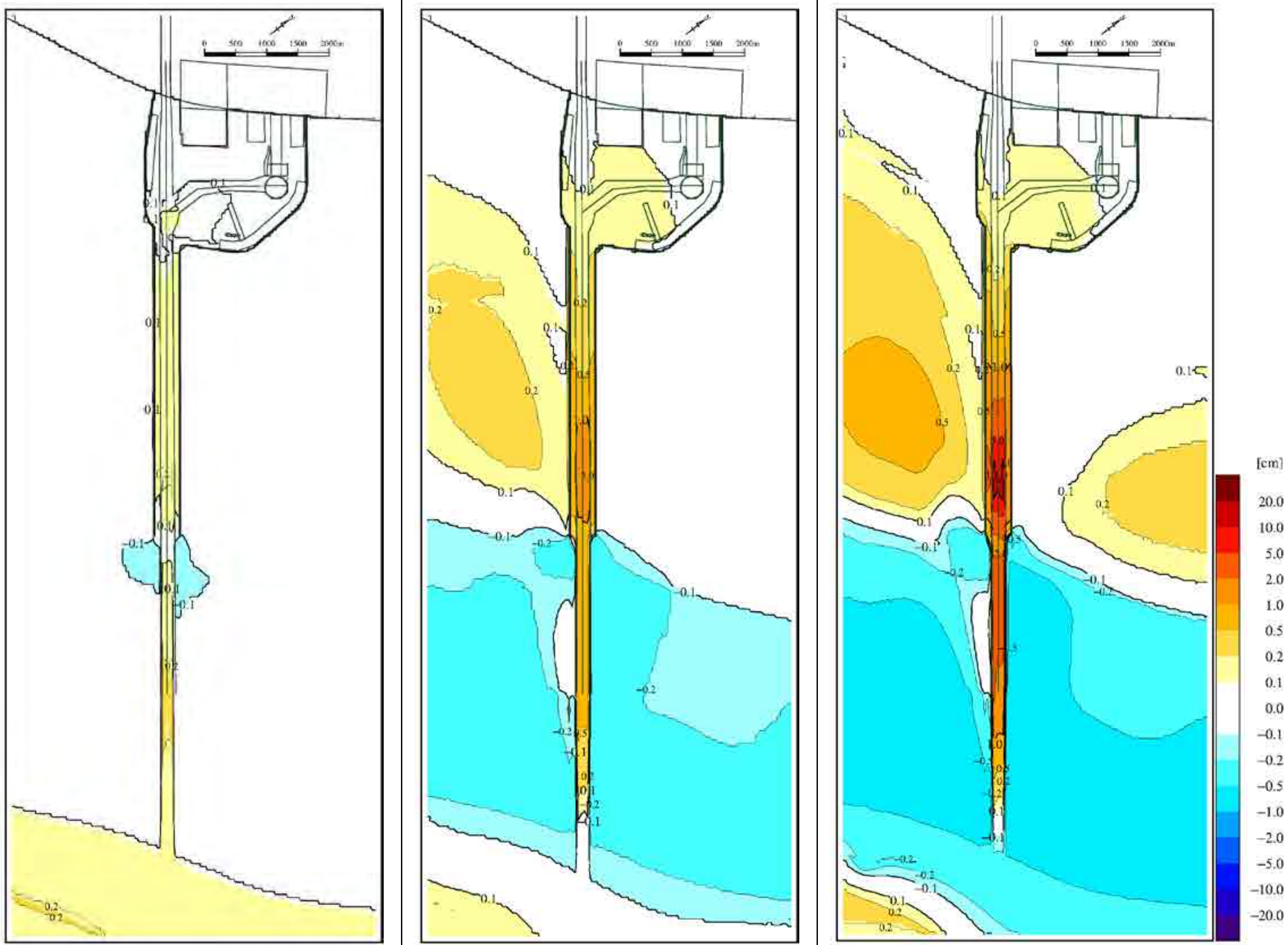
Figure 4.6.3 (1) Thickness of Sedimentation (1st Phase -C：Training Dike 3,000 m)

Ordinal Wave (per day)	High Wave (per day)	Extreme Wave (per day)
		

Source: JICA Study Team

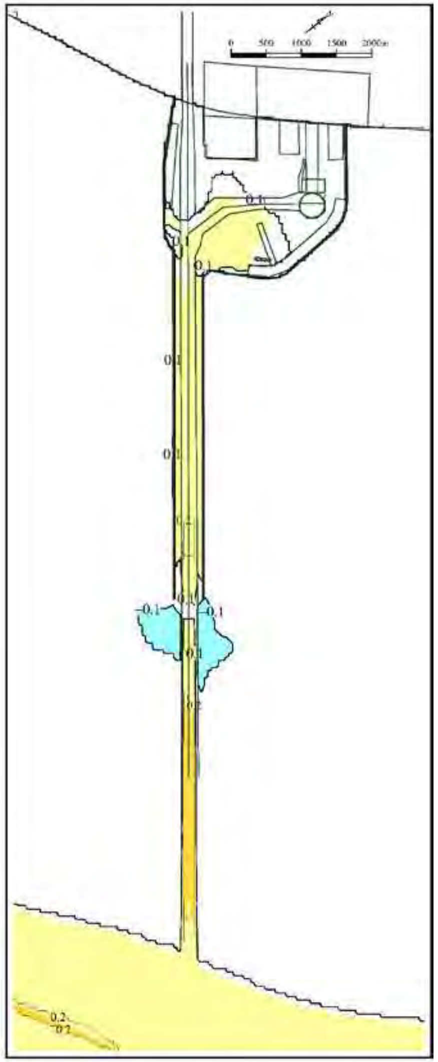
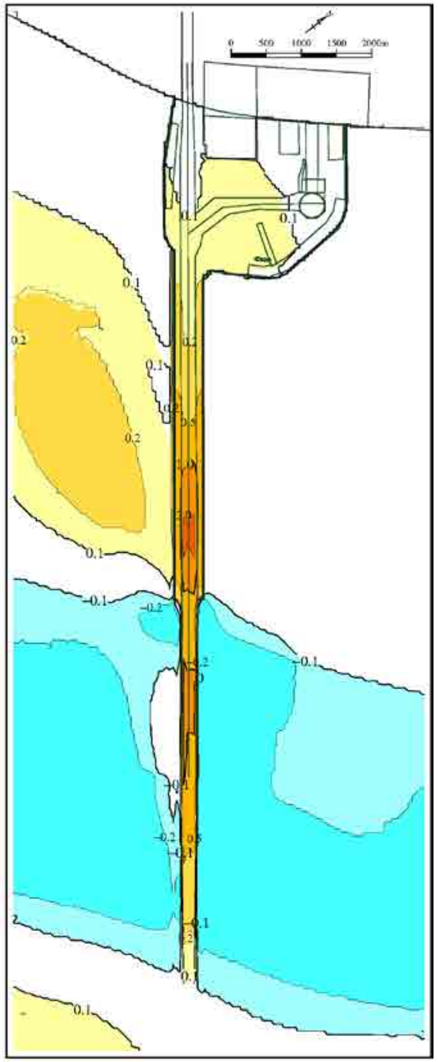
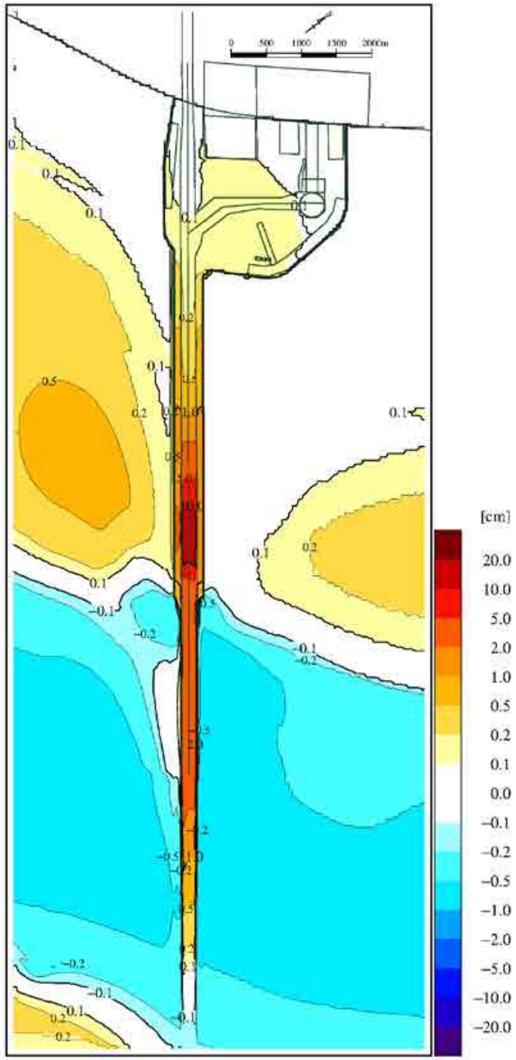
Figure 4.6.3 (2) Thickness of Sedimentation (3rd Phase -C：Training Dike 3,000 m)

Ordinal Wave (per day)	High Wave (per day)	Extreme Wave (per day)

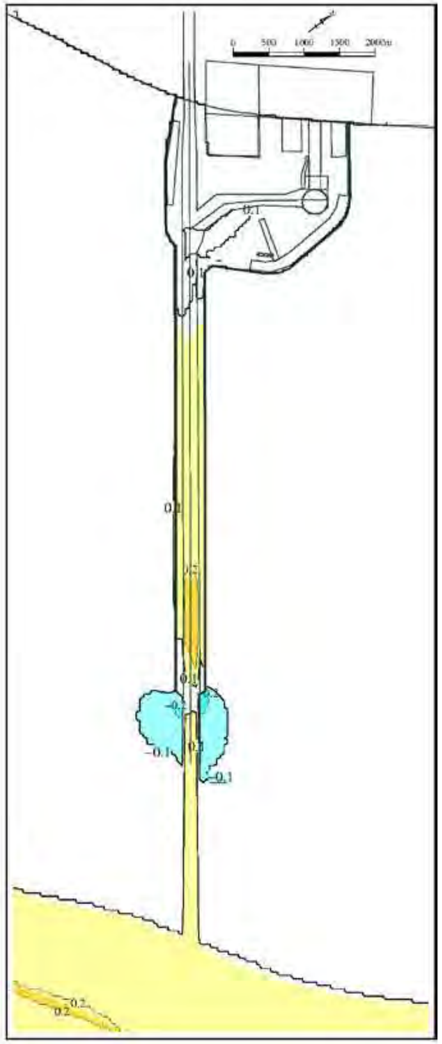
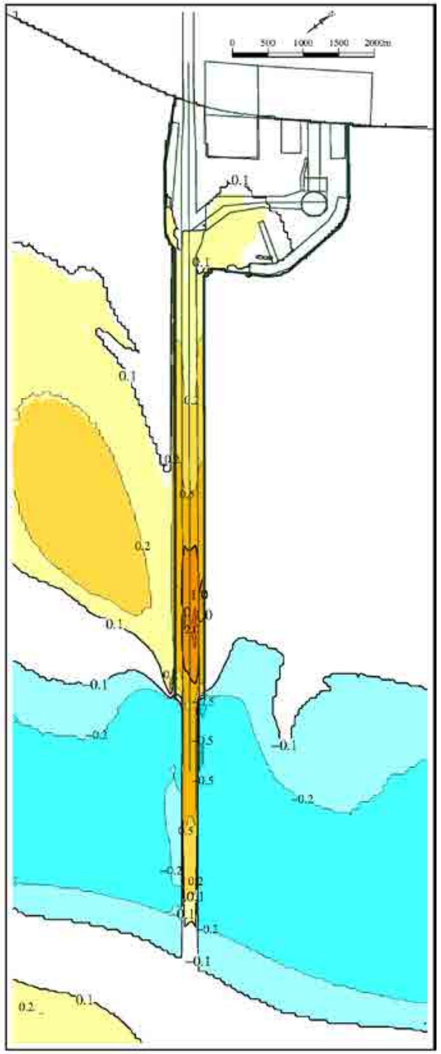
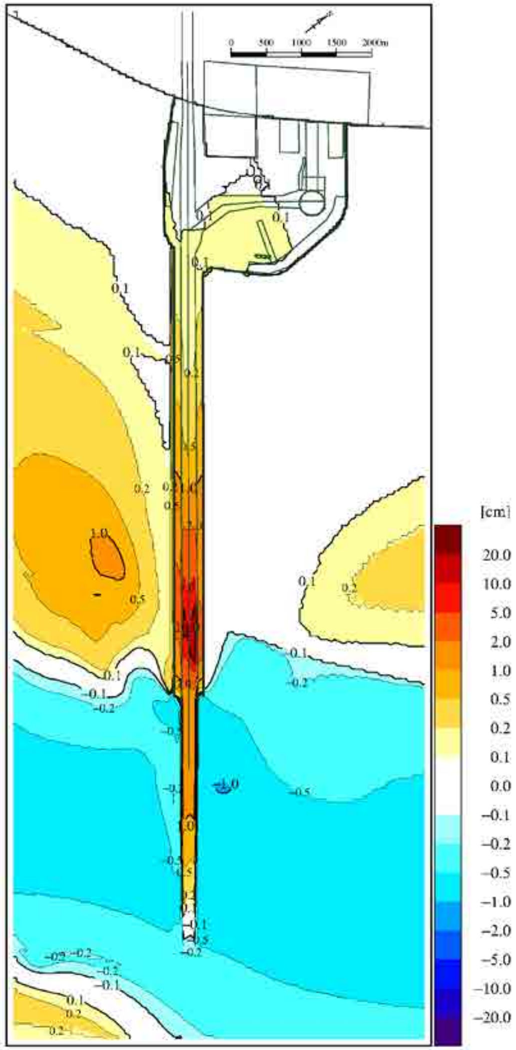


Source: JICA Study Team

Figure 4.6.4 (1) Thickness of Sedimentation (1st Phase -D：Training Dike of 4,500 m）

Ordinal Wave (per day)	High Wave (per day)	Extreme Wave (per day)
		

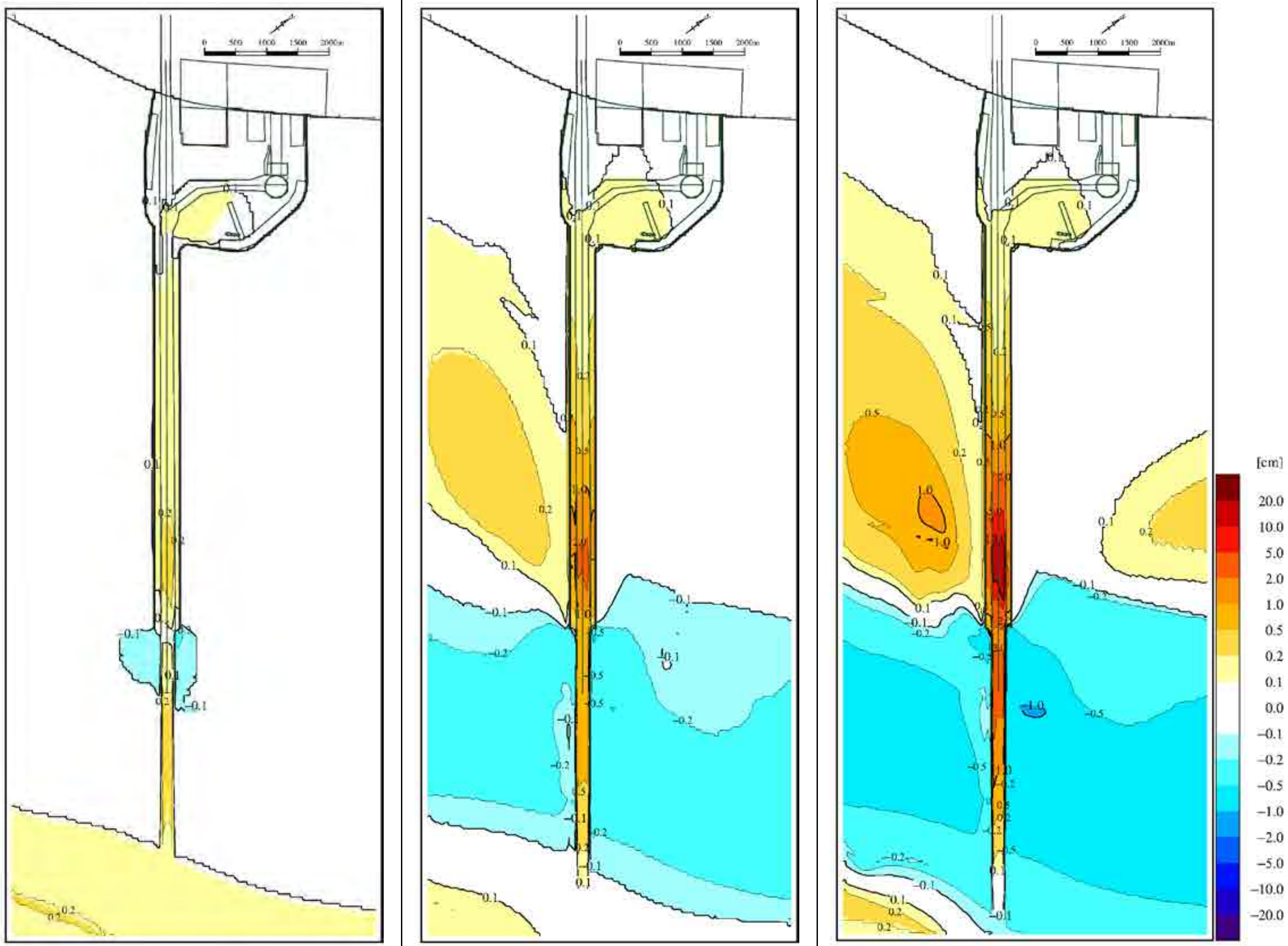
Source: JICA Study Team Figure 4.6.4 (2) Thickness of Sedimentation (3rd Phase -D：Training Dike of 4,500 m）

Ordinal Wave (per day)	High Wave (per day)	Extreme Wave (per day)
		

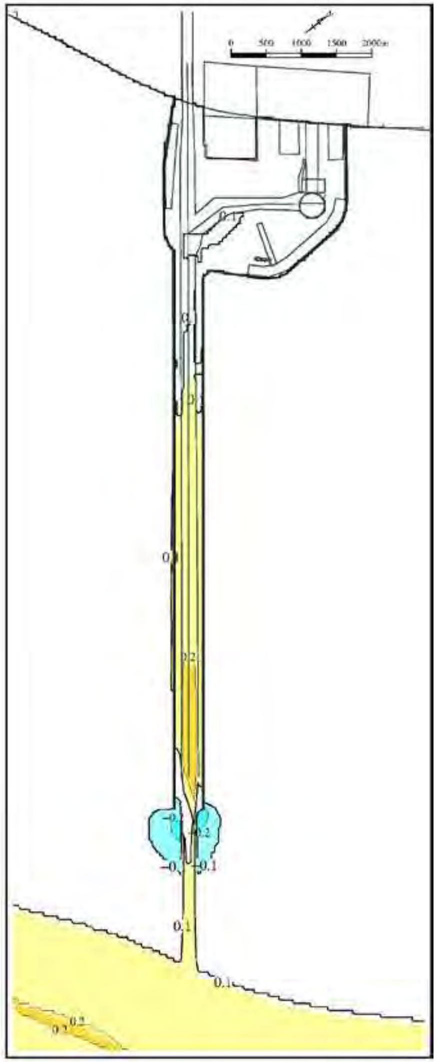
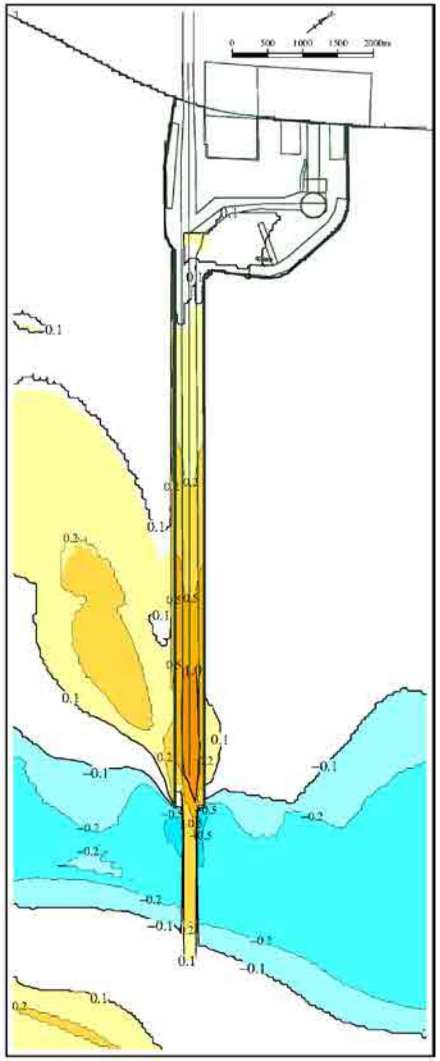
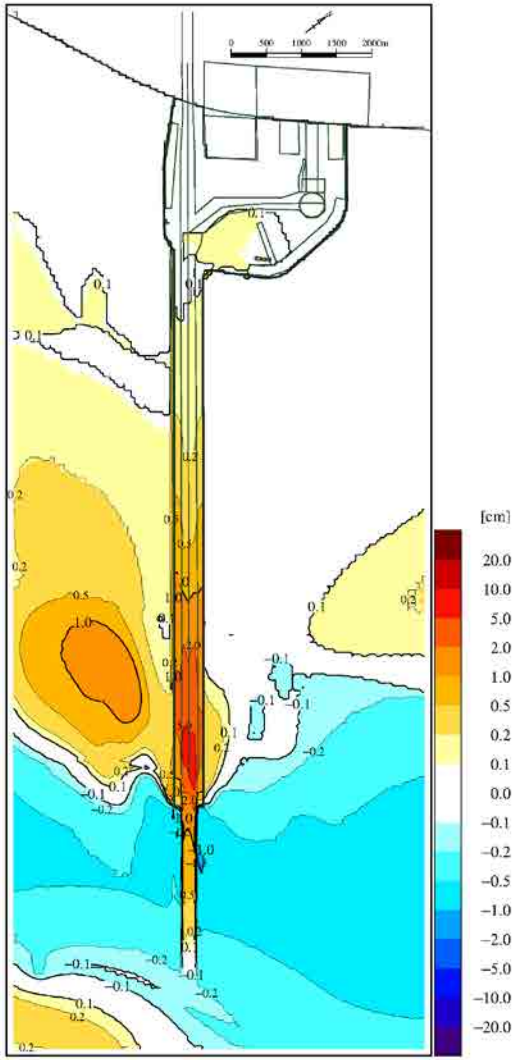
Source: JICA Study Team

Figure 4.6.5 (1) Thickness of Sedimentation（1st Phase -E : Training Dike 6,000 m）

Ordinal Wave (per day)	High Wave (per day)	Extreme Wave (per day)

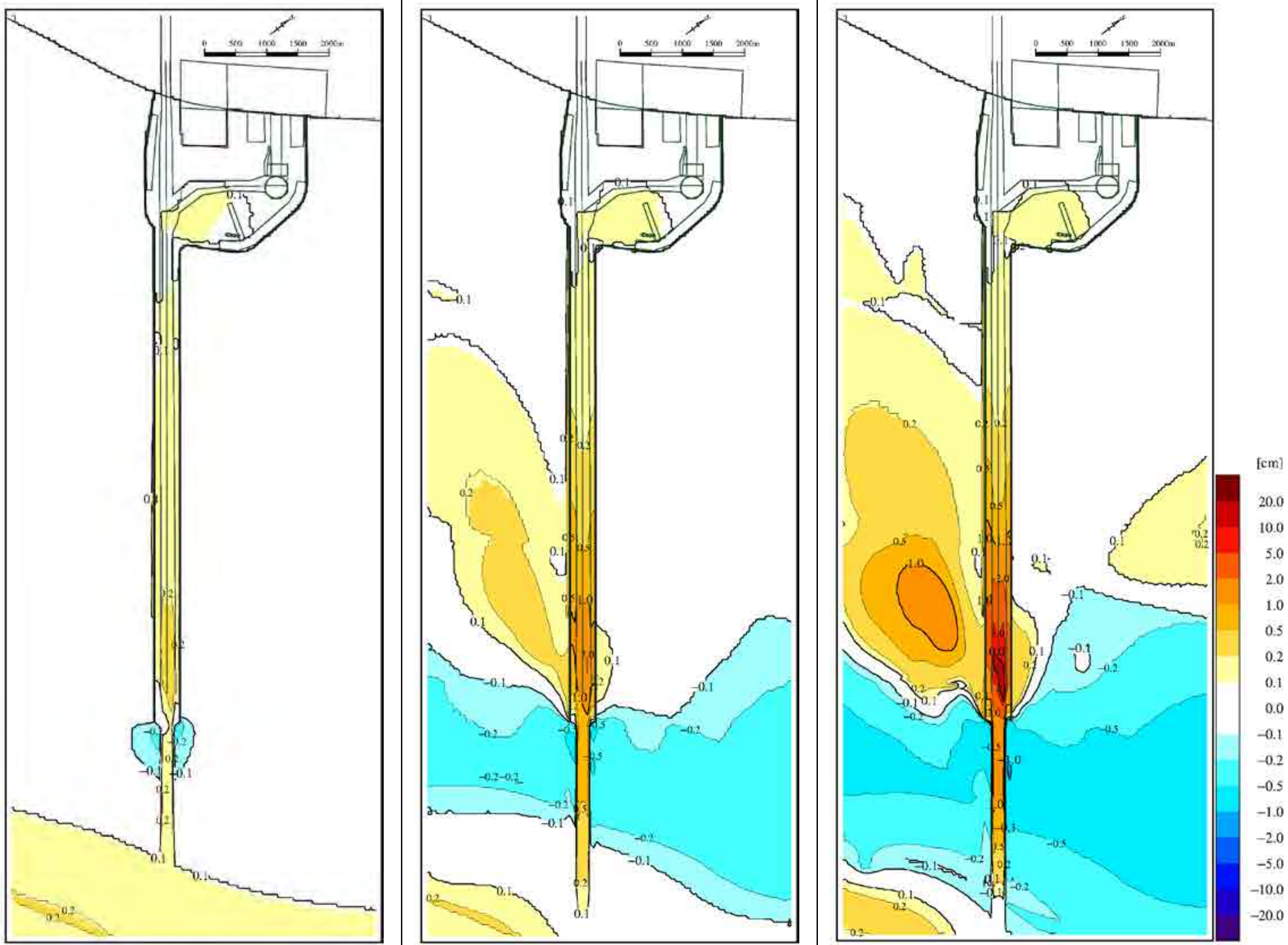


Source: JICA Study Team Figure 4.6.5 (2) Thickness of Sedimentation（3rd Phase -E : Training Dike 6,000 m）

Ordinal Wave (per day)	High Wave (per day)	Extreme Wave (per day)
		

Source: JICA Study Team Figure 4.6.6 (1) Thickness of Sedimentation（1st Phase -F：Training Dike of 7,500 m）

Ordinal Wave (per day)	High Wave (per day)	Extreme Wave (per day)



Source: JICA Study Team

Figure 4.6.6 (2) Thickness of Sedimentation（3rd Phase -F：Training Dike of 7,500 m）

4.7. Estimation of Annual Channel and Harbor Sedimentation Volume

The number of times of wave attack for each representative wave condition times the sedimentation volume by numerical simulation was considered as an annual sedimentation volume. Tables 4.7.1 and 4.7.2 and Figures 4.7.1 and 4.7.2 show the annual sedimentation volume for each case of different length of training dikes as countermeasures.

Annual thickness of sedimentation for the 1st Phase at the inner basin block is between 13 cm and 23 cm and between 42 cm and 65 cm at the navigational channel block. Annual total sedimentation volume is between 1.30 million m^3. Sedimentation volume becomes less by extending the length of the training dike.

Annual thickness of sedimentation for the 3rd Phase at the inner basin block is between 20 cm and 26 cm and between 47 cm and 73cm at the navigational channel block. Thus, the annual total sedimentation volume will increase by 0.2 to 0.3 million m^3 by deepening the navigational channel and basin.

Table 4.7.1 Annual Sedimentation Volume for the 1st Phase (Upper: Volume, Lower: Thickness)

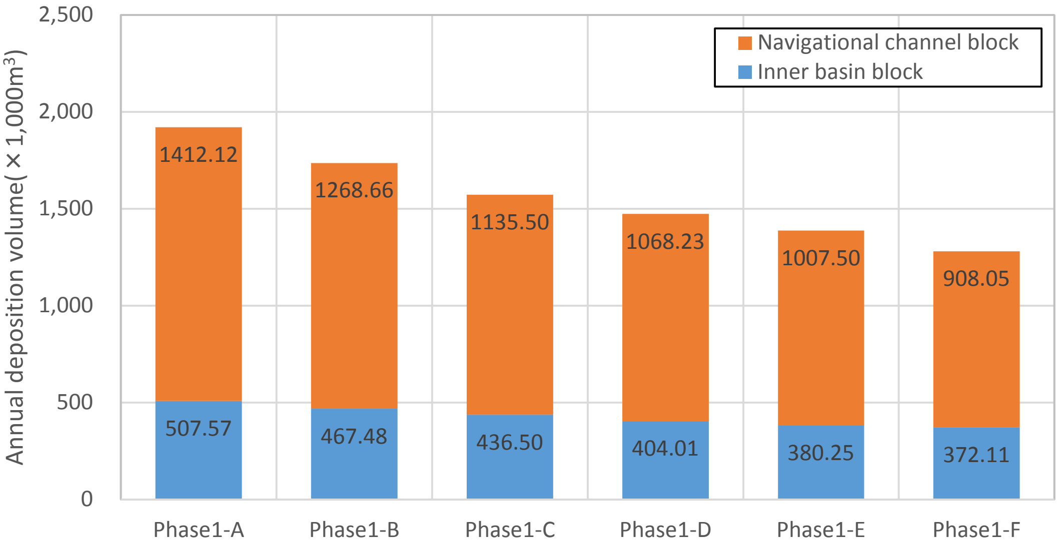
Case	1st Phase1-A	1st Phase -B	1st Phase -C	1st Phase -D	1st Phase -E	1st Phase -F
Training Dike	Without	1,500 m	3,000 m	4,500 m	6,000 m	7,500 m*1
Inner basin block	507,570 m^3 (25.3 cm)	467,480 m^3 (23.3 cm)	436,500 m^3 (21.7 cm)	404,010 m^3 (20.1 cm)	380,250 m^3 (18.9 cm)	372,110 m^3 (18.5 cm)
Navigational channel block	1,412,120 m^3 (65.4 cm)	1,268,660 m^3 (58.7 cm)	1,135,500 m^3 (52.6 cm)	1,068,230 m^3 (49.5 cm)	1,007,500 m^3 (46.6 cm)	908,050 m^3 (42.0 cm)
Total	1,919,690 m^3	1,736,140 m^3	1,572,000 m^3	1,472,240 m^3	1,387,740 m^3	1,280,150 m^3

Source: JICA Study Team

Table 4.7.2 Annual Sedimentation Volume for the 3rd Phase (Upper: Volume, Lower: Tthickness)

Case	3rd Phase-A	3rd Phase -B	3rd Phase 2-C	3rd Phase -D	3rd Phase -E	3rd Phase -F
Training Dike	Without	1,500 m	3,000 m	4,500 m	6,000 m	7,500 m*1
Inner basin block	528,980 m^3 (26.4 cm)	488,010 m^3 (24.3 cm)	463,840 m^3 (23.1 cm)	435,430 m^3 (21.7 cm)	418,300 m^3 (20.8 cm)	411,140 m^3 (20.5 cm)
Navigational channel block	1,703,760 m^3 (72.8 cm)	1,535,290 m^3 (65.6 cm)	1,380,860 m^3 (59.0 cm)	1,290,820 m^3 (55.2 cm)	1,214,990 m^3 (51.9 cm)	1,088,410 m^3 (46.5 cm)
Total	2,232,740 m^3	2,023,300 m^3	1,844,700 m^3	1,726,240 m^3	1,633,290 m^3	1,499,550 m^3

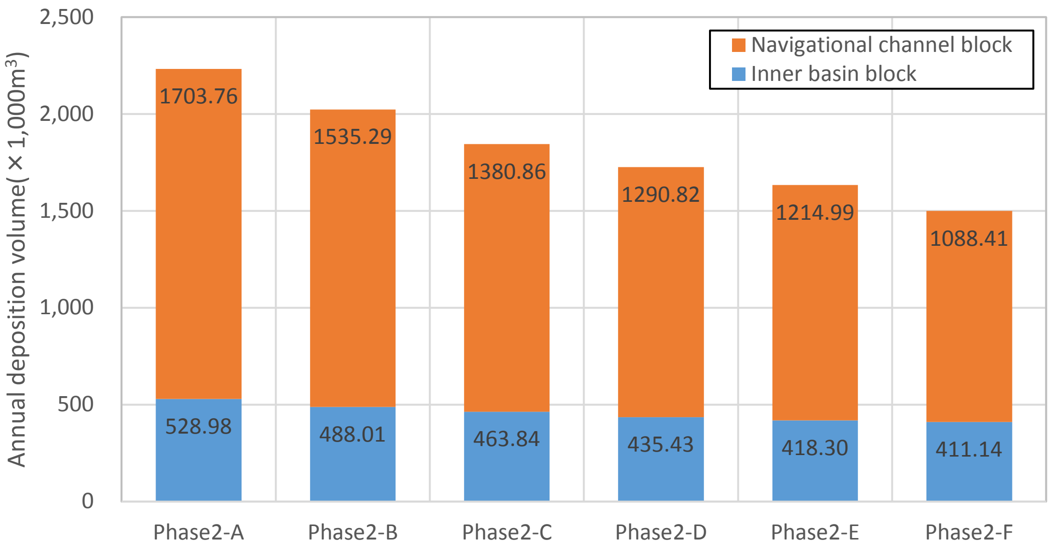
Source: JICA Study Team



Training Dike Without 1,500 m 3,000 m 4,500 m 6,000 m 7,500 m

Source: JICA Study Team

Figure 4.7.1 Annual Sedimentation Volume for the 1st Phase



Training Dike Without 1,500 m 3,000 m 4,500 m 6,000 m 7,500 m

Source: JICA Study Team

Figure 4.7.2 Annual Sedimentation Volume for the 3rd Phase

Tables 4.7.3 and 4.7.4, and Figures 4.7.3 and 4.7.4 show the sedimentation volume and thickness per day for extreme wave conditions. Expected total sedimentation volumes for each case were between 0.03 and 0.08 million m^3. Maximum sedimentation becomes bigger as the training dike becomes longer as a whole and maximum sedimentation thickness of around 20 cm per day occurred at the tip of the channel for cases 3rd Phase -D and 3rd Phase -E.

Table 4.7.3 Sedimentation Volume per Day in the 1st Phase for Extreme Wave

(Upper：sedimentation volume, Lower: sedimentation thickness)

Case	1st Phase1-A	1st Phase -B	1st Phase -C	1st Phase -D	1st Phase -E	1st Phase -F
Training Dike	Without	1,500 m	3,000 m	4,500 m	6,000 m	7,500 m*1
Inner basin block	6,610 m^3 (1.0 cm)	4,980 m^3 (0.5 cm)	3,380 m^3 (0.2 cm)	2,310 m^3 (0.2 cm)	1,790 m^3 (0.1 cm)	1,730 m^3 (0.1 cm)
Navigational channel block	59,540 m^3 (7.6 cm)	56,500 m^3 (9.7 cm)	51,220 m^3 (11.8 cm)	45,710 m^3 (12.1 cm)	38,950 m^3 (12.7 cm)	27,110 m^3 (9.5 cm)
合計	66,150 m^3	61,480 m^3	54,590 m^3	48,020 m^3	40,740 m^3	28,840 m^3

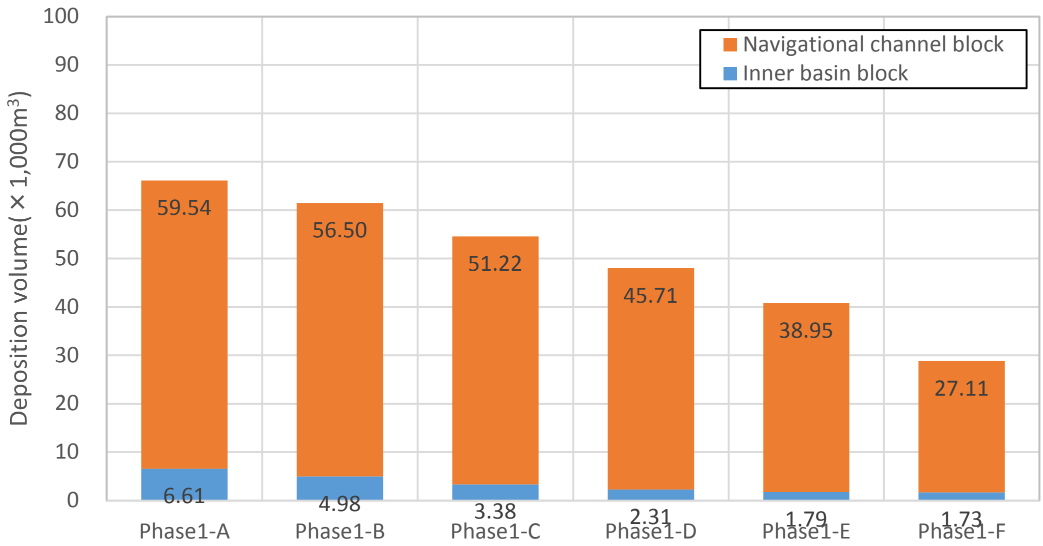
Source: JICA Study Team

Table 4.7.4 Sedimentation Volume per Day in the 3rd Phase for Extreme Wave

(upper：sedimentation volume, lower: sedimentation thickness)

Case	3rd Phase -A	3rd Phase -B	3rd Phase -C	3rd Phase -D	3rd Phase -E	3rd Phase -F
Training Dike	Without	1,500 m	3,000 m	4,500 m	6,000 m	7,500 m*1
Inner basin block	6,250 m^3 (0.9 cm)	4,580 m^3 (0.4 cm)	3,290 m^3 (0.2 cm)	2,430 m^3 (0.2 cm)	1,790 m^3 (0.1 m)	1,740 m^3 (0.1 cm)
Navigational channel block	72,560 m^3 (9.7 cm)	69,140 m^3 (10.2 cm)	64,810 m^3 (16.9 cm)	60,700 m^3 (17.2 cm)	52,290 m^3 (19.1 cm)	36,640 m^3 (14.8 cm)
合計	78,810 m^3	73,710 m^3	68,090 m^3	63,130 m^3	54,070 m^3	38,380 m^3

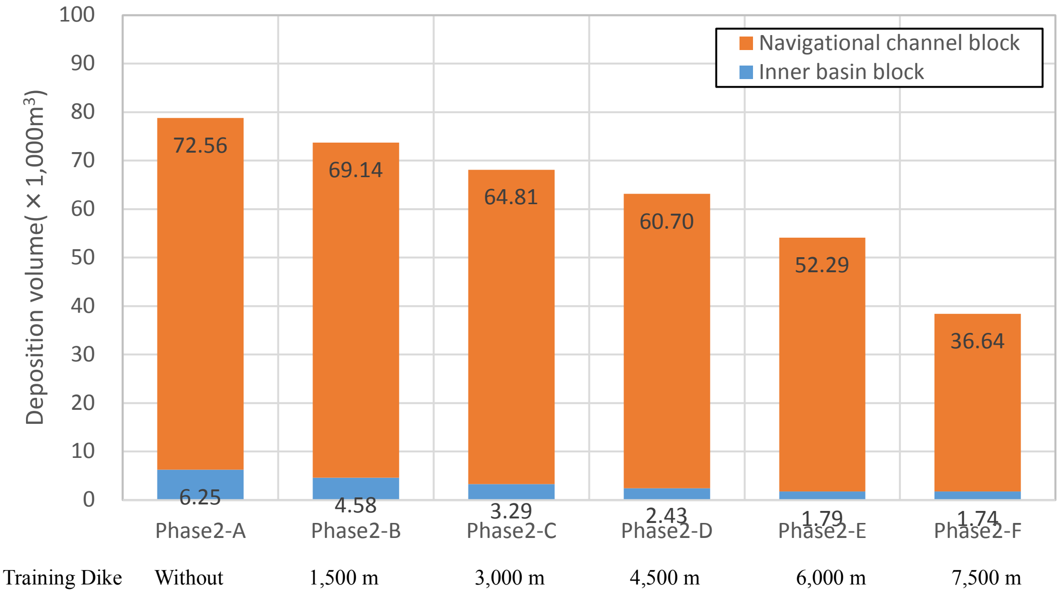
Source: JICA Study Team



Training Dike Without 1,500 m 3,000 m 4,500 m 6,000 m 7,500 m

Source: JICA Study Team

Figure 4.7.3 Sedimentation Volume per Day for the 1st Phase by Extreme Wave Condition



Source: JICA Study Team

Figure 4.7.4 Sedimentation Volume per Day for the 3rd Phase by Extreme Wave Condition)

Efficiency of training dike as a countermeasure of channel and basin sedimentation, construction cost of training dike, and annual maintenance dredging cost during the CTT operation period were obtained for each case of different lengths of training dikes in order to select the most appropriate countermeasure of channel and basin sedimentation. Construction of training dike and completion of initial dredging were considered to be completed in 2020 while the initial construction payment of training dike occurred in 2020. Maintenance dredging cost for the entire period of CTT operation was evaluated as present value by considering the social discount rate of 12%. Table 4.7.5 shows the results and the "without training dike" case showed the most cost efficient result, which can be evaluated by the annual sedimentation volume times unit cost of maintenance dredging cost.

Table 4.7.5 Evaluation of Construction of Training Dike as a Countermeasure of Sedimentation

Case	3rd Phase -A	3rd Phase -B	3rd Phase -C	3rd Phase -D	3rd Phase -E	3rd Phase -F
Length of training dike	N/A	1,500 m	3,000 m	4,500 m	6,000 m	7,500 m[*1]
Construction cost	M$0	M$37.77	M$99.83	M$165.0	M$278.4	M$374.0
Maintenance dredging	M$91.18	M$86.27	M$82.39	M$81.37	M$81.18	M$79.70
Total present value	M$91.18	M$124.04	M$182.22	M$246.37	M$359.58	M$453.7

Source: JICA Study Team

Part 1. Scenario 1

Two scenarios of coal demand by Decision No.5964/ QD-BCT (9 Oct. 2012) as Scenario1 and the JICA Study Team estimates upon the request of the Ministry of Industry and Trade (MOIT) as Scenario 2 were used in this study. Part 1 showed the study results of case for coal demand of Scenario 1.

Chapter 5. Conceptual Design and Proposal of Optimum Planning of the CTT

5.1. Planning of Ocean Transport

5.1.1. Planning of Ocean Transport

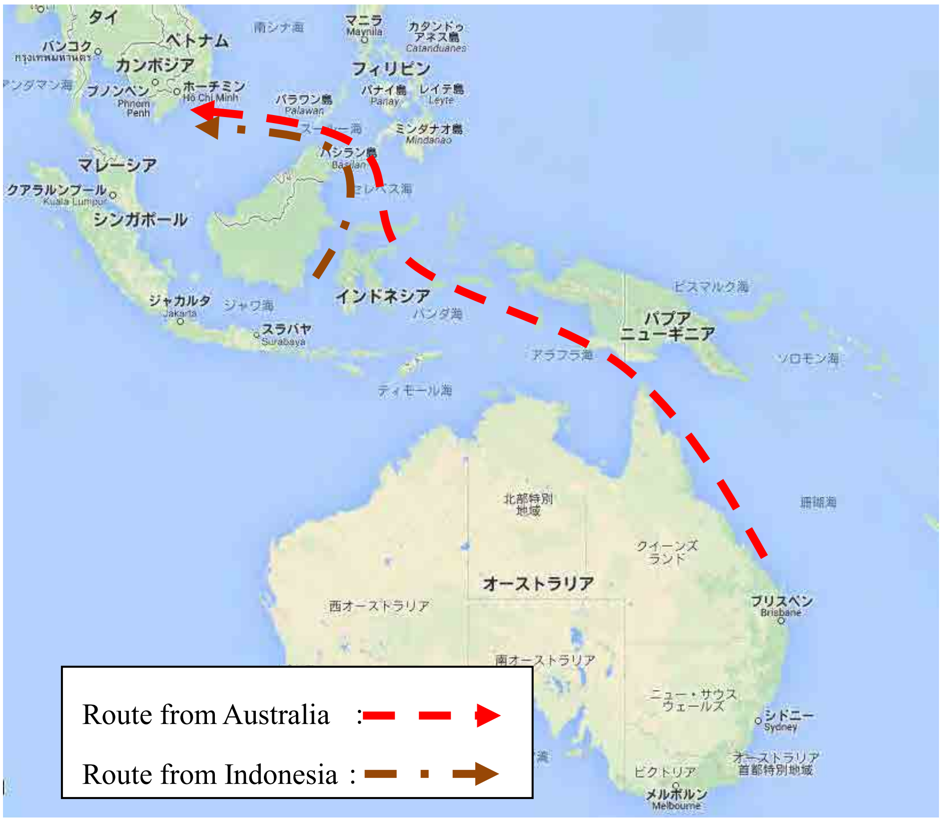
The conditions of supply sources for coal, ocean transport planning, and ocean freight shall be studied.

(1) Outline of Ocean Transport

1) Loading ports of coal for the Coal Transhipment Terminal (CTT) Project

It is assumed to procure coal from Australia and Indonesia in the CTT Project, although procurement plan of coal for coal-fired power plant (CFPP) in the southern part of Vietnam has not been decided and loading ports have not been specified yet. Australia and Indonesia are main supplying countries of coal and its distances in transit from Australia and Indonesia are more efficient than other coal producing countries.

Transit time from Australian coal loading ports to Duyen Hai is 11 to 12 days, and transit time from Indonesian loading ports is 4 to 5 days.



Source: Google Map

Figure 5.1.1 Route of Ocean Transport from Australia and Indonesia to Duyen Hai

Other coal supplying countries do not seem to be realistic supply sources for the CTT Project, as capacity of export from China and USA is limited, and distances from Russia, South Africa, and Colombia to Vietnam are rather long and not competitive.

2) Vessel Types for the CTT Project

The cases of vessel types whose deadweight is more than 30,000 DWT shall be studied, as it is more proper to load larger volume of coal per vessel from the view point of loading operation and chartering vessels. Approximate DWTs of each type of vessel are shown below.

Capesize : 130,000-180,000 DWT
Panamax : 63,000-80,000 DWT (Post-Panamax : 100,000 DWT)
Handy : 30,000-55,000 DWT (30,000 DWT vessel and 55,000 DWT vessel are usually different types, but ocean freight levels are quite similar)

Most of coal loading ports are designed for larger vessels such as Capesize and Panamax, which have no cranes. On the other side, most of Handy type vessels have cranes on deck and the cranes disturb the shifting operation of vessel for changing a loading hold to another, and they are restricted to call coal loading ports. Also smaller type of vessels than Handymax are also not realistic like the following example. In case of using 20,000 DWT vessels for transport 3 million t of coal per year, the number of ocean transports is 150 times per year. In case for transport 30 million t per year, the number of ocean transports is 1,500 times, which is not realistic.

(2) Ocean Freight

Estimation of current ocean freight for each vessel type is mentioned in Table 5.1.1.

Table 5.1.1 Ocean Freight for Each Vessel Type

		Vessel type		
		Capesize	Panamax	Handy
Loading from	Australia	USD 15/MT	USD 18/MT	USD 29/MT
	Indonesia	USD 8/MT	USD 10/MT	USD 15/MT

Source: JICA Study Team

The ocean freights are possibly fluctuated by market demand of major cargo and supply of vessel, but it is generally the case that larger vessel can reduce ocean freight per t. The freights in Table 5.1.1 are calculated based on actual costs and will be different from actual freight, which is based on market supply and demand. However, cost basis in the calculation should be better for long-term planning.

The change of fuel price impacts the freights, but the difference of freight among Capesize, Panamax and Handy vessels will not be so different.

Freights in Table 5.1.1 do not include the cost of loading and unloading coal.

Reduction by increasing vessels' capacity can be found in Table 5.1.2.

Case 1 shows the reduction of ocean freight in total by changing from Handy size vessel to Panamax vessel for the Duyen Hai CFPPs and changing from 10,000 DWT barge to Panamax for the other CFPPs.

Case 2 shows the reduction of ocean freight by changing from Handy size vessel to Panamax vessel for the Duyen Hai CFPPs and for all CFPPs as an example. This case is not realistic because Handy size of vessel can not go in to the Hau River for Song Hau and Long Phu. In addition to that, other CFPPs other than the Duyen Hai CFPPs can not use Duyen Hai Port since the capacity of Duyen Hai Port is limited.

Table 5.1.2 Reduction of Ocean Freight

Freight Table including 10,000DWT Barge

	Panamax	Handy	Barge
	70,000 - 100,000DWT	30,000 - 55,000DWT	10,000DWT
Freight from Indonesia	US$10 /MT	US$15 /MT	US$28 /MT
Freight from Australia	US$18 /MT	US$29 /MT	

<Case 1>

Reduction of Ocean freight by change from Handy to Panamax (for Duyen Hai) / from 10,000DWT Barge to to Panamax (excluding Duyen Hai)

	Annual volue of coal (for Duyen Hai CFPP)	Merit by change from Handy to Panamax	Annual volue of coal (excluding Duyen Hai CFPP)	Merit by change from 10,000DWT Barge to to Panamax	Total Merit
1st Phase	4.76 mil. MT	US$24 mil./year	3.77 mil. MT	US$68 mil./year	US$92 mil./year
2nd Phase	5.95 mil. MT	US$30 mil./year	11.91 mil. MT	US$214 mil./year	US$244 mil./year
3rd Phase	5.95 mil. MT	US$30 mil./year	25.14 mil. MT	US$453 mil./year	US$482 mil./year

<Case 2>

Reduction of Ocean freight by change to Panamax (100% from Indonesia)

	Annual volue of coal	Merit by change from Handy to Panamax
1st Phase	8.53 mil. MT	US$43 mil./year
2nd Phase	17.86 mil. MT	US$89 mil./year
3rd Phase	31.09 mil. MT	US$155 mil./year

Reduction of Ocean freight by change to Panamax (50% from Indonesia : 50% from Australia)

	Annual volue of coal	Merit by change from Handy to Panamax
1st Phase	8.53 mil. MT	US$68 mil./year
2nd Phase	17.86 mil. MT	US$143 mil./year
3rd Phase	31.09 mil. MT	US$249 mil./year

Reduction of Ocean freight by change to Panamax (100% from Australia)

	Annual volue of coal	Merit by change from Handy to Panamax
1st Phase	8.53 mil. MT	US$94 mil./year
2nd Phase	17.86 mil. MT	US$196 mil./year
3rd Phase	31.09 mil. MT	US$342 mil./year

Source: JICA Study Team

Generally, it is the case that freights of bigger vessels are cheaper than smaller vessels.

As an extreme example, the CTT is not necessary, in case coal is transported directly from Indonesia to the Vietnamese power plants such as Long Phu and Song Hau by 10,000 DWT barge. However, huge increase of ocean freight is expected for barge transport from Indonesia to Vietnam, which is USD 482 million per year in the 3rd Phase.

Economic disadvandage of using 10,000 DWT barge without the CTT has been confirmed. This method is unrealistic for the following four reasons:

i) Safety of voyage (risk of capsizing and sinking, health and safety of the crew).

ii) Necessity of bigger coal stock yard due to stoppage of voyage by monsoon.

iii) Incease of congestion in the unloading berth due to fluctuation of transit time between Indonesia and CTT / Necessity of expanding unloading facility of the CTT.

iv) Dificulty of securing approximately 30 x 10,000 DWT barges at the 1st Phase because there are no such numbers of 10,000 DWT barges at the market.

Economic merit of increasing vessel's capacity and unreality of using 10,000 DWT barges for ocean transport has been confirmed. Arrangement of chartering 20,000–30,000 DWT barge would be difficult for importing 30 million t per year of coal from Indonesia and/or Australia.

Table 5.1.3 Size and Age by Year of Delivery - Bulkcarriers

DWT	10,000 - 40,000		40,000 - 65,000		65,000 - 100,000		100,000 +	
	No. of vessel	000DWT	No. of vessel	000DWT	No. of vessel	000DWT	No. of vessel	000DWT
Total	**2,415**	**69,476**	**2,793**	**149,069**	**2,240**	**177,639**	**1,545**	**288,805**

Source: JICA Study Team

Out of 2,415 vessels with 10,000–40,000 DWT, 200–300 vessels are navigating South East Asia with 20,000–30,000 DWT. In case that 30 million t of coal per year are imported and a vessel with 25,000 DWT (average) makes 30 round trips per year between Indonesia and Vietnam, a minimum of 40 vessels are required. Even if the arrangement itself is possible, big impact to freight market is expected. Also the number of berths shall be impacted.

5.1.2. Coal Logistics Planning

(1) Coal Demand

According to the Decision dated on 9 October 2012 by the Ministry of Industry and Trade (MOIT), coal demand for the CFPPs up to 2030 are shown in Table 5.1.4.

The JICA Study Team's study is based on coal demand based on this Table 5.1.4, however, the assumption of coal demand will be updated for the Final Report of this study in case MOIT issues the updated information of coal demand.

Table 5.1.4 Coal-Fired Electric Power Plant which Should be Considered for CTT and Coal Demand

		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Long Phu Power Center																		
Long Phu Power Plant I	Capacity (MW)					600	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (mil tons)					0.074	1.414	1.786	1.786	1.786	1.786	1.786	2.381	2.381	2.381	2.381	2.381	2.381
Long Phu Power Plant II	Capacity (MW)												1,200	1,200	1,200	1,200	1,200	1,200
	Coal (mil tons)												2.381	2.381	2.381	2.381	2.381	2.381
Long Phu Power Plant III	Capacity (MW)												1,000	2,000	2,000	2,000	2,000	2,000
	Coal (mil tons)												0.118	2.381	2.381	2.381	2.381	3.779
Song Hau Power Center																		
Song Hau Power Plant I	Capacity (MW)				600	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (mil tons)				0.074	1.414	1.885	1.984	1.984	1.984	1.984	1.984	2.381	2.381	2.381	2.381	2.381	2.381
Song Hau Power Plant II	Capacity (MW)																	2,000
	Coal (mil tons)																	3.779
Song Hau Power Plant III	Capacity (MW)																	2,000
	Coal (mil tons)																	2.835
Duyen Hai Power Center																		
Duyen Hai Power Plant II	Capacity (MW)					600	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (mil tons)					0.223	1.563	1.885	1.885	1.885	1.885	1.885	2.381	2.381	2.381	2.381	2.381	2.381
Duyen Hai Power Plant III	Capacity (MW)				600	600	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (mil tons)				1.786	1.984	2.058	2.877	2.877	2.877	2.877	2.877	3.571	3.571	3.571	3.571	3.571	3.571
Long An Power Center																		
	Capacity (MW)												1,200	1,200	1,200	1,200	1,200	1,200
	Coal (mil tons)												1.786	2.381	2.381	2.381	2.381	2.381
Bac Lieu Power Center																		
	Capacity (MW)																	1,200
	Coal (mil tons)																	2.381
An Giang Power Center																		
	Capacity (MW)																	2,000
	Coal (mil tons)																	2.835
TOTAL	Capacity (MW)	0	0	0	1,200	3,000	4,800	4,800	4,800	4,800	4,800	4,800	8,200	9,200	9,200	9,200	9,200	16,400
	Coal (mil tons)	0.00	0.00	0.00	1.86	3.70	6.92	8.53	8.53	8.53	8.53	8.53	15.00	17.86	17.86	17.86	17.86	31.09

Source：Decision No.5964/QD-BCT (9Oct2012)

(2) Coal Storage Planning in the Stockyard of the CTT

As a general operation in the CFPP, the CFPP requires 1 to 2 months of coal stock in the stockyard. In this study, planning total coal stock amount is 1.5 months stock as a total volume in both stockyards of the CFPP and CTT.

Minimum required stock amount in the stockyard of CFPP is set at 0.6 month, and in the stockyard of CTT is set at 0.9 month in this study. This is to determine in detail by discussion with each CFPP utilizing CTT.

Coal stock amount above is based on "(a) Harbor Type" which is recommended as the most suitable type of CTT as written in Chapter 5.2. In case the assumption of harbor type is changed, coal stock amount is to be adjusted since the difference of climate conditions in harbor causes the capacity of unloading facility to decrease, then an additional coal stock amount will be required.

5.1.3. Secondary Transport

(1) Outline of Secondary Transport

In the CTT Project, imported coal shall be delivered by a small vessel or barge to each CFPP from the CTT, in some period after unloading from the vessel. This transport from the CTT to each CFPP is referred to as "Secondary Transport".

From the viewpoint of operational efficiency, it is ideal to use larger sizes of small vessel or barge for Secondary Transport, however, it was found out that DWT of usual large barges existing in Vietnam is approximately 2,000 DWT and it is difficult to refer it as similar cases with Secondary Transport of CTT Project.

It is expected for a 10,000 DWT barge could go through, once the Hau River Bypass Canal is completed. Specifications of LOA, draft, and breadth for 10,000 DWT barge can be various, but the following specifications are assumed among CTT Project Team as an example.

Table 5.1.5 Specification Assumed for a 10,000 DWT Barge

LOA	95.40 m
Draft	4.75 m
Breadth	28.80 m

Source: JICA Study Team

Boat and barge is more economical and suitable for shallow water depth. In general, it is suitable for river transport. Self-propelled coastal vessel is less impacted by monsoon because of its shape of deeper draft and stability.

Main focus of the secondary transport in the Feasibility Study (F/S) stage is for Long Phu and Song Hau because their period of starting operations are earlier and volumes are larger. Route from the CTT to Long Phu/Song Hau CFPP is through Quan Chanh Bo Canal and the Hau River. But by using barge, it would be also possible to pass through the entrance of the Hau River even though it requires more transit time from the CTT to Long Phu/Song Hau. It is expected for a self-propelled coastal vessel to be more suitable to be used for the secondary transport from the CTT to Bac Lieu, because it can navigate the open ocean.

Table 5.1.6 Outline of Secondary Transport

Name of CFPP	Rough Distance from CTT (km)	Proper Mode of Transportation
Duyen Hai	10	Barge / Conveyor
Long Phu	70	Barge
Song Hau	90	Barge
Long An	110	Barge
Bac Lieu	160	Coastal Vessel / Barge
An Giang	210	Barge

Source: JICA Study Team

Actual results of using 10,000 DWT on the Hau River is confirmed, which was for transporting sand from Can Tho City along the Hau River to Singapore. Below are the details.

- Cargo/transportation detail : Sand produced in Cambodia / Transporting sand from Cambodia to Can Tho by small barge – Trans-load from small barge to 10,000 DWT barge by floating crane;
- Transporting from Can Tho to Singapore by 10,000 DWT barge through the Hau River and ocean.
- Duration : 2008-2010
- Volume : Approximately 5 million t
- Type of barge (example) : 10,000 DWT (LOA : 90 m, Draft with full load: 4.5 m, Breadth : 27 m) brought from Singapore and Indonesia
- Transit time (round trip) : 10–14 days
- Freight : approx. USD 10-15/MT
- Others: Speed for transit was slow down during monsoon season and sometimes navigations themselves were suspended.

Study of 5,000 DWT is also necessary. Because there is tide restriction on the Hau River entrance for 10,000 DWT and there is a regulation to limit 24.80 m as maximum on the Hau River Bypass Canal, although actual results of using 10,000 DWT barges on the Hau River has been confirmed and the Hau River Bypass Canal allows 10,000 DWT barge to go through.

Cost estimation with 5,000 DWT barge shall be made in this study and the following specifications are assumed among CTT Project Team as an example.

Table 5.1.7 Specifications Assumed for a 5,000 DWT Barge

LOA	89.00 m
Draft	3.50 m
Breadth	23.00 m

Source: JICA Study Team

There is no accurate information of consumption for each power plant, but 10,000 MT per day at the 1st Phase and 70,000 MT per day at the 3rd Phase are expected to be consumed. The same volume shall be shipped out from the CTT.

Table 5.1.8 Specifications Assumed for a 5,000 DWT Barge

	1st Phase	2nd Phase	3rd Phase
Annual volume to be shipped out from CTT	3,770,000 MT	11,910,000 MT	25,140,000 MT
Case of using 10,000 DWT	377 barge/ year	1,191 barge/year	2,514 barge/year
	1.1 barge/day	3.4 barge/day	7.2 barge/day
Case of using 5,000 DWT	754 barge/ year	2,382 barge/year	5,028 barge/year
	2.2 barge/day	6.8 barge/day	14.4 barge/day

Source: JICA Study Team

(2) Cost of Secondary Transport

As mentioned in Section 5.1.3(1), there is no existing market of 5,000 DWT barge in Vietnam and the general cost (fare) of 10,000 DWT could not be obtained from the market. And the direction of the study to estimate the cost of secondary transport shall be based on the capital expenditure of barge building and operating expenditures.

Below are the assumptions for estimation:

i) To estimate the number of 5,000 DWT barges and tug boats
Duration for loading: 4 hours/ Berthing and un-berthing : 2.5 hours + buffer = 1 cycle time : 8 hours / Same to be applied for unloading (1 cycle time : 8 hours)

ii) Average transit time form CTT to power plants (Song Hau and Long Phu) : 16 hours (4 knots per hour = 7 km per hour for 70-90 km)
*This transit time is based on the assumption that barges and tug boats can go through the Hau River Bypass Canal and the Hau River. If not, the cost will be increased accordingly.

iii) To operate 5,000 DWT barges and tugs with the assumption of (i) and (ii) smoothly, 5 x 5,000 DWT barges are required for 1st Phase (Annual shipping volume from CTT : 3.77 million t per year)
The number of tug boats shall be two thirds of the number of barges, considering the ratio between loading - unloading duration and transit time.

Table 5.1.9 Simulation to Navigate 5,000 DWT Barges (1st Phase)

				10 days volume							120,000							Occupancy							39%						
				Loading & handling hours							140							Annualy volume							4,200,000						
		D1			D2			D3			D4			D5			D6			D7			D8			D9			D10		
		M	D	N	M	D	N	M	D	N	M	D	N	M	D	N	M	D	N	M	D	N	M	D	N	M	D	N	M	D	N
CTT	Berth 1	1		3		5		1		3		5		1		3		5		1		3		5		1		3		5	
	Berth 2		2		4				2		4				2		4				2		4				2				
Transit			1			1			1			1			1			1			1			1			1			1	
					3			3			3			3			3			3			3			3			3		
							5				5				5				5				5				5				5
Long Phu 1					1		3		5		1		3		5		1		3		5		1		3		5		1		3
Transit				2			2			2			2			2			2			2			2			2			2
						4			4			4			4			4			4			4			4			4	
Song Hau 1						2		4				2		4				2		4				2		4				2	

Source: JICA Study Team

iv) To estimate the number of 5,000 DWT barges and tug boats for the 2nd Phase and the 3rd Phase in the same manner as (i) and (ii).

v) Interest :3% (same as the CTT Project)

Duration of depreciation for barges and tug and repayment: 20 years

vi) Others <Information sources>

- Building cost of 5,000 DWT barge : USD 2,500,000 / Barge <Vietnamese and Japanese shipbuilding companies>
- Building cost of tug boat (2,500 HP) : USD 3,000,000 / tug boat <Vietnamese and Japanese shipbuilding companies>
- Fuel consumption of round trip between CTT and power plants around Long Phu and Song Hau : USD 6,600 per round trip <Vietnamese barge operator>
- Other expenses such as salaries of crews and maintenance, etc. : USD 15,000 per barge per month <Vietnamese barge operator>

Based on the above assumptions, cost for secondary transport is estimated at USD 2.00/MT for the 1st Phase. On top of 2.00 MT the fixed cost and profit of a barge operator(s) are added and USD 2.20-2.40/MT shall be the actual freight. About 5-10% of cost reduction is expected in case of using 10,000 DWT barge.

Table 5.1.10 Cost Estimation for Secondary Transport (Excluding Fixed Cost and Profit of Barge Operator)

	1st Phase	2nd Phase	3rd Phase
Annual shipping volume (MT)	3,770,000	11,910,000	25,140,000
Daily shipping volume (MT)	12,567	39,700	83,800
No. of barges	5	14	32
Building Cost of barges	US$2,500,000	US$2,500,000	US$2,500,000
No. of tug boats	4	10	22
Building Cost of tug boats	US$3,000,000	US$3,000,000	US$3,000,000
Annual repayment	US$1,646,785	US$4,369,021	US$9,813,493
No. of secondary transport	754	2382	5028
Fuel consumption per round trip	US$6,600	US$6,600	US$6,600
Annual fuel consumption	US$4,976,400	US$15,721,200	US$33,184,800
Monthly other expenses per barge	US$15,000	US$15,000	US$15,000
Annual other expenses	US$900,000	US$2,520,000	US$5,760,000
Annual total expenses	US$7,523,185	US$22,610,221	US$48,758,293
Freight (per MT)	US$2.00	US$1.90	US$1.94

Source: JICA Study Team

5.2. Determination of Port and Terminal Layout Plan

5.2.1. Condition for Port Layout Planning

(1) Handling Volume of Coal and Target Year

Forecast volumes of coal imports published in the latest decision of the Government of Vietnam are used in planning port facilities for the CTT. Transshipment volume of coal to the CFPPs is obtained by subtracting the transshipment volume for Duyen Hai II and III from the total volume of coal imports. Table5.2.1 shows the import and transshipment volumes of coal to examine port facilities.

Table 5.2.1 Import and Transshipment Volumes of Coal (unit: million t)

	Year	Import Volume	Transshipment Volume
1st Phase	2020	8.53	3.770
2nd Phase	2025	17.86	11.91
3rd Phase	2030	31.09	25.14

Source: Decision No.5964/QD-BCT (9 Oct 2012)

The CTT Project will be developed based on a phased plan. According to the increment of coal volume, the target year of the 1st Phase is set in 2020, that of the 2nd Phase is in 2025 and that of the 3rd Phase is in 2030.

(2) Design Vessel

1) Vessel for Coal Importation

Vessel size for imported coal will be Panamax size in the 1st Phase, over-Panamax size in the 2nd Phase and Capesize in the 3rd Phase. Scale of the Panamax is around 55,000–85,000 DWT, scale of the over-Panamax is around 100,000 DWT and that of the Capesize is around 160,000 DWT.

However, as the Government of Vietnam wishes to introduce an over-Panamax size vessel at the early stage, port facilities will be designed to accommodate an over-Panamax size vessel in the 1st Phase. Table 5.2.2 shows the specifications of over-Panamax vessels.

Table 5.2.2 Specifications of over-Panamax Vessels (around 100,000 DWT)

Dead Weight Tonnage	Number	LOA(m)	Draft(m)	Beam(m)
95,000～96,999	54	235.44	14.37	38.36
97,000～98,999	27	240.26	14.15	39.49
99,000～100,999	5	247.14	13.84	42.35
101,000～102,999	1	253.93	14.62	40.01
103,000～104,999	6	244.54	13.95	43.00
Total or Average	93	244.26	14.19	40.64

Source: Fair Play 2013

Considering the above figures, specifications of the design vessel and the coal unloading berth for the 1st and 2nd Phase are set as follows:

Specifications of the design vessel		Specifications of the coal unloading berth	
DWT	100,000	Length (m)	300
LOA (m)	250.0	Depth of Water (m)	16.0
Draft (m)	14.5		
Beam (m)	40.0		

Specifications of the Capesize vessels to be introduced in the 3rd Phase are as follows:

Table 5.2.3 Specifications of the Capesize Vessels (around 160,000 DWT)

Dead Weight Tonnage	Number	LOA (m)	Draft (m)	Beam (m)
155,000～156,999	3	269.67	17.31	46.40
157,000～158,999	5	280.00	17.64	43.01
159,000～160,999	3	280.28	17.52	45.00
161,000～162,999	18	280.08	17.50	45.05
163,000～164,999	7	287.75	17.85	44.01
Total / Average	36	279.56	17.56	44.69

Source: Fair Play 2013

Considering the above figures, additional specifications of the design vessel and the coal unloading berth for the 3rd Phase are set as follows:

Specifications of the design vessel		Specifications of the coal unloading berth	
DWT	160,000	Length (m)	350.0
LOA (m)	280.0	Depth of Water (m)	19.0
Draft (m)	17.5		
Beam (m)	45.0		

2) Vessel for Transshipment

A vessel of 5,000 DWT to 10,000 DWT is planned to be introduced for the transshipment to CFPPs from CTT, considering the size of domestic shipping fleet, the efficiency of transshipment, and the navigability of the Hau River. Therefore, design vessel for the loading berth is set as follows:

Specifications of the design vessel		Specifications of the coal loading berth	
DWT	5,000	Length (m)	130.0
LOA (m)	109.0	Depth of Water (m)	7.5
Draft (m)	6.5		
Beam (m)	17.0		

Specifications of the design vessel		Specifications of the coal loading berth	
DWT	10,000	Length (m)	160.0
LOA (m)	137.0	Depth of Water (m)	9.0

Draft (m) 8.2
Beam (m) 19.9

(3) Conditions on Coal Handling

1) Capacity of Unloader and Loader

The capacity of unloader and loader installed at the quayside is generally determined by the handling volume of coal, scale of stock yard, and economic efficiency.

In this study, considering the result of the "Phase I Study" and the size of design vessel, the unloader should meet the following conditions:

Capacity: 2,500 t per hour for unloading
Unloader Type: a continuous coal unloader
Unloading Efficiency: 75%
Number: two unloaders per berth

Considering the result of the "Phase I Study" and the size of the design vessel, the loader for transshipment should meet the following conditions:

Capacity: 1,500 t per hour for loading
Loading Efficiency: 90%
Number: one loader per berth

2) Operational Days per Year and Working Hours per Day

A coal loading/unloading port is usually operated through the year on a round-the-clock basis. Though the operation of CTT should be examined in consideration of rules and regulations of Vietnam, the following conditions are set in this study:

i) Operation Days per Year

Operation days per year are usually determined in consideration of days of heavy weather, days for maintenance, special holidays, and so on in the case of other bulk terminals. In this study, operation days per year are set at 350 days.

ii) Working Hours per Day

Based on a three-shift working system, working hours per day are usually determined in consideration of time for meal breaks, resting, takeover, maintenance, and so on in the case of other bulk terminals. In this study, working hours per day are set at 18 hours.

(4) Calmness of the Port

Considering the operating rate of coal handling and stability of mooring, 97.5% calmness is determined. The planning area is enclosed by breakwaters and calmness of 97.5% or more is secured. A study on wave forecasting and hindcasting revealed that calmness of more than 99% is secured inside the breakwaters. In case of coal unloading berth is allocated offshore, installing of breakwater is considered.

5.2.2. Port Facilities Planning

(1) Method of Determining the Required Number of Berths

The number of berths to cope with the handling volume is calculated using the following formula:

Number of berths = Berthing days per year / (Operation days per year x Berth occupancy ratio)

Hereto;

Berthing days per year = Number of calling vessels per year x Average berthing days per vessel
Number of calling vessels per year = Handling volume per year / Average carrying volume per vessel
Average berthing days per vessel = (Average carrying volume per vessel /Average handling capacity per day) + Idling days

(Note: this method uses the average value, the peak ratio is sometimes not adequately taken into account.)

Regarding berth occupancy ratio, “Port Development – A Handbook for Planner in Developing Countries” issued by the United Nations Conference on Trade and Development (UNCTAD) indicates the advisable berth occupancy ratios as shown in Table 5.2.4 in the case of break bulk cargo berth. These ratios should not be exceeded.

Table 5.2.4 Berth Occupancy Ratio

Number of Berth	Berth Occupancy Ratio
1	40%
2	50%
3	55%
4	60%
5	65%
6 - 10	70%

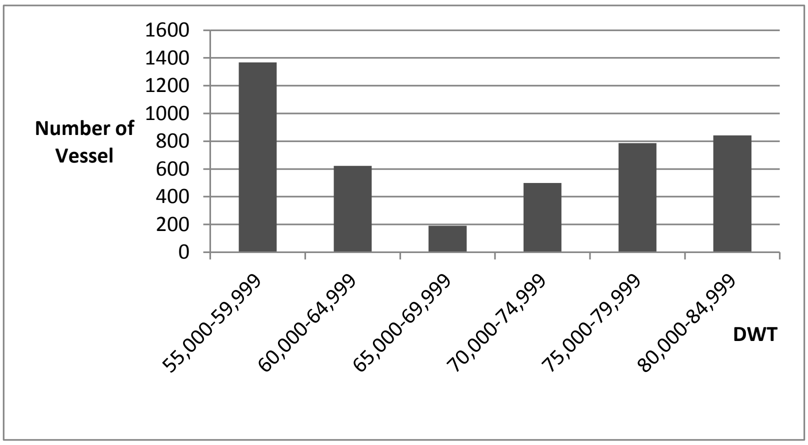
Source: “Port Development – A Handbook for Planner in Developing Countries by UNCTAD

In this study, required number of berths is to be determined from a comprehensive point of view taking into account the above figures, average waiting time of vessels computed by a queuing theory and other factors.

(2) Required Number of Coal Unloading Berths

1) 1st Phase: Handling volume of coal is 8,530 thousand t per year.

The number of Panamax vessels (from 55,000 to 85,000 DWT) by DWT is shown in Figure 5.2.1. Average carrying volume of a Panamax vessel in the 1st Phase is set at 70,000 t.



Source: Fair Play, April 2014

Figure 5.2.1 Number of Vessels by DWT

Required days for unloading 70,000 t of coal are calculated as follows: Idling time is set at 0.5 days, which includes procedures for entering and departing the port, tidal waiting time, and time for mooring and unmooring, etc.

Average berthing days: 1.54 days ((70,000 / (2,500 x 2 x 0.75 x 18)) + 0.5 = 1.54)

Total number of calling vessels is calculated as follows:

Number of calling vessels per year: 122 (8,530,000 /70,000 = 121.9)

Under the above conditions and the assumption that berth occupancy rate is 50%, the number of berths is calculated as follows:

Number of berths: 2 (122 x 1.54 / (350 x 0.5) = 1.07)

The number of berths is two and berth occupancy ratio becomes 26.8% (calculated as (122 x 1.54) / (350 x 2)), which satisfies the advisable berth occupancy ratio by UNCTAD. Average waiting time of vessels is estimated to fall within a range of 0.06 to 0.12 days. To verify that two berths are appropriate, berth occupancy ratio and average waiting time of vessels in the case of only one berth is calculated using the same method above and the queuing theory. As a result, berth occupancy ratio becomes 53.7% which exceeds the criteria of UNCTAD. The average waiting time of vessels is estimated to fall within a range from 0.9 to 1.8 days, which is unacceptable compared with the average berthing time of 1.54 days. Therefore, the required number of coal unloading berths in the 1st Phase is set at 2.

2) 2nd Phase: Handling volume of coal is 1,786 thousand t.per year

Design vessel used is the over-Panamax, therefore average carrying volume is set at 100,000 t. The method to determine the number of berths is the same as the 1st Phase.

Average berthing days: 1.98 days
Number of calling vessels per year: 179
Number of berths: 3 ((179 x 1.98) / (350 x 0.5) = 2.02)

Therefore, the number of berths is three and berth occupancy ratio becomes 33.7%. In the case of two berths, the same as in the 1st Phase, berth occupancy ratio becomes 50.5%, which slightly exceeds the criteria of UNCTAD. The average waiting time of vessels is calculated to fall within a range of 0.34 to 0.68 days. Considering the necessity to respond to the increasing demand toward the 3rd Phase and some constraints related to the approach channel which will be explained in Section 5.2.2 (3), required number of coal unloading berths in the 2nd Phase is set at three. Therefore, one additional berth capable of accommodating a Capesize vessel in the 3rd Phase will be developed with the specifications of the over-Panamax.

3) 3rd Phase: Handling volume of coal is 31,090 thousand t.

In the 3rd Phase, over-Panamax and Capesize vessels are utilized simultaneously to handle the planned volume of coal. For the purpose of balanced usage of two types of berths, allotted volume of transporting coal by two types of vessels is assumed as follows:

Over-Panamax vessel: transporting 15,000 thousand t of coal (150 vessels per year)
Capesize vessel: transporting 16,090 thousand t of coal (101 vessels per year)

Coal transported by the over-Panamax is to be handled at two berths already developed in the 1st Phase. Berth occupancy ratio in this case becomes 42.4% which satisfies the criteria of UNCTAD and the average waiting time is calculated to fall within a range of 0.22 to 0.44 days. Therefore, two berths for the over-Panamax are enough to handle the planned volume in the 3rd Phase.

Under the assumption that the berth occupancy ratio is 50%, the number of berths to be developed for the Capesize is as follows:

Average berthing time per vessel: 2.87 days
Number of berths: 2 ((101 x 2.87) / (350 x 0.5) = 1.66)

The number of berths is two while the berth occupancy ratio becomes 41.4%, which satisfies the criteria of UNCTAD. In addition, the average waiting time of vessels ranges from 0.29 to 0.59 days, which is acceptable compared with the average berthing time of 2.87 days. Therefore, required number of coal unloading berths for the Capesize in the 3rd Phase is set at two, of which one berth already developed in the 2nd Phase is to be upgraded. During actual operations, balanced usage of two types of berths and allocation plan of two types of vessels are essential to avoid vessel congestion and to handle the planned volume of coal smoothly.

(3) Required Number of Coal Loading Berths

The method to examine the required number of coal loading berths is the same as the one used for unloading berths.

1) 1st Phase: Transshipment volume of coal is 3,770 thousand t per year

Idling time for a transshipment vessel of 100,000 DWT is much less compared with unloading vessels because such vessels are used for domestic shipping only. Therefore, idling time is set at around 0.11 days (around 2 hours). Under the assumption that berth occupancy ratio is 50%, the number of berths is calculated as follows:

Average berthing time: 0.32 days
Number of calling vessels per year: 754
Number of berths: 2 ((754 x 0.32) / (350 x 0.5) = 1.38)

The number of berths is two and berth occupancy ratio becomes 34.5%, which satisfies the criteria of UNCTAD. Average waiting time of vessels is estimated to fall within a range of 0.02 to 0.04 days, which is a relatively short period of time compared with the average berthing time of 0.32 days. In the case that the number of berths is one, berth occupancy ratio becomes 68.1%, which exceeds the criteria of UNCTAD and average waiting time of vessels is estimated to range from 0.34 to 0.67 days. This means that the figures exceed the average berthing time so it may not be possible to cope with the demand. Therefore, the required number of coal loading berths in the 1st Phase is set at two.

2) 2nd Phase: Transshipment volume of coal is 11,910 thousand t per year.

Under the assumption that berth occupancy ratio is 60%, the number of berths is as follows:

Number of calling vessels per year: 2,382
Number of berths: 4 ((2,382 x0.32) / (350 x 0.6) = 3.63)

The number of berths is four and berth occupancy ratio becomes 54.4%. This figure satisfies the criteria of UNCTAD and the average waiting time of vessels is calculated ranging from 0.02 to 0.04 days which seems to be relatively small compared with the average berthing time of 0.32 days. In the case that the number of berths is three, berth occupancy ratio becomes 73.6%, which greatly exceeds the criteria of UNCTAD. The average waiting time of vessels is estimated to fall within a range of 0.10 to 0.20 days. Therefore, the required number of coal loading berths in the 2nd Phase is set at four.

3) 3rd Phase: Transshipment volume of coal is 25,140 thousand t per year.

Under the assumption that berth occupancy ratio is 70 %, the number of berths is calculated as follows:

Number of calling vessels per year: 5,028

Number of berths: 7 ((5,028 x 0.32) / (350 x 0.7) = 6.57)

In this case, the number of berths is seven and berth occupancy ratio becomes 65.6%, which satisfies the criteria of UNCTAD, while the average waiting time of vessels is estimated to fall within a range of 0.01 to 0.03 days, which is satisfactory compared with the average berthing time of 0.32 days. In the case of six berths, berth occupancy ratio becomes 76.6%, which exceeds the criteria of UNCTAD while the average waiting time of vessels is calculated to fall within a range of 0.05 to 0.09. Considering the usage of 2,000 to 3,000 DWT of vessels in addition to 5,000 DWT of vessels, the required number of coal loading berths in the 3rd Phase is set at seven.

Remarks: Average waiting time of vessels in this report is to be calculated using the computational function in the website (http://queueingtoolpal.org/). Under the assumption that distribution of the arrival ratio follows Poisson distribution and that of the berthing time follows exponential distribution or constant, computational calculation is conducted. Though no data on port activities are obtained because facilities are still in the planning stage, actual waiting time of vessels seems to fall within the range of the two figures.

(4) Approach Channel and Basin

1) 1st Phase and 2nd Phase

The scale of the approach channel and basin in the 1st Phase and 2nd Phase are set as follows:

i) Approach Channel

The approach channel is to be developed as a one-way channel because the number of calling vessels is limited and for economic efficiency of the CTT Project. The width of the approach channel is set at least five times the beam of the design vessel based on the report of UNCTAD and the Japanese technical standard. Therefore, the width is set at 200 m or more. It is necessary to install navies in the approach channel to secure the safety of navigation.

Regarding the depth of the approach channel, many bulk terminals worldwide utilize tidal differences, so such an idea may be considered in determining the channel depth. Ideal depth of the channel is 16.0 m which is calculated by multiplying the draft (14.5 m) of the design vessel by 1.1. To obtain the practical depth, half of the tidal difference (around 3.13 m) is subtracted from 16.0 m. As a result, the depth of the approach channel is set at 14.5 m. Regarding the channel for transshipment, the approach channel and the Hau River Bypass Canal satisfy the specifications necessary for a transshipment vessel to navigate.

ii) Basin

The depth of the basin for the over Panamax is to be at 16.0 m, which is equivalent to 1.1 times the draft (14.5 m), while the turning basin should better have a diameter of nearly two times the LOA because the water area has sufficient calmness and this port is exclusively used for coal transport. Regarding a basin for transshipment, it is recommended that a turning basin developed for the Duyen Hai Power Plant be utilized in the 1st Phase. The required water depth of the basin is 9.0 m.

In the 2nd Phase, because the number of calling vessels for transshipment will increase, a turning basin for transshipment is to be developed to avoid congestion; the size of the turning basin should provide a minimum turning diameter of two times the length of the design vessel.

2) 3rd Phase

The Capesize is added as the design vessel in the 3rd Phase, so the scale of the channel and basin are set as follows:

i) Approach Channel

The width of the approach channel is to be 225 m or more, which is five times the beam (45 m) of the Capesize. The depth of the approach channel utilizing the tidal difference is to be at 17.5 m.

ii) Basin

The basin for the Capesize has to be developed in the same manner as above. The depth of the turning basin is to be at 19.0 m and a turning basin with a diameter of nearly two times LOA.

(5) Breakwater

In the case that coal unloading berth is allocated outside of the existing plan of breakwater, it is necessary to install breakwater for maintaining calmness in the channel and turning basin. The calmness of 97.5% is considered in terms of operation rate of coal handling and stability of mooring vessels in this study.

The result of short term wave observation shown in Chapter 3.3, the wave directions of east-northeast (ENE) and south-southwest (SSW) prevail at the planning site. The hindcast wave date from 2000 to 2010 shown in Ttable 5.2.5, which is estimated by wave deformation analysis also shows that directions of ENE and SSW prevail.

The frequency of wave direction of SSW with over 1.5 m high is less than 2.5% of all waves. On the other hand, the frequency of wave direction of SSW with over 1.5 m high is larger than 2.5% of all waves. Therefore, it is necessary to install breakwater to prevent waves with ENE directions. The minimum length of breakwater which is estimated from the calculation of wave diffraction is also considered.

Table 5.2.5 Yearly Compound Frequency Table by Wave Height and Direction (ST2:2000~2010)

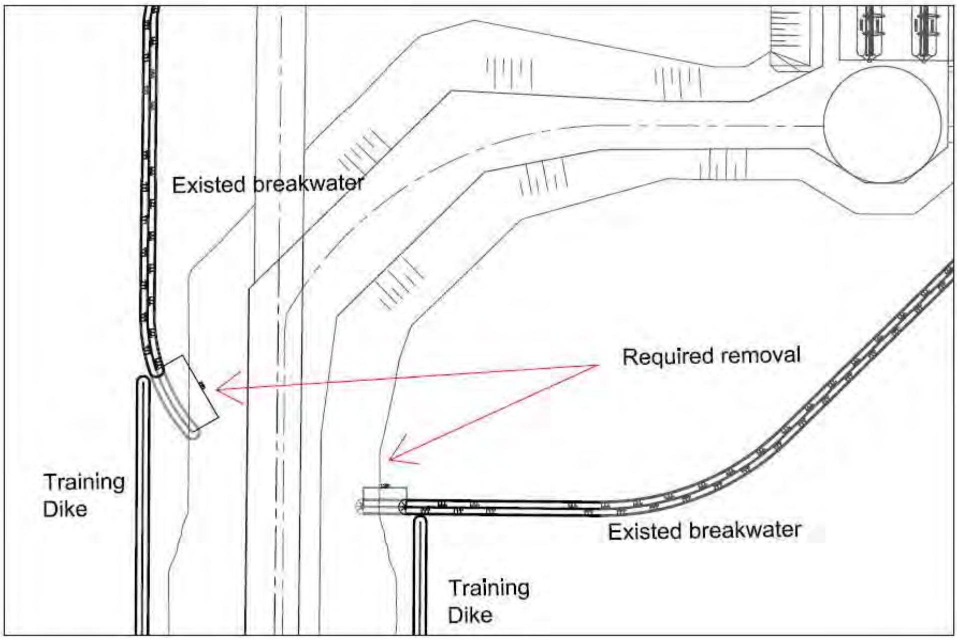
Mecon ERR. 640

H(m) \ Deg	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	CALM	出現頻度 (回)	出現頻度 (%)	累積出現頻度 (回)	累積出現頻度 (%)
CALM																	1201	1201	3.8	1201	3.8
~0.1	0	0	24	52	23	23	2	12	36	1	0	0	0	0	0	0		173	0.6	1374	4.4
~0.2	0	0	122	91	57	21	17	56	90	4	0	0	0	0	0	0		458	1.5	1832	5.8
~0.3	0	24	322	18	15	11	6	61	264	23	0	0	0	0	0	0		744	2.4	2576	8.2
~0.4	0	66	806	96	23	9	17	187	504	41	0	0	0	0	0	0		1749	5.6	4325	13.8
~0.5	0	170	1853	205	35	12	21	298	847	46	0	0	0	0	0	0		3487	11.1	7812	24.9
~0.6	0	173	1422	144	34	11	27	322	949	71	0	0	0	0	0	0		3153	10.0	10965	34.9
~0.7	0	201	1586	122	26	4	11	213	790	57	0	0	0	0	0	0		3004	9.6	13969	44.5
~0.8	0	184	1184	143	22	3	3	155	544	40	0	0	0	0	0	0		2278	7.3	16247	51.7
~0.9	0	160	1107	101	9	6	5	144	534	34	0	0	0	0	0	0		2100	6.7	18347	58.4
~1.0	0	87	918	92	2	2	0	62	380	32	0	0	0	0	0	0		1575	5.0	19922	63.4
~1.1	0	66	843	51	0	0	0	84	327	13	0	0	0	0	0	0		1384	4.4	21306	67.8
~1.2	0	79	920	42	0	0	0	61	267	13	0	0	0	0	0	0		1382	4.4	22688	72.2
~1.3	0	58	715	21	0	0	0	47	147	10	0	0	0	0	0	0		998	3.2	23686	75.4
~1.4	0	74	889	10	0	0	0	31	116	6	0	0	0	0	0	0		1126	3.6	24812	79.0
~1.5	0	46	688	8	0	0	0	19	45	3	0	0	0	0	0	0		809	2.6	25621	81.6
~1.6	0	47	735	7	0	0	0	7	42	1	0	0	0	0	0	0		839	2.7	26460	84.3
~1.8	0	103	1062	4	0	0	0	11	40	0	0	0	0	0	0	0		1220	3.9	27680	88.1
~2.0	0	86	819	3	1	1	2	5	18	0	0	0	0	0	0	0		935	3.0	28615	91.1
~2.2	0	119	669	4	0	0	0	2	5	0	0	0	0	0	0	0		799	2.5	29414	93.7
~2.4	0	98	593	3	0	0	0	0	0	0	0	0	0	0	0	0		694	2.2	30108	95.9
~2.5	0	40	186	1	0	0	0	0	0	0	0	0	0	0	0	0		227	0.7	30335	96.6
~3.0	0	41	663	4	0	0	0	0	0	0	0	0	0	0	0	0		708	2.3	31043	98.8
~3.5	0	25	275	1	0	0	0	0	0	0	0	0	0	0	0	0		301	1.0	31344	99.8
~4.0	0	12	48	0	0	0	0	0	0	0	0	0	0	0	0	0		60	0.2	31404	100.0
~5.0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0		2	0.0	31406	100.0
5.0~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0.0	31406	100.0
出現頻度 (回)	0	1939	####	1223	247	103	111	1777	5945	395	0	0	0	0	0	0	1201	31406	100.0		
出現頻度 (%)	0.0	6.2	58.7	3.9	0.8	0.3	0.4	5.7	18.9	1.3	0.0	0.0	0.0	0.0	0.0	0.0	3.8	100.0			

Source: Wave deformation calculated by the JICA Study Team based on offshore wave data provided from Met Office (UK).

(6) Removal of Existing Breakwater for the Duyen Hai CFPP

As mentioned above, the channel width and depth is expanded. The part of existing breakwater which is overlapped with the channel should be removed to maintain its stability. Although the calmness of the port is not maintained due to the removal of the breakwater, the calmness of 97.5% is ensured by installing the training dike from the mouth of the port to offshore along the channel. The length of the removal is determined by considering the slope stability of the breakwater.

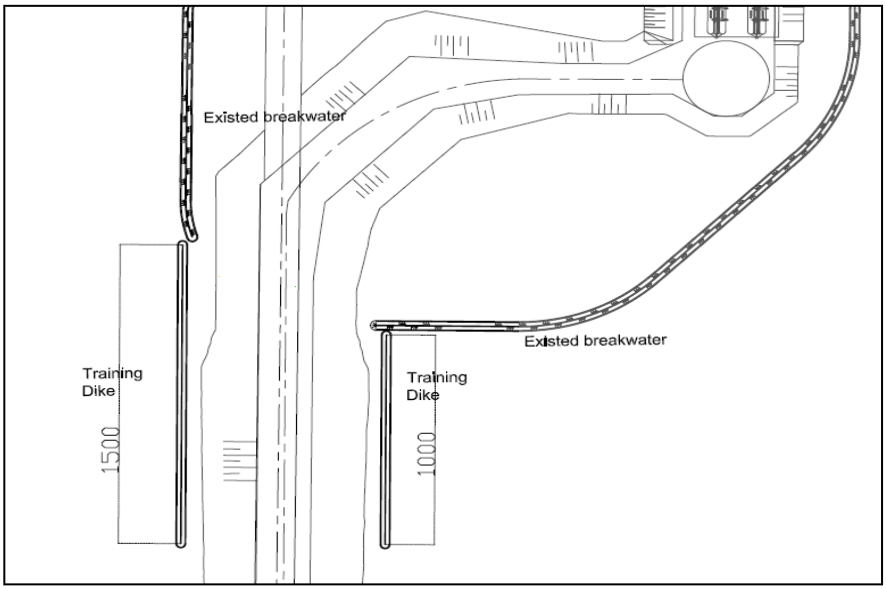


Source: JICA Study Team

Figure 5.2.2 Layout of Removal of Existing Breakwater

(7) Training Dike

As a result of the simulation study of channel deposition shown in Chapter 4.7, the case that a training dike is not constructed is most efficient. However, installation of a training dike is necessary to maintain the calmness of the port because the top part of the existing breakwater is removed. The training dike is allocated from the mouth of the port to offshore along the channel. The length of the training dike is determined by considering stopping distance of large vessels.



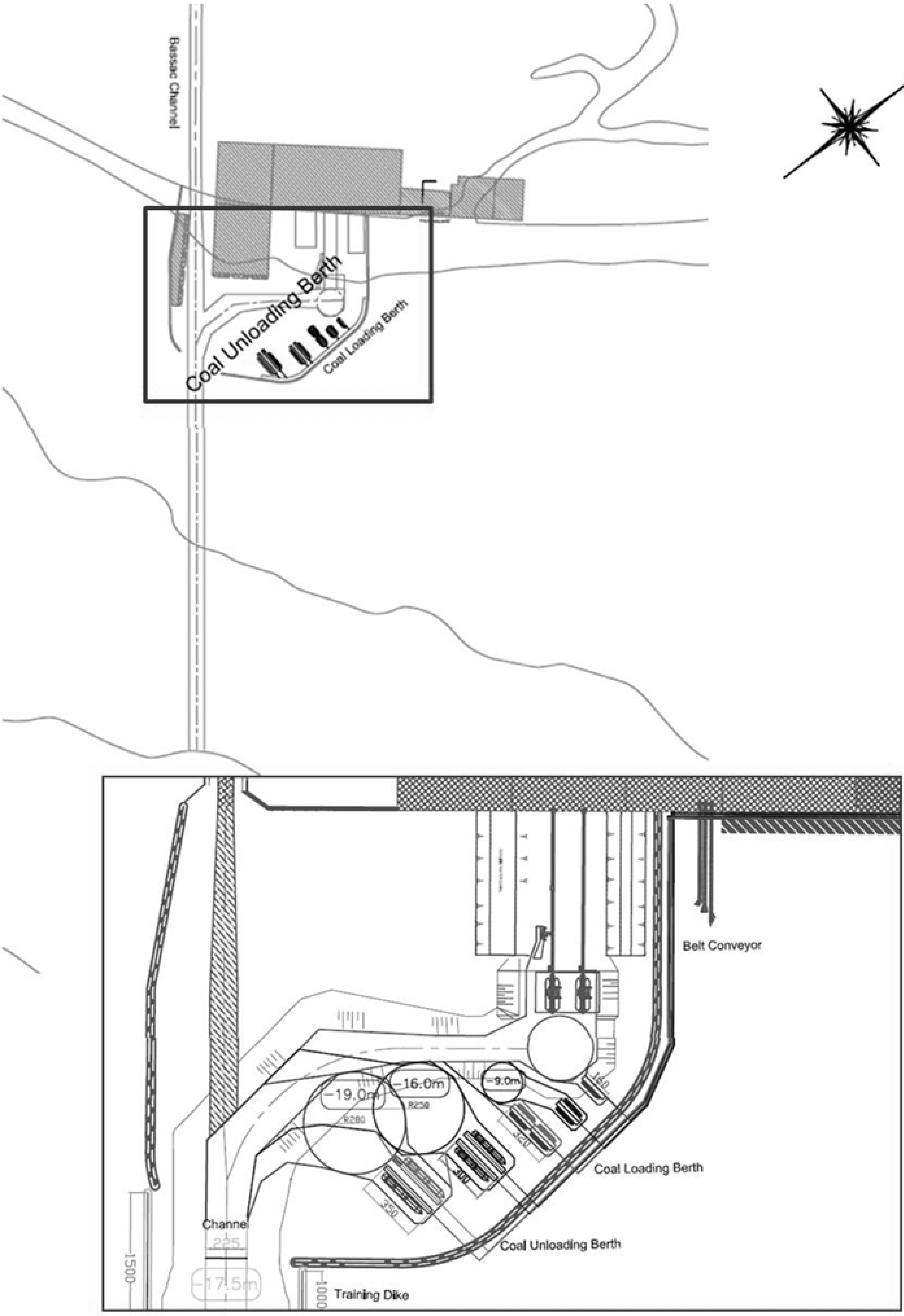
Source: JICA Study Team

Figure 5.2.3 Layout of a Training Dike

(8) Alternative Plans of Port Layout

Based on the above conditions, three types of berth locations are shown in Figure 5.2.4 to Figure 5.2.6.

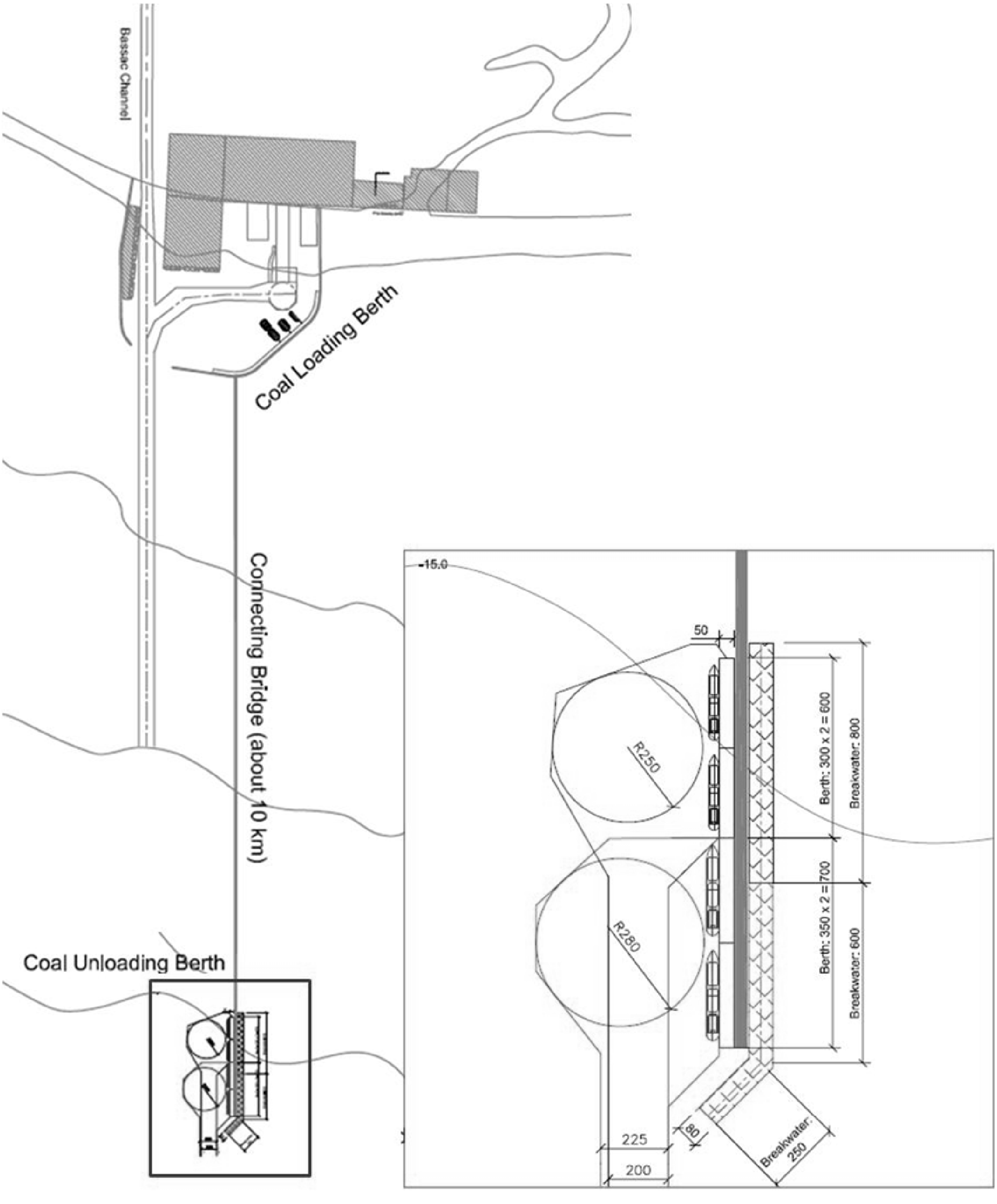
1) In the harbor type



Source: JICA Study Team

Figure 5.2.4 In Harbor Type

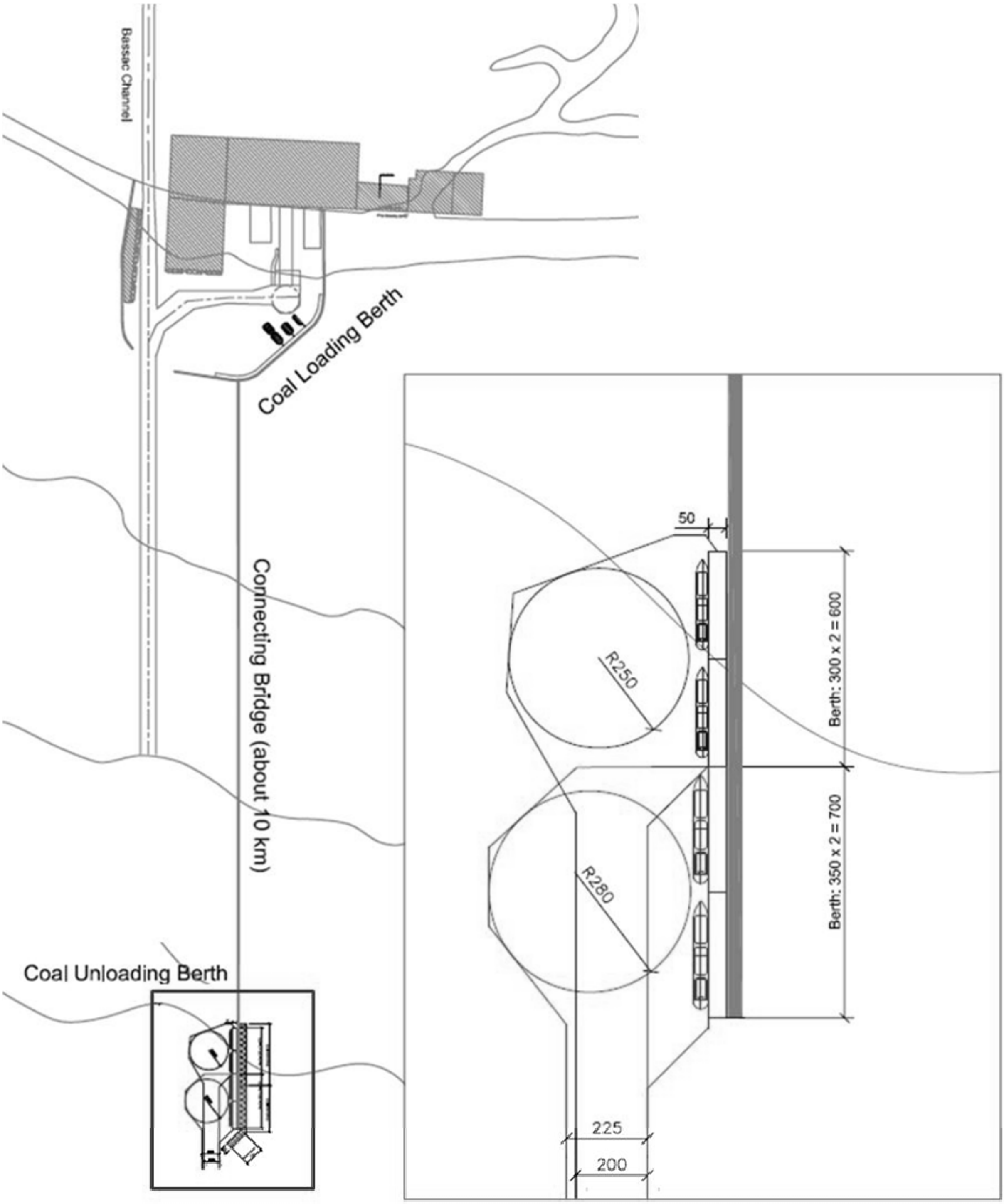
2) Offshore Type with Breakwater



Source: JICA Study Team

Figure 5.2.5 Offshore Type with Breakwater

3) Offshore Type without Breakwater



Source: JICA Study Team

Figure 5.2.6 Offshore Type without Breakwater

5.2.3. Preliminary Selection of the Coal Storage Yard Site

(1) Candidate Location

The following locations are compared as candidates for the coal storage yard site.

(a) South side of the Hau River Bypass Canal
(b) Land side of the power plant area
(c) North side of the power plant area (onshore)
(d) North side of the power plant area (offshore)
(e) South side of the power plant area (offshore)

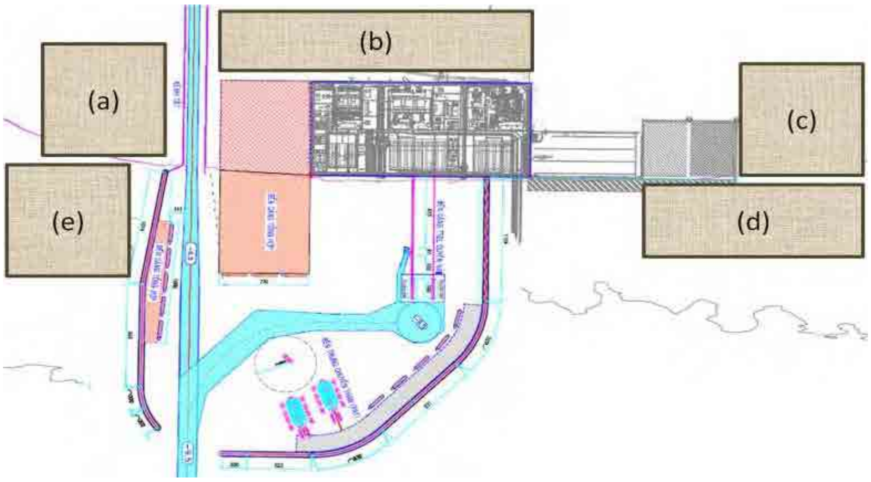


Figure 5.2.7 Candidate Locations of the Coal Storage Yard

(2) Pre-conditions of the Comparative Study

Below are the following conditions applied for the comparative study.

- Area: Maximum approximately 200 ha (width 1,000 m x length 2,000 m)
- It may be required to be extended.
- Loading berth will be located inside of the breakwater
- Duyen Hai Power Plant will use coal from this coal storage yard

(3) Comparative Factors of the Coal Storage Yard Location

Candidates will be compared based on the following seven factors as mentioned below.

1) Distance from loading berth
2) Accessibility to the Duyen Hai Power Plant
3) Capability of extension (land availability)
4) Compensation to existing residence
5) Construction cost
6) Impact on the surrounding environment
7) Surrounding situations by CTT construction works

8) Surrounding situations by exploitation and operation of CTT
9) Related expenses for CTT such as preparation of lifeline, etc.

(4) Given Points in the Comparative Table

Each candidate will get points from 1 to 5 for each factor mentioned above. Grade of each point is explained below.

- Point 5 : Excellent (there is no demerit and more than one merit)
- Point 4 : Good (there is no demerit and one merit)
- Point 3 : Ordinary (standard points)
- Point 2 : Countermeasure is required (demerit should be considered)
- Point 1 : Not recommended (serious demerit)

(5) Results of the Comparative Study

According to the comparative study, each candidate got the following points as shown in Table 5.2.6.

Table 5.2.6 Results of the Comparative Study

No.	Condition	(a)	(b)	(c)	(d)	(e)
1	Distance from loading berth	1	3	3	3	1
2	Accessibility to the Duyen Hai Power Plant	1	5	4	4	1
3	Capability of extension	5	1	3	3	3
4	Compensation to existing residence	3	1	3	5	5
5	Construction cost	3	4	4	2	2
6	Impact on the surrounding environment	3	1	3	2	2
7	Surrounding situations by CTT construction works	3	3	3	3	3
8	Surrounding situations by exploitation and operation of CTT	3	3	3	3	3
9	Related expenses for CTT such as preparation of lifeline, etc.	3	3	3	3	3
	Total Points	25	24	29	28	23

(6) Explanation of the Comparative Table

Reasons for obtaining such points are explained below.

1) Distance from Loading Berth

Items	(a)	(b)	(c)	(d)	(e)
Distance from loading berth	More than 5 km from loading berth and crossing over the channel for transporting coal to/from the loading/unloading berth is necessary (serious demerit)	Approximately 3 km to 5 km from loading berth (standard)	Approximately 3 km from loading berth (standard)	Approximately 3 km from loading berth (standard)	More than 5 km from loading berth and crossing over the channel (serious demerit)

2) Accessibility to the Duyen Hai Power Plant

Items	(a)	(b)	(c)	(d)	(e)
Accessibility to the Duyen Hai Power Plant	Approximately 2 km from the power plant and crossing over the channel is necessary (serious demerit)	Just behind the power plant (nearest location to the plant without objection)	Approximately 1 km from the power plant (near location to the plant)	Approximately 1 km from the power plant (near location to the plant)	Approximately 2 km from the power plant and crossing over the channel is necessary (serious demerit)

3) Capability of Extension

Items	(a)	(b)	(c)	(d)	(e)
Capability of extension	Easy to be extended to the sea side, west side and north side (it can be extended in 3 directions)	There are residential areas, roads, and a power plant around the location (extension is not possible : serious demerit)	Easy to be extended to the sea side and east side (it can be extended in 2 directions)	Easy to be extended to the sea side and east side (it can be extended in 2 directions)	Easy to be extended to the sea side and west side (it can be extended in 2 directions)

4) Compensation to Existing Residence

Conditions of resettlement of the existing residence for each candidate location and condition of the fish pond are summarized in the table shown below.

Items	(a)	(b)	(c)	(d)	(e)
Conditions of resettlement	There is a community, and approx. 80 families are living in the area inside the dike.	There are family houses, retailer shops, restaurants, and small factories (approx.:80 in numbers.). Because many people are living in this area, the resettlement will be difficult.	Fishermen and farmers are living in the community, 20 families which are necessary to be resettled are living in the targeted area required in the 3rd Phase (72 ha)	No residents are living in the area along the coastal area; therefore resettlement and land acquisition is not necessary.	No residents are living in the coastal area; therefore resettlement is not necessary. 10 watching houses for fish ponds are available.
Fishery and Fish pond	Almost land utilization is allocated for fish ponds, and fishing activity is conducted.	Fish ponds are placed but small in numbers.	Fishermen are conducting small-scale aquaculture which utilize the rivers	Having shallow coastal area and no fishing operation is conducted.	Conduct of aquaculture which utilizes ponds.
Evaluation	There are many fish ponds and little residence (standard compensation as similar project)	There are some residence (time consuming cumbersome procedure is necessary by following JICA's guideline : serious demerit)	There are many fish ponds and little residence (standard compensation as similar project)	There is no fish pond and residence (no compensation)	There is no fish pond and residence (no compensation)

5) Construction Cost

Items	(a)	(b)	(c)	(d)	(e)
Construction cost	There is no access road for construction (there is no serious factor of additional cost)	Same work items with (a), but there is access road (there is no factor of additional cost)	Same condition with (b) (there is no factor of additional cost)	Revetment construction is required and reclamation quantity becomes larger than (b) (there is a factor of additional cost but not so serious)	Revetment construction is required and reclamation quantity becomes larger than (a) (there is a factor of additional cost but not so serious)

6) Impact on the Surrounding Environment

Table below shows the explanation of the evaluations in this category.

Items	(a)	(b)	(c)	(d)	(e)
Ecology and mangroves	A little forest remained in the area, but is not considered valuable.	Mangrove forest is not present in almost all of the area.	A little mangrove forest is available in the area, but is not considered valuable as designated in IUCN red data book.	No vegetation including mangrove. Formerly, there are mangrove trees along the coastal area, but vegetation has disappeared by soil erosion.	Mangroves are planted for protection of coastal area from erosion (by the World Bank Project). For implementation of the project, many mangrove trees have to be cut down.
Farmland	A little farmland is available	A little farmland is available	Farming is conducted along to the coastal area.	No farmland	No farmland
Topography and Geographical Features	There are many fish ponds and require large-scale land reclamation for the project.	Land reclamation of some area has been completed but some area remained as existing pond.	Land reclamation for power plant area has been completed, but still requires necessary reclamation for the existing ponds and fish ponds.	Having long and shallow coastal area and require large-scale land reclamation.	Having shallow coastal area and require large-scale land reclamation.
Marshes and river	Available marshes	Available marshes	Available marshes and small rivers	Available rivers flowing to sea	Available many marshes

7) Surrounding Situation of the CTT Construction Works

There is a little difference between each candidate.

8) Surrounding Situation of the Exploitation and Operation of the CTT

There is a little difference between each candidate.

9) Related Expenses for the CTT such as Preparation of Lifeline, Etc.

There is a little difference between each candidate.

(7) Recommended Location of the Coal Storage Yard

According to the results of the comparative study, candidate location (c) is recommended as the coal storage yard. When alarger area is required than tentative area, candidate location (d) might be used for the extension of the yard.

(8) Candidate Locations (a) and (e)

Tra Vinh Province PC had expressed their request about the selection of coal storage site at candidate locations (a) and (e) (see Appendix D).

Locations (a) and (e) had a disadvantage on the coal transportation from unloading/loading berths to the candidate site due to their long distance transportation and necessity of crossing the channel and had low evaluation in coal storage site selection although other factors showed appropriate results as shown above.

Construction of new port and imported coal unloading and loading berths at the other side of the canal entrance is the possible idea to overcome these disadvantages. Construction and maintenance cost of coal transportation facilities and equipment could be reduced. But careful consideration of the following issues are necessary:

- Construction cost will be increased because of the necessity of constructing new breakwater and additional channel and basin dredging, therefore, total project cost will significantly increase.
- Maintenance cost of coal transportation facilities and equipment could be less because of the short total length of these facilities.
- Secondary transportation of coal by barge is necessary for coal supply to Duyen Hai CFTT that affects the total cost of coal for Duyen Hai CFTT.

The JICA Study Team concluded by considering the above issues that sites (c) and (d) were the most appropriate sites for coal storage and the draft final report (DF/R) was complied based on this idea. Because the request of the local government should be appreciated, sites (a) and (e) were also considered as candidates of coal storage yard and the results are given in Appendix D.

5.2.4. Terminal Planning

(1) Conditions for Terminal Planning

The following conditions for terminal planning are set up.

- Coal handling volume at terminal (stock): 25.14 million t/year
- Specific gravity: 0.9
- Yard operation efficiency: 0.75
- Unloader: continuous type 2,500 t/h
- Ship loader: 1,500 t/h

- Stacker / reclaimer: 5,500 t/h, 3,000 t/h
- Belt conveyor (unloading): 5,500 t/h
- Belt conveyor (discharging): 3,300 t/h
- Coal stock volume at each coal-fired power plant: for 15 days to 30 days

(2) Coal Stock Volumes Corresponding to Three Alternative Plans of Unloading Berth

1) Inside the Breakwaters Plan

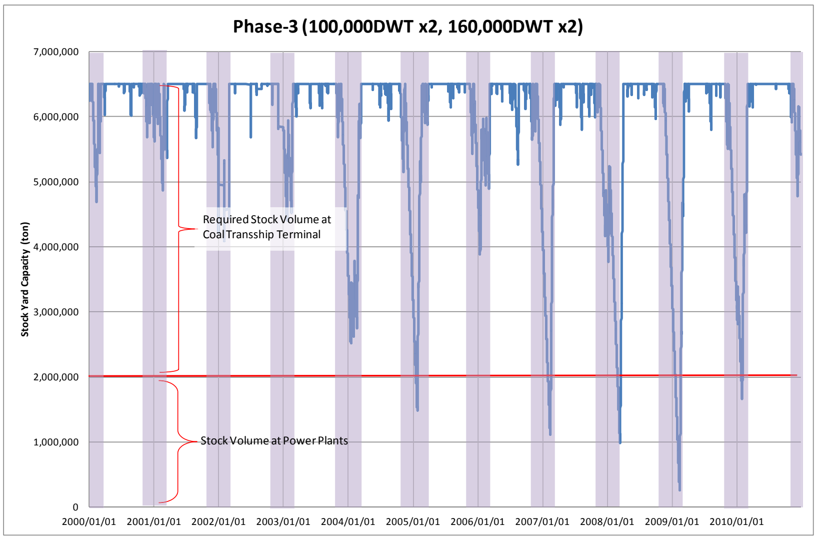
A stable coal handling toward the wave condition could be done. Therefore, the coal stock volume at the terminal is determined to be for 30 days (1 month) of annual coal handling volume. It is calculated as follows: 25.14 million t/year divided by 12 months is equal to 2.095 million t/month.

2) Outside the Breakwaters (with Breakwater) Plan

As same as above "Inside the Breakwaters Plan", a stable coal handling toward the wave condition could be done. Therefore, the coal stock volume at the terminal is determined to be for 30 days (1 month) of annual coal handling volume.

3) Outside the Breakwaters (without Breakwater) Plan

Without breakwater, waves affect coal unloading operation and coal unloading operation rate goes down. Especially from November to February, almost no coal unloading operation can be conducted. Thus, it is necessary to stock coal at the stock yard from March and October. The required coal stock volume at the terminal is calculated at 4.5 million t/year based on the wave data from January 2001 to December 2010, with an assumption that coal stock volume at each coal-fired power plant is for 30 days. Figure 5.2.8 shows the coal stock volume at the terminal.



Source: JICA Study Team

Figure 5.2.8 Coal Stock Volume at the Terminal (Outside the Breakwaters (without Breakwater))

(3) Terminal Layouts Corresponding to Three Alternative Plans of Unloading Berth

1) Stockpile

The dimensions of stockpile are determined as illustrated in Figure 5.2.9 below.

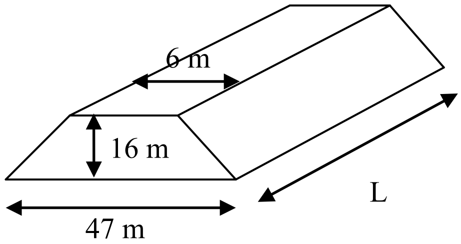


Figure 5.2.9 Dimensions of Stockpile

The sectional area is calculated as follows: A＝(6+47) x 16÷2＝424 m^2.

Coal stock volume, length, and number of stockpile and required terminal areas for alternative plans are computed and summarized below. Terminal layouts of alternative plans are shown in Figures 5.2.10 to 5.2.12.

Table 5.2.7 Required Terminal Areas for Alternative Plans

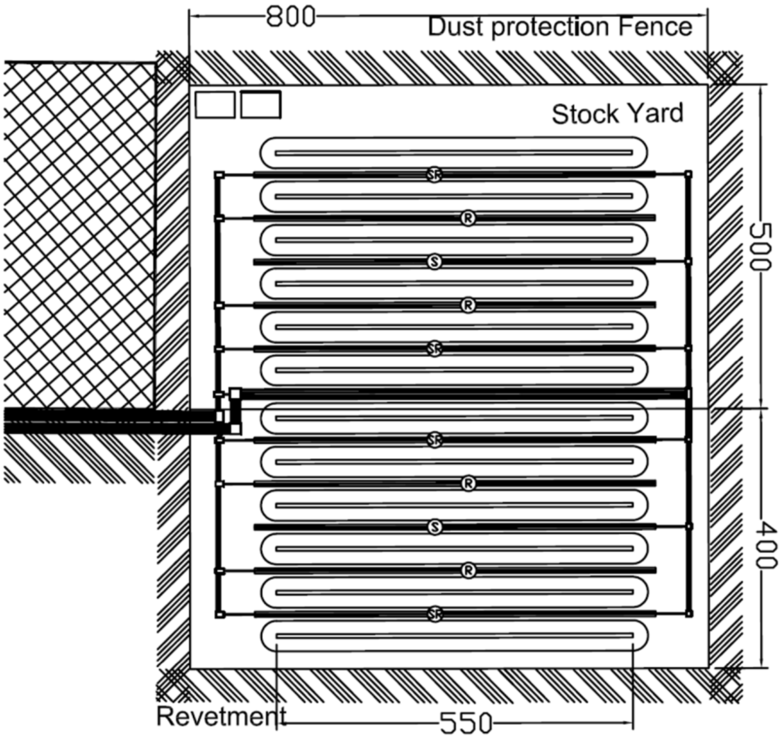
	Coal Stock Volume (million t)	Yard Operation Efficiency	Length of Stockpile (m)	Number of Stockpile	Required Terminal Area (ha)
Inside Breakwaters	2.095	0.75	550	12	72
Outside Breakwaters (with breakwater)	2.095	0.75	550	12	72
Outside Breakwaters (without breakwater)	4.50	0.75	1,200	12	135

Source: JICA Study Team

To prevent from coal fire in the stockpile, countermeasures such as temperature monitoring of inside stockpile, water sprinkling, roller compaction by bulldozer, or coal transportation from pile to pile are taken into consideration.

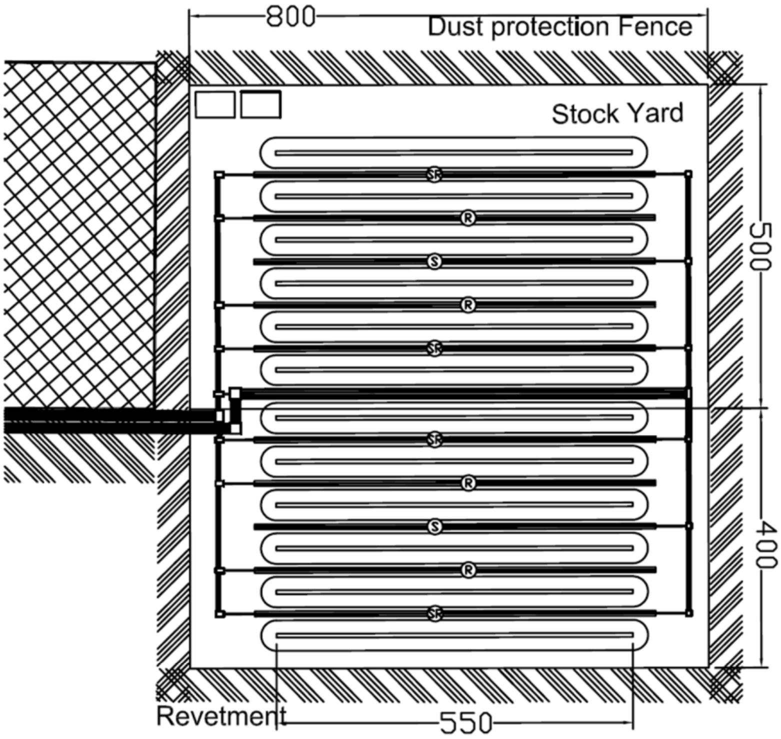
2) Other Facilities

Administration building, maintenance house, fire fighting, sub-station, wind protection wall, security fence. and so on are installed.



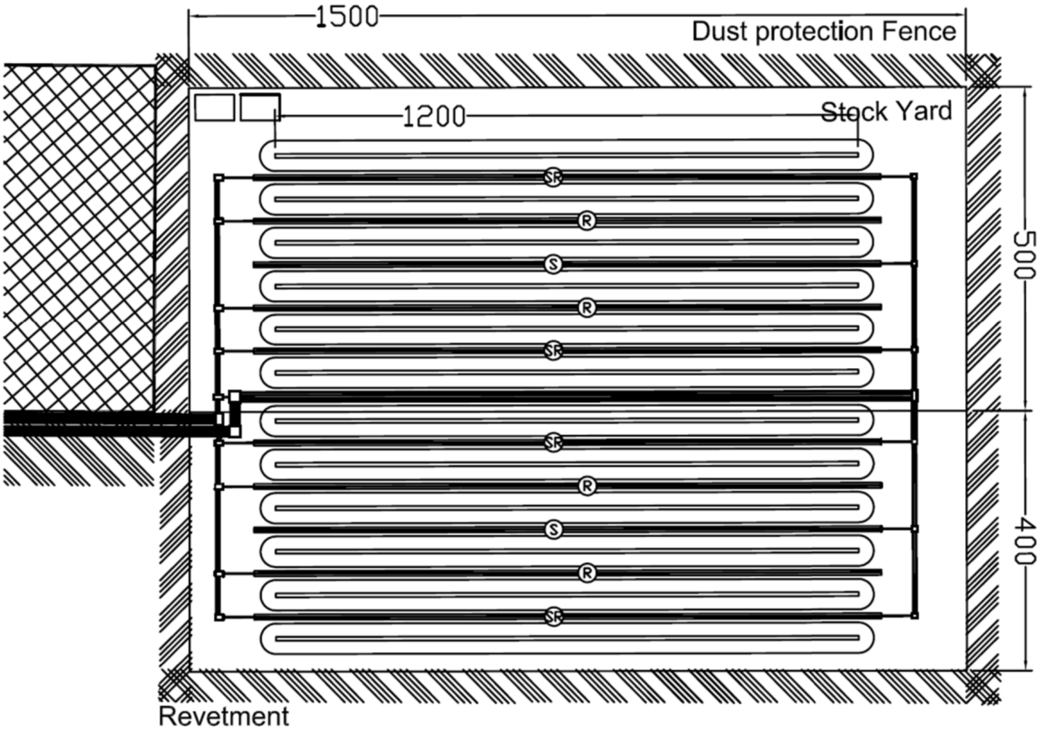
Source: JICA Study Team

Figure 5.2.10 Terminal Layout (Inside the Breakwaters)



Source: JICA Study Team

Figure 5.2.11 Terminal Layout (Outside the Breakwaters (with breakwater))



Source: JICA Study Team

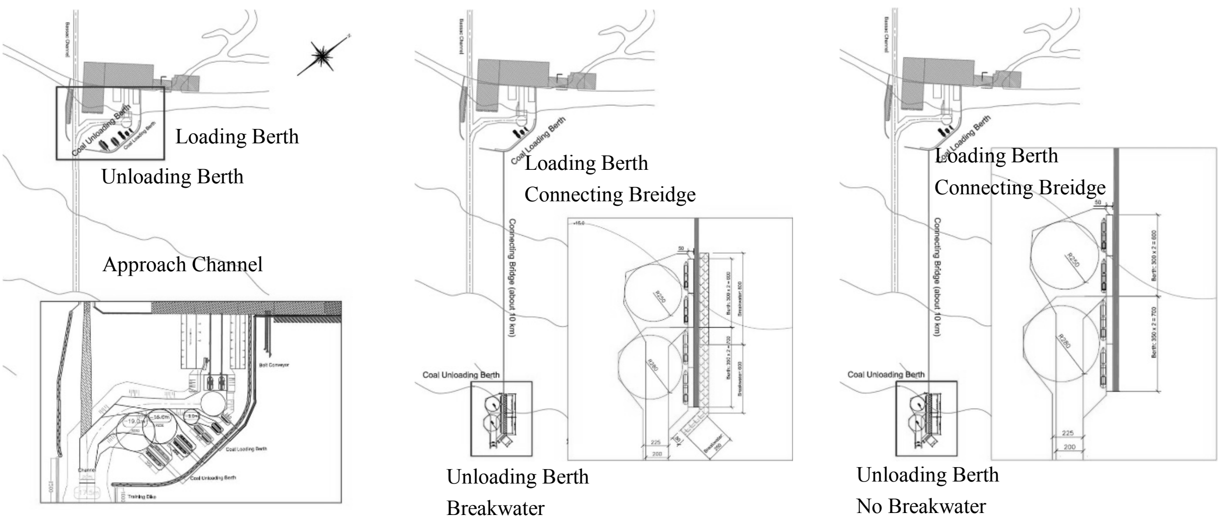
Figure 5.2.12 Terminal Layout (Outside the Breakwaters (without breakwater))

5.2.5. Preliminary Selection of the Terminal Type

(1) Candidates of Terminal Type

The following types are compared as main candidates of the terminal. Sketch of each candidate is shown in Figure 5.2.13.

(a) In harbor type (b) Offshore type with Breakwater (c) Offshore type without Breakwater



Source: JICA Study Team

Figure 5.2.13 Candidate Types of the Terminal

(2) Pre-conditions of the Comparative Study

The following conditions are applied for this comparative study tentatively.

Table 5.2.8 Pre-conditions of the Comparative Study

No.	Item	Condition
1	Coal demand	Calculated based on the "Decision No.5964/QD-BCT(9 Oct. 2012)"
2	Coal consumption	3.1 K t/Mw
3	Target ship size in 2020	70,000 DWT
4	Target ship size in 2025	100,000 DWT
5	Target ship size in 2030	160,000 DWT
6	Coal stock of the power plant	0.5 month for operation
7	Low activity ratio period of the berth without breakwater	4 months (From Nov to Feb)
8	Location of the loading berth	In harbor
9	Location of the coal stock yard	North-east of the power plant
10	Type of breakwater	Caisson
11	Type of training dike	Rubble type
12	Coal stock capacity of the coal stock yard	0.02 ha/K t
13	Working day of the terminal	350 days/year
14	Working time of the terminal	18 hours/day
15	Capacity of the coal unloading equipment	2,500 t/h
16	Operation efficiency of the coal unloading equipment	75 %
17	Capacity of the coal loading equipment	1,500 t/h
18	Target ship size for loading	5,000～10,000 DWT
19	Operation efficiency of the coal loading equipment	90%

Source: JICA Study Team

(3) Comparative Table of the Terminal Type in 2020 (1st Phase)

Based on the pre-conditions, necessary facilities are studied for each type. Conditions and facilities necessary for each type in 2020 are shown in Table 5.2.9.

Table 5.2.9 Comparative Table of the Terminal Type in 2020 (1st Phase)

No.	Condition Factor	Unit	In Harbor Type	Offshore Type with Breakwater	Offshore Type without Breakwater
1	Coal demand	K t/year	8,530	8,530	8,530
2	Area of the coal storage yard	ha	22	22	45
3	Stacker reclaimer	Unit	3	3	3
4	Unloading berth number	Berth	2	2	2
5	Unloading equipment number	Unit	4	4	4
6	Loading berth number	Berth	2	2	2
7	Loading equipment number	Unit	2	2	2
8	Belt conveyer of unloading line	km	13	33	33
9	Belt conveyer of loading line	km	10	10	10
10	Access bridge	km	N/A	12	12
11	Breakwater	km	N/A	2	2
12	Initial dredging and disposal	m^3	20,000,000	N/A	N/A
13	Maintenance dredging	m^3/year	1,790,000	N/A	N/A
14	Channel protection dike	km	2.5	N/A	N/A

15	Buildings and wall	L.S.	1.0	1.0	2.0

Source: JICA Study Team

(4) Initial Cost Points of the Terminal Type in 2020 (1st Phase)

Initial construction cost and coal handling equipment cost for the 1st phase is estimated tentatively for comparing each type. Estimated initial cost points for each type in 2020 is shown in Table 5.2.10.

Table 5.2.10 Comparative Table for the Initial Cost Points of the Terminal Type in 2020 (1st Phase)

No.	Cost Factor	In Harbor Type	Offshore Type with Breakwater	Offshore Type without Breakwater
1	Earthworks of storage yard	255	255	478
2	Stacker reclaimer	97	97	97
3	Unloading berth	309	309	309
4	Unloading equipment	264	264	264
5	Loading berth	44	44	44
6	Loading equipment	66	66	66
7	Belt conveyer of unloading line	517	1,294	1,294
8	Belt conveyer of loading line	230	230	230
9	Belt conveyer in storage yard	10	10	10
10	Access bridge	0	1,500	1,500
11	Breakwater	0	1,230	0
12	Initial dredging and disposal	972	0	0
13	Channel protection dike	236	0	0
14	Buildings and wall	261	261	489
	Total Initial Cost Points	3,261	5,559	4,780

Source: JICA Study Team

Note: Unit is cost points

(5) Additional Facilities and Construction Works

Required facilities and construction works up to 2030 (3rd Phase) are shown in Table 5.2.11.

Table 5.2.11 Additional Facilities and Construction Works up to 2030 (3rd Phase)

No.	Facilities and Construction Works	Unit	In Harbor Type	Offshore Type with Breakwater	Offshore Type without Breakwater
1	Coal demand	K t/year	31,090 (8,530)	31,090 (8,530)	31,090 (8,530)
2	Coal stock volume at CT	K t	2,591 (314)	2,591 (314)	10,363 (1,257)
3	Area of the coal storage yard	ha	72(22)	72 (22)	135(45)
4	Stacker reclaimer	unit	10(3)	10 (3)	10(3)
5	Unloading berth number	berth	4 (2)	4 (2)	4 (2)
6	Unloading equipment number	unit	8 (4)	8 (4)	8 (4)
7	Loading berth number	berth	7(2)	7(2)	7 (2)
8	Loading equipment number	unit	7 (2)	7 (2)	7 (2)
9	Belt conveyer of unloading line	km	31 (13)	71 (31)	71(31)
10	Belt conveyer of loading line	km	21 (10)	21 (10)	21 (10)

11	Access bridge	km	(N/A)	12 (12)	12 (12)
12	Breakwater	km	(N/A)	2 (2)	2 (2)
13	Initial dredging and disposal	m^3	17,500,000 (20,000,000)	(N/A)	(N/A)
14	Maintenance dredging	m^3/year	2,090,000	(N/A)	(N/A)
15	Channel protection dike	km	2.5(2.5)	(N/A)	(N/A)
16	Buildings and wall	L.S	2.0 (1.0)	2.0 (1.0)	4.0 (2.0)

Note : Quantity is required in 2030, ( ) is required in 2020

Source: JICA Study Team

(6) Additional Cost Points up to 2030 (3rd Phase)

Additional cost points for the required facilities and construction works up to 2030 (3rd Phase) are shown in Table 5.2.12.

Table 5.2.12 Additional Cost Points up to 2030 (3rd Phase)

No.	Cost Factor	In Harbor Type	Offshore Type with Breakwater	Offshore Type without Breakwater
1	Earthworks of storage yard	579	579	1,086
2	Stacker reclaimer	225	225	225
3	Unloading berth	309	309	309
4	Unloading equipment	305	305	305
5	Loading berth	110	110	110
6	Loading equipment	166	166	166
7	Belt conveyer of unloading line	686	1,490	1,490
8	Belt conveyer of loading line	276	276	276
9	Belt conveyer in storage yard	10	10	10
10	Initial dredging and disposal	868	0	0
11	Channel protection dike	0	0	0
12	Buildings and wall	236	236	442
	Total Additional Cost Points	3,769	3,705	4,417

Note : Unit is cost points

Source: JICA Study Team

(7) Operation and Maintenance Cost up to 2050

Operation and maintenance cost points of the terminal up to 2050 (30 years) are shown in Table 5.2.13.

Table 5.2.13 Operation and Maintenance Cost Points up to 2050 (30 years)

No.	Cost Factor	In Harbor Type	Offshore Type with Breakwater	Offshore Type without Breakwater
1	Maintenance of civil facilities	419	795	819
2	Maintenance of equipment	2,055	3,236	3,236
3	Maintenance dredging	2,395	0	0

4	Terminal operation	750	750	750
	Total O/M Cost Points	5,619	4,781	4,805

Source: JICA Study Team

(8) Comparison of the Total Cost Points and Recommendations

Total cost points including initial construction, equipment supply, additional works, and O/M cost of the each terminal type up to 2050 (30 years) are shown in Table 5.2.14.

Table 5.2.14 Total Cost Points of Each Terminal Type

No.	Cost Factor	In Harbor Type	Offshore Type with Breakwater	Offshore Type without Breakwater
1	Initial cost in 2020	3,261	5,559	4,780
2	Additional works in 2030	3,769	3,705	4,417
3	O/M cost up to 2050	5,619	4,781	4,805
	Total Cost Points	**12,649**	**14,045**	**14,003**

Source: JICA Study Team

According to the result of the comparative study, type (a) In Harbor Type is recommended as the most suitable type of CTT. Plan, design, and any study in the following section will be carried out in the condition that basic type of terminal is “In Harbor Type”.

(9) Additional Candidate (Use of floating crane barge for transshipment of imported coal)

As requested by VINACOMIN in the meeting on 25 June 2014, additional candidate will be evaluated. Details of this type are explained below.

- Floating equipment will be used to unload the coal from import vessels to barge.
- Barges will be used to transfer the coal from import vessels to the coal stock yard.
- Coal will be exported from the loading berth.

In this type, barge operation from import vessel to the coal stock yard will be affected by the sea condition. Therefore, operation will not be possible during monsoon season even if there is a breakwater for the unloading berth.

Required facilities of this type are floating equipment with same capacity of unloader, barges, tug boats, unloading berth, and unloading equipment at the coal stock yard, loading berth, and coal stock yard with same size of type (c).

On the other hand, breakwater, trestle with belt conveyer, initial and maintenance dredging, unloading berth will not be required. The operation of this type will require the related cost of operation of barges from the floating equipment to the unloading berth.

Summary of cost points of this additional candidate is shown and compared with the types (a) to (c) in Table 5.2.15.

Table 5.2.15 Total Cost Points of the Additional Terminal Type

No.	Cost Factor	(a)	(b)	(c)	Additional
1	Initial cost in 2020	3,261	5,559	4,780	2,649
2	Additional works in 2030	3,769	3,705	4,417	4,660
3	O/M cost up to 2050	5,619	4,781	4,805	6,058
	Total Cost Points	12,649	14,045	14,003	13,367

Source: JICA Study Team

As a result, type (a) In Harbor Type is recommended as the most suitable type of CTT.

5.2.6. Proposed Development Planning

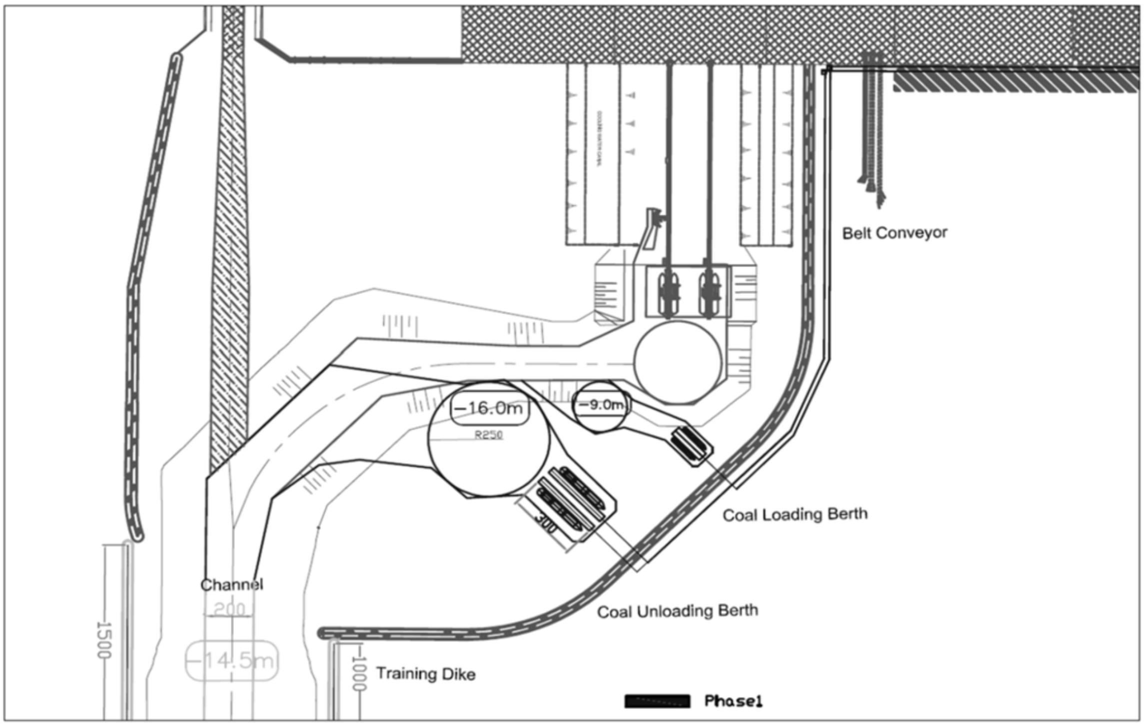
The staging plan for the port and terminal planning is proposed as follows: The plan is divided into three phases depending on increasing coal demand. Each port and its terminal facilities, which are studied in the above section are summarized in this section.

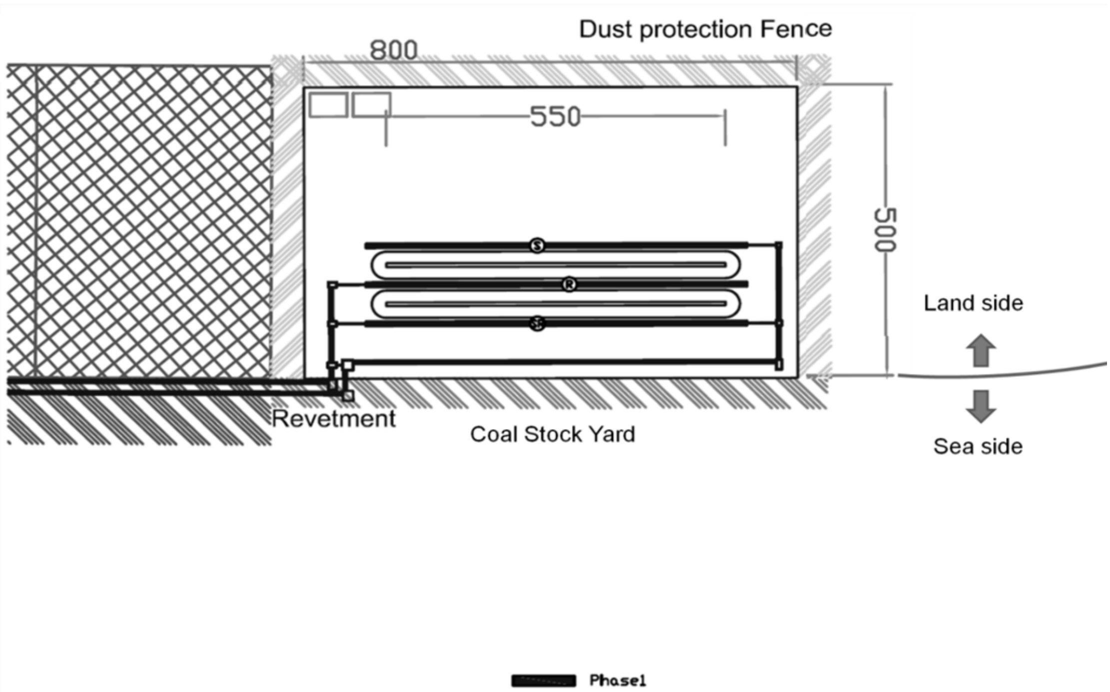
(1) Short-Term Development Plan

The short term development plan as the 1st Phase for the target year 2020 is as follows:

Table 5.2.16 Short-Term Development Plan

Coal Demand		8.530 million t	
Port Facility		Unloading Berth	Loading Berth
	Design Vessel	Panamax (55,000～85,000 DWT)	Small barge (5,000DWT~10,000 DWT)
	Berth	Berth 2 berths Length 300 m/berth Depth -16.0 m	Berth 2 berths Length 160 m/berth Depth -9.0 m
	Approach Channel	Length 8,200 m Width 200 m Depth 14.5 m	Existed channel for Duen Hai CFPP
	Turning Basin	Depth 16.0 m	Depth -9.0 m
	Handling Equipment	Unloader 4 Capacity 2,500 t/h	Ship Loader 2 Capacity 1,500 t/h
	Training Dike	Required Length 2.5 km (Both side of channel)	
Terminal Facility		Coal Stock Volume 3.77 million t, Terminal Area 22 ha	
	Yard Machinery	Stacker 1 set Capacity 5,500 t/h Stacker/Reclaimer 1 set Capacity 5,500 t/h / 3000 t/h Reclaimer 1 set Capacity 3,000 t/h	
	Belt Conveyor	For Unloading Length 13 km Capacity 5,500 t/h For Loading Length 10 km Capacity 3,300 t/h	
	Stockpile	Capacity 314,000 t Stockpile 2 piles Height of Pile 16 m Length of Pile 550 m	
	Revetment	Required length 800 m	
	Dust Protection Fence	Height 8 m Length 2,600 m	
Layout of Port and Terminal		Figure 5.2.14	





Source: JICA Study Team

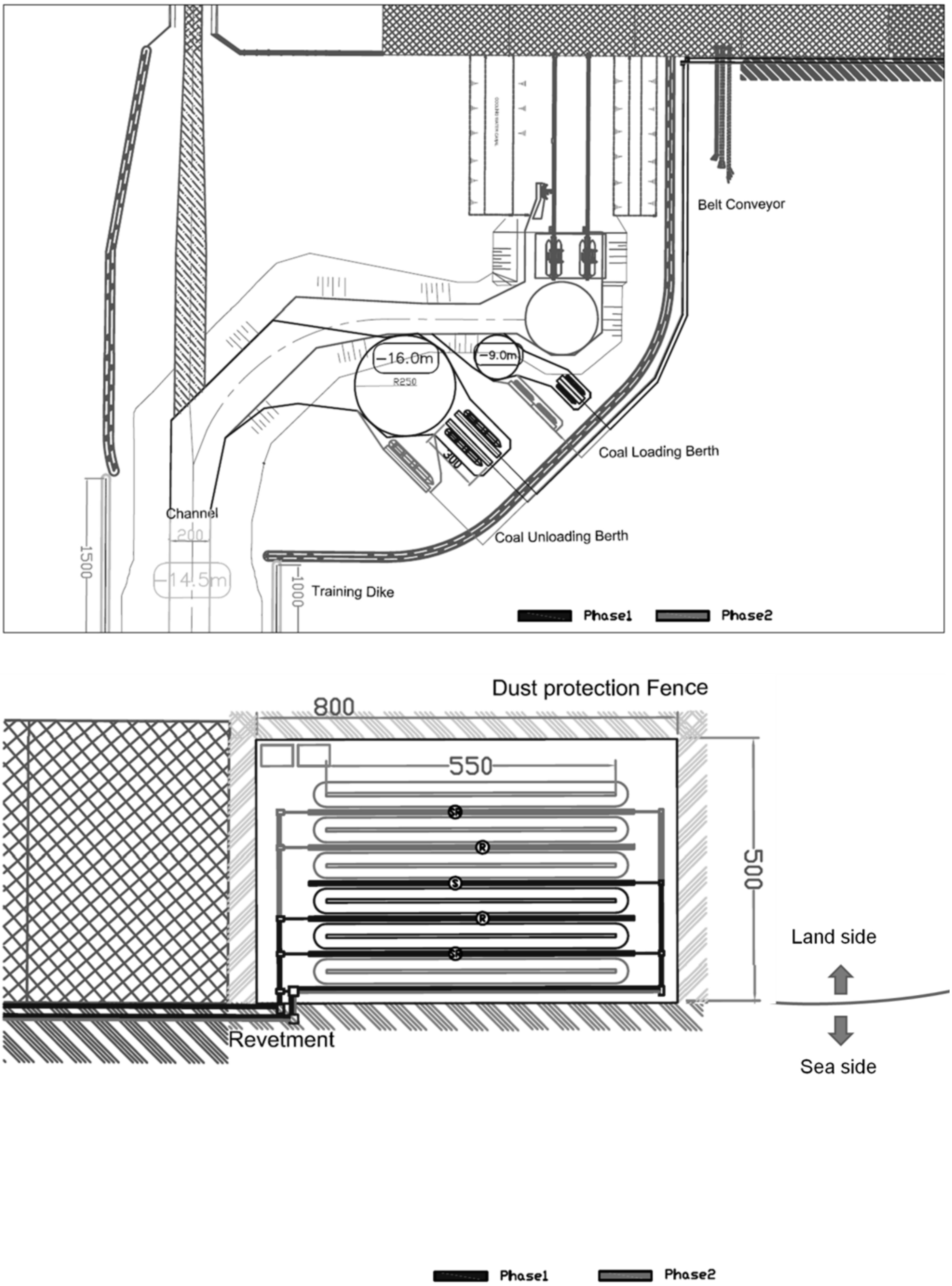
Figure 5.2.14 Layout of the Short-Term Development Plan

(2) Midterm Development Plan

The midterm development plan as the 2nd Phase for the target year 2025 is as follows:

Table 5.2.17 Midterm Development Plan

Coal Demand		17.860 million t	
Port Facility		Unloading Berth	Loading Berth
	Design Vessel	Post-Panamax (100,000 DWT)	Small barge (5,000DWT~10,000 DWT)
	Berth	Berth 3 berths Length 300 m/berth Depth -16.0 m (One berth is to be upgraded in the 3rd Phase for the Capesize.)	Berth 4 berths Length 160 m/berth Depth -9.0 m
	Approach Channel	Length 8,200 m Width 200 m Depth 14.5 m	Existed channel for Duen Hai CFPP
	Turning Basin	Depth 16.0 m	Depth -9.0 m
	Handling Equipment	Unloader 6 Capacity 2,500 t/h	Ship Loader 4 Capacity 1,500 t/h
	Training Dike	Required Length 2.5 km (Both side of channel)	
Terminal Facility		Coal Stock Volume 11.91 million t, Terminal Area 40 ha	
	Yard Machinery	Stacker 1 set Capacity 5,500 t/h Stacker/Reclaimer 2 sets Capacity 5,500 t/h / 3000 t/h Reclaimer 2 sets Capacity 3,000 t/h	
	Belt Conveyor	For Unloading Length 21 km Capacity 5,500 t/h For Loading Length 11 km Capacity 3,300t/h	
	Stockpile	Capacity 992,000 t Stockpile 6 piles Height of Pile 16 m Length of Pile 550 m	
	Revetment	Required length 800 m	
	Dust Protection Fence	Height 8 m Length 1,800 m	
Layout of Port and Terminal		Figure 5.2.15	



Source: JICA Study Team

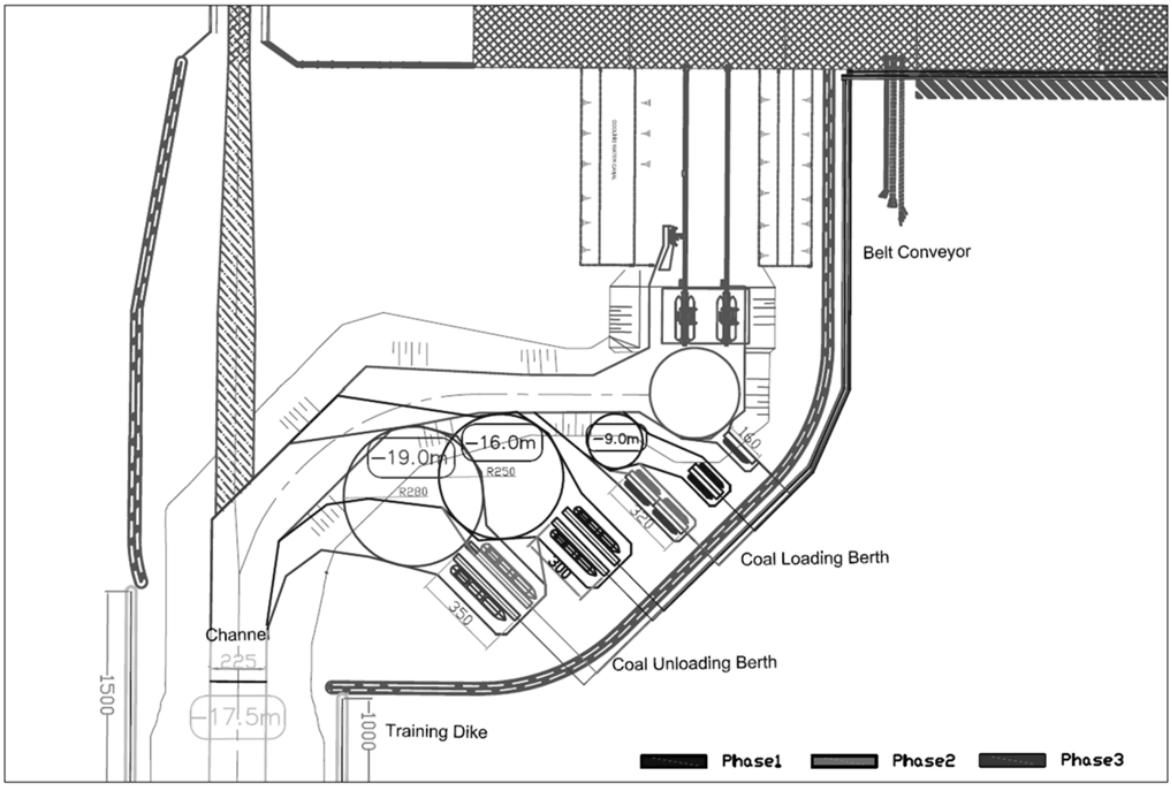
Figure 5.2.15 Layout of the Midterm Development Plan

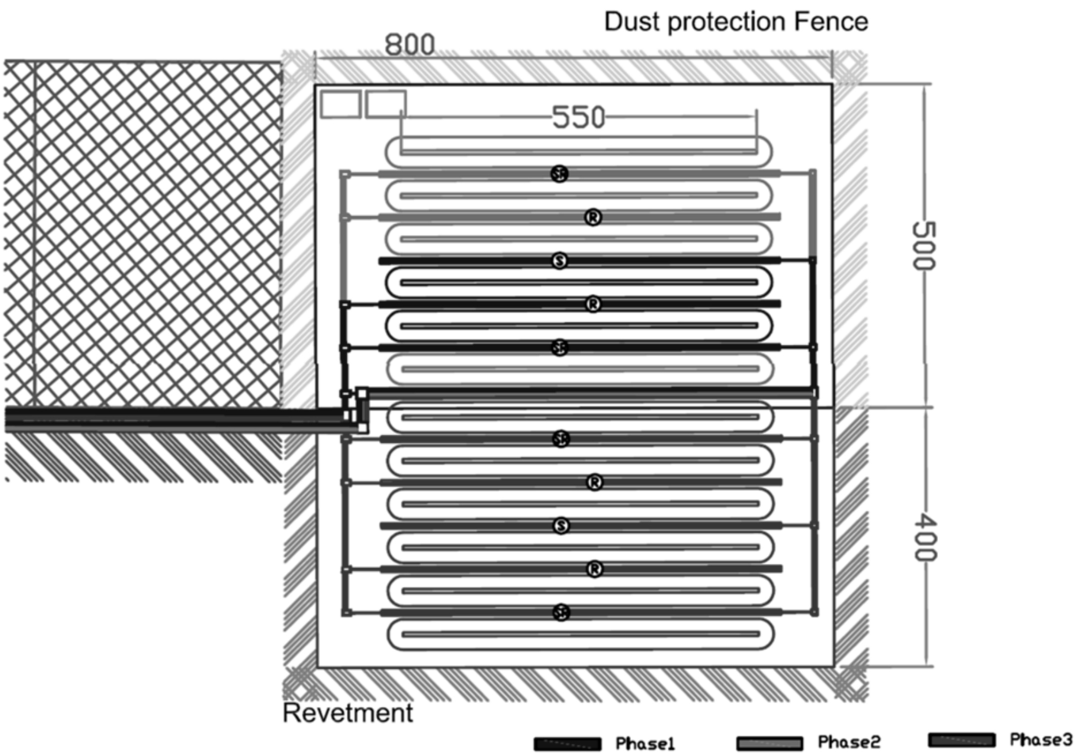
(3) Long-Term Development Plan

The long-term development plan as the 3rd Phase for the target year 2030 is as follows:

Table 5.2.18 Long-Term Development Plan

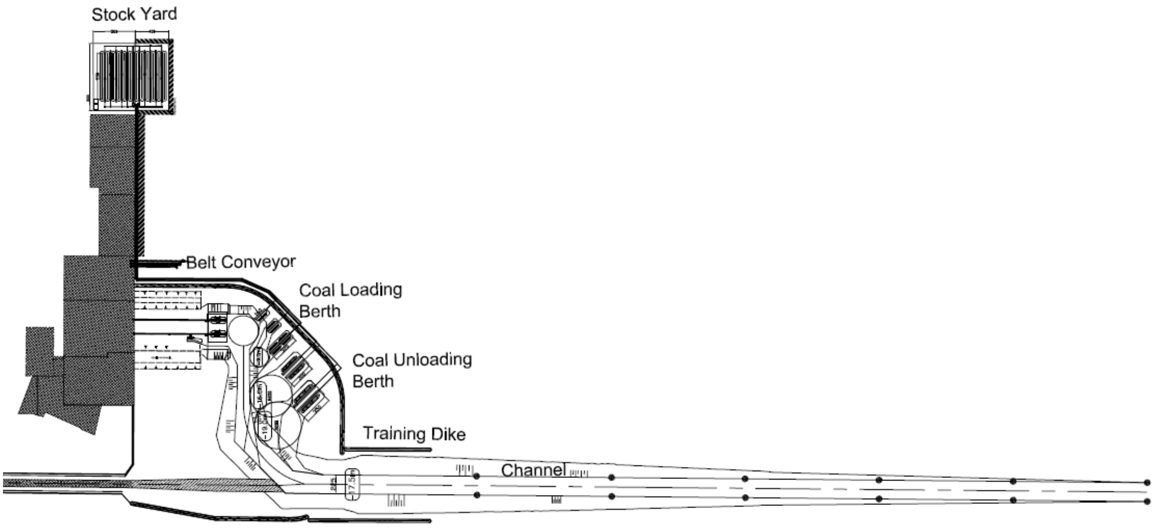
Coal Demand		31.090 million t	
Port Facility		Unloading Berth	Loading Berth
	Design Vessel	Post-Panamax (100,000 DWT) Capesize (160,000 DWT)	Small barge (5,000DWT~10,000 DWT)
	Berth	- Post-Panamax Berth 2 berths Length 300 m/berth Depth -16.0 m - Capesize Berth 2 berths Length 350 m/berth Depth -19.0 m	Berth 7 berths Length 160 m/berth Depth -9.0 m
	Approach Channel	Length 9,800 m Width 225 m Depth 17.5 m	Channel existed for Duen Hai CFPP
	Turning Basin	Post-Panamax Depth 16.0 m Capesize Depth 19.0 m	Depth -9.0 m
	Handling Equipment	Unloader 8 Capacity 2,500 t/h	Ship Loader 7 Capacity 1,500 t/h
	Training Dike	Required Length 2.5 km (Both side of channel)	
Terminal Facility		Coal Stock Volume 25.14 million t, Terminal Area 72 ha	
	Yard Machinery	Stacker 2 sets Capacity 5,500t/h Stacker/Reclaimer 4 sets Capacity 5,500 t/h / 3000 t/h Reclaimer 4 sets Capacity 3,000 t/h	
	Belt Conveyor	For Unloading Length 31 km Capacity 5,500 t/h For Loading Length 21 km Capacity 3,300 t/h	
	Stockpile	Capacity 2,100,000 t Stockpile 12 piles Height of Pile 16 m Length of Pile 550 m	
	Revetment	Required length 1,600 m	
	Dust Protection Fence	Height 8 m Length 2,600 m	
Layout of Port and Terminal		Figure 5.2.16, Figure 5.2.17	





Source: JICA Study Team

Figure 5.2.16 Layout of Terminal Plan for the Long-Term Development



Source: JICA Study Team

Figure 5.2.17 General Layout of Port and Terminal Plan in the 3rd Phase

5.3. Conceptual Design of Port and Terminal Facilities

Conceptual design is conducted to assess the project costs of the main port and terminal facilities based on the collected data, survey results, or design planning from this study. At the stage of basic design or detailed design, it is necessary to survey in more detail and to revise the design conditions or project planning based on the survey results.

The design is based on the Japanese design standard for port structure and BS, rock manual or related standard in Vietnam are used as reference.

5.3.1. Design Conditions

Design conditions include commonly applicable conditions at the site and specifically applied conditions for each specific structure. Commonly applicable natural conditions and design conditions at the site are shown in this section.

(1) Natural Conditions

1) Tidal Level

The relation between the Chart Datum Level (CDL) and the National Datum Level in Vietnam (NDL) are shown in Figure 5.3.1. The height written in this report is based on CDL.

CDL = NDL + 3.117m

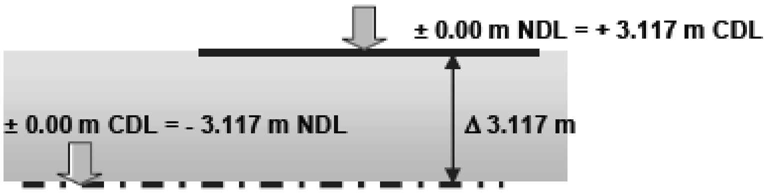


Figure 5.3.1 Relationship between CDL and NDL

In this study, the survey of tidal level has been done at the two sites of the project area for one month from 15 April to 15 May 2014. Table 5.3.1 shows the average, maximum, and minimum tidal levels. It is confirmed that these values are equivalent to the values of the previous study for the "Improvement Project of Navigation Channel to the Bassac River Trs Vinh Province" (hereinafter referred to as the "previous study").

Table 5.3.1 Water Level Obtained from the Observation at the Site

Station	Location	Water level [m] – Chart Datum		
		Average	Max	Min
WL01	Sea	3.136	4.479	0.978

Source: JICA Study Team

No tidal observation has been done for this study, therefore, tidal levels in the previous study are used. Below are the tidal levels from the previous study.

- HHWL : +5.17 m
- HWL : +4.71 m
- MWL : +3.13 m
- LWL : +1.22 m
- LLWL : +0.92 m

2) Tidal Current

Table 5.3.2 shows the average, maximum and minimum tidal currents observed at the two locations in project area from 4 September to 4 December 2009. According to the observation, the average current speed is approximately 0.3 m/s, the maximum current speed is approximately 0.85 m/s, and the minimum current speed is approximately 0.05 m/s. It is relatively quite current and no tidal current has been considered for the design of marine structure.

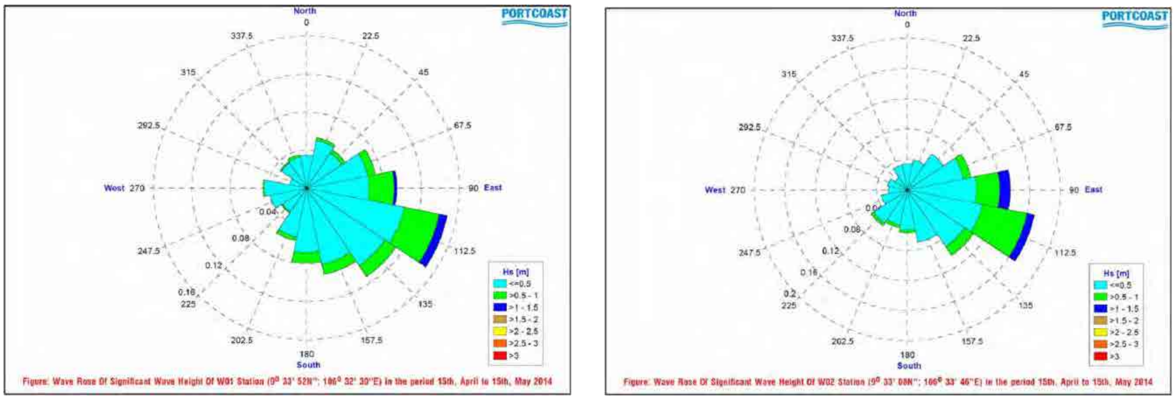
Table 5.3.2 Average Current Velocity Obtained from the Tidal Observation at the Site

Station	Location	Average current velocity [m/s]		
		Average	Max	Min
W01	Sea	0.266	0.830	0.088
W02	Sea	0.318	0.866	0.037

Source: JICA Study Team

3) Waves

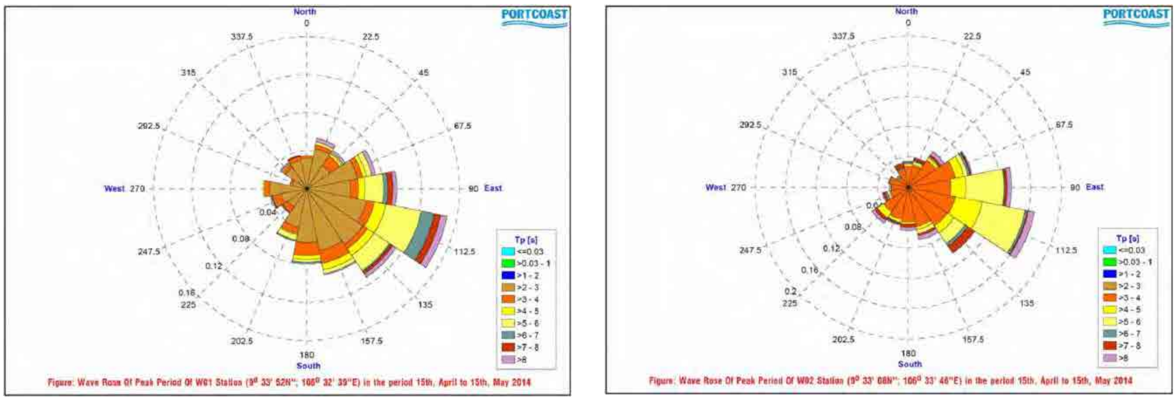
Wave observation has been done at two locations in the project area, as shown in Figure 5.3.2, for one month from 15 April to 15 May 2014. The relationships between wave direction and wave height and frequency are shown in Figure 5.3.3. Wave directions are mainly affected by east-southeast in this season.



a) Observation point W01 b) Observation point W02

Source: JICA Study Team

Figure 5.3.2. Wave Rose of Significant Wave Height and Wave Direction



a) Observation point W01 b) Observation point W02

Source: JICA Study Team

Figure 5.3.3 Wave Rose of Peak Period and Wave Direction

Offshore wave height and period for several return periods had been obtained through extreme statistics analysis of estimated ocean wave data, which were obtained by using the nearby typhoon record during the period of 1977 to 2012, because no long-term wave observation has been done for this study. The results of this analysis are shown in Table 5.3.3. Fifty-year return period is used for the design.

Table 5.3.3 Offshore Wave Height and Period for Several Return Periods

Return Period	Wave Height (m)	Period(s)
1	3.67	7.5
3	4.43	8.4
5	4.79	8.9
10	5.27	9.4
25	5.90	10.1
50	6.38	10.6
100	6.86	11.1

Source: JICA Study Team

From this result, it is determined that H_0=6.38 m and T_0=10.6 s as design offshore wave**.** Wave deformation analysis by energy balance equation has been done to obtain the design wave height for each water depth. The results of this simulation are shown in Table 5.3.4. Details of this table are shown in Appendix C. In the table, H1/3 is the significant wave height and H'0 is the equivalent deepwater wave height. Wave direction is defined from the north direction in a clockwise manner.

Table 5.3.4 Design Wave Height for Each Water Depth

(H_0=6.38 m, T_0=10.6 s, 50 years return period)

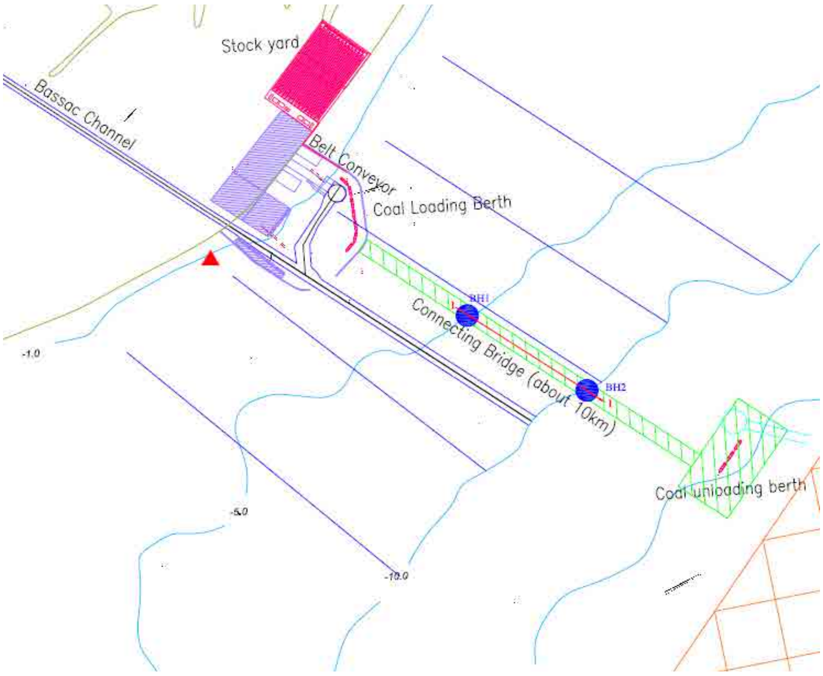
Water Depth	Off-shore Wave Direction	E	ESE	SE
-2.0 m (at the location of revetment)	H1/3 (m)	3.68	3.71	3.72
	H'0 (m)	5.51	5.90	6.06
	Wave direction (° from N)	115	122	129
-5.0 m (at the location of head of training dike 6 km far from base)	H1/3 (m)	5.05	5.40	5.57
	H'0 (m)	5.56	5.96	6.11
	Wave direction (° from N)	112	121	130
-10.0 m (at the location of head of training dike 10 km far from base)	H1/3 (m)	5.45	5.72	5.80
	H'0 (m)	5.76	6.04	6.12
	Wave direction (° from N)	106	117	128
-16.0 m (at the location of	H1/3 (m)	5.48	5.71	5.77
	H'0 (m)	5.82	6.08	6.14

berth for 100,000 DWT)	Wave direction (° from N)	103	114	127
-19.0 m (at the location of berth for 160,000 DWT)	H1/3 (m)	5.53	5.77	5.18
	H'0 (m)	5.90	6.15	6.19
	Wave direction (° from N)	102	115	126

Source: JICA Study Team

4) Soil Conditions

In this study, boring surveys at two locations along the anticipated line location of trestle with water depth of -5 m and -10 m have been done. The location of boring surveys and the results are shown as follows:



Source: JICA Study Team

Figure 5.3.4 Location of Boring Surveys

BOREHOLE LOG

THE FEASIBILITY STUDY ON THE COAL TRASSHIPMENT TERMINAL PROJECT FOR THERMAL POWER CENTER IN MEKONG DELTA IN THE SOCIALIST REPUBLIC OF VIETNAM

BOREHOLE: BH1

Co-ord (m): N = 1056507 | Sheet: 1 / 2
E = 616407 | Location: Offshore
Ground elevation (m): - 4.24 | Date commenced: 17/4/2014
Depth (m): 50,0m | Date completed: 18/4/2014

Layer	Elevation (m)	Depth (m)	Thickness (m)	SOIL AND ROCK DESCRIPTION	SPT Depth (m)	N_0	N_1	N_2	N	Sample No. (Depth of the sample (m))
1	-4,54	0,30	0.30	Medium dense, grey, poorly graded sand (SP)						
2			13.30	Very soft, brownish grey, grey, Fat clay (CH)	2.75	0	0	0	0	U1 2.00 - 2.60
					4,75	0	0	1	1	U2 4.00 - 4.60
					6.75	0	0	1	1	U3 6,00 - 6,60
					8,75	0	0	1	1	U4 8.00 - 8.50
					10,75	0	0	1	1	U5 10,00 - 10,60
	-17.84	13.60			12,75	0	1	1	2	U6 12,00 - 12,60
3	-19,24	15,00	1,40	Medium dense, Brownish grey, grey, poorly graded sand (SP)	14.4	3	4	6	10	U7 14,00 - 14,40
4			12,00	Stiff, brownish grey, yellowish grey, lean clay with sand (CL)	16,6	3	4	5	9	U8 16,00 - 16,50
					18,4	3	5	6	11	U9 18.00 - 18.40
					20.4	5	7	8	15	U10 20,00 - 20,40
					22,6	5	6	7	13	U11 22.00 - 22.40
					24,4	4	7	7	14	U12 24,00 - 24,40
	-31.24	27.00			26.4	5	7	6	13	U13 26,00 - 26,40
6			11.40	Very stiff, bluish grey, brownish grey, Fat clay (CH)	28.4	5	7	10	17	U14 28.00 - 28.40
					30.4	6	6	10	16	U15 30,00 - 30,40
					32.4	5	8	9	17	U16 32.00 - 32.40
6			11.40	Very stiff, bluish grey, brownish grey, Fat clay (CH)	34.6	6	8	10	18	U17 34,00 - 34,60
					36.5	5	7	10	17	U18 36.00 - 36.50
	-42.64	38.40			38.4	13	25	40	65	U19 38,00 - 38,40
7			4.40	Very dense, grey, yellowish grey, Poorly graded sand with silty clay (SP-SC)	40.0	11	25	50	75	D20 40,00 - 40.45
	-47.04	42.80			42.0	13	27	54	81	D21 42,00 - 42,45
8			4,00	Very stiff, grey, bluish grey, brownish grey, Sandy Lean clay (CL)	44.4	8	11	12	23	U22 44,00 - 44,40
	-51.04	46.80			46.3	8	10	11	21	U23 46.00 - 46.25
10			3.20	Midium dense, bluish grey, Clayey sand (SC)	48.4	6	8	10	18	U24 48,00 - 48,40
	-54,24	50,00			50,0	5	9	11	20	U25 49.60 - 50,00

Source: JICA Study Team

Figure 5.3.5 Boring Holes at Survey Point BH1

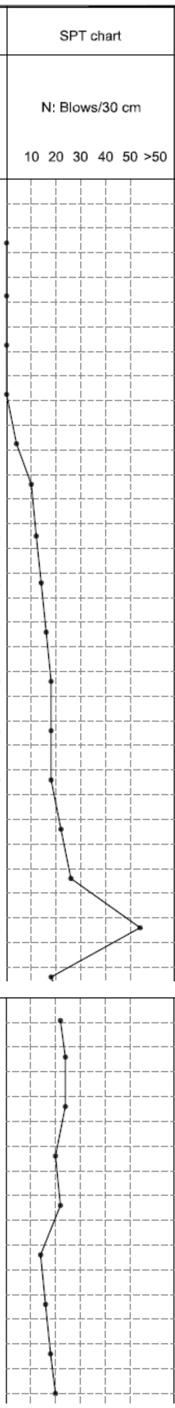
BOREHOLE LOG

THE FEASIBILITY STUDY ON THE COAL TRASSHIPMENT TERMINAL PROJECT FOR THERMAL POWER CENTER IN MEKONG DELTA IN THE SOCIALIST REPUBLIC OF VIETNAM

BOREHOLE: BH2

Co-ord (m): N = 1054952 E = 618830 | Sheet: 1 / 2
Ground elevation (m): - 8.77 | Location: Offshore
Depth (m): 50,0m | Date commenced: 19/4/2014
Date completed: 20/4/2014

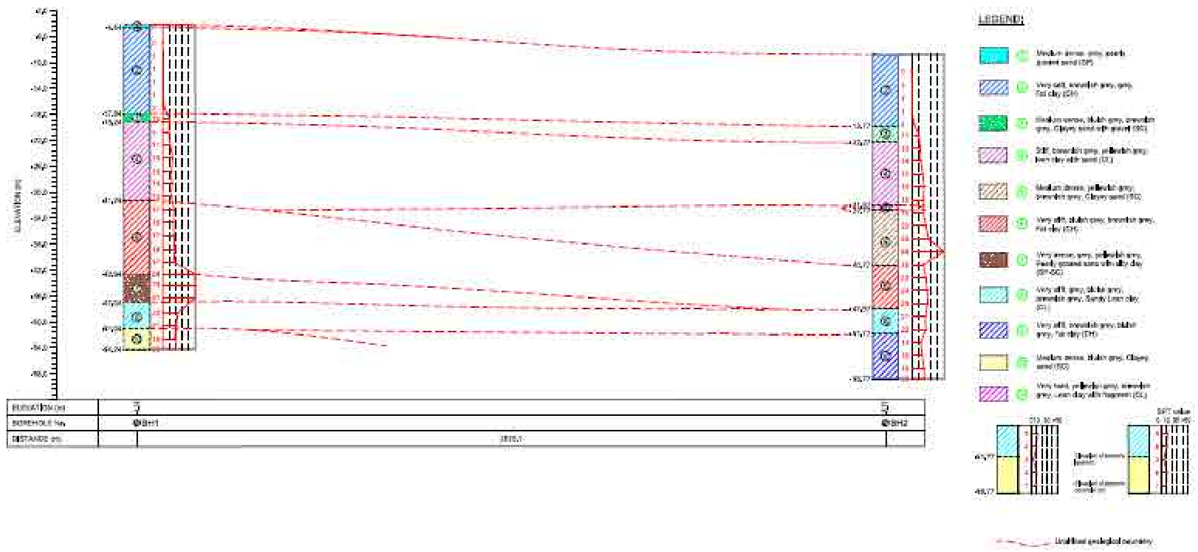
Layer	Elevation (m)	Depth (m)	Thickness (m)	SOIL AND ROCK DESCRIPTION	SPT Depth (m)	N0	N1	N2	N	Sample No. (Depth of the sample (m))
2			11.00	Very soft, brownish grey, grey, Fat clay (CH)	2.6	0	0	0	0	U1 2.00 - 2.50
					4,75	0	0	1	1	U2 4.00 - 4.70
					6.75	0	0	1	1	U3 6.00 - 6.70
					8.75	0	0	1	1	U4 8.00 - 8.70
	-19,77	11,00			10,75	0	1	3	4	U5 10.00 - 10.70
3	-22,27	13,50	2.50	Medium dense, bluish grey ,grey, Clayey sand with gravel (SC)	12,4	4	5	6	11	U6 12.00 - 12.40
4			9,70	Stiff, brownish grey, yellowish grey, Lean clay with sand (CL)	14,5	4	6	7	13	U7 14.00 - 14.50
					16.4	5	7	7	14	U8 16.00 - 16.40
					18,4	6	8	9	17	U9 18.00 - 18.40
					20.4	15	9	10	19	U10 20,00 - 20,40
	-31,97	23,20			22.4	7	8	10	18	U11 22.00 - 22.40
TK1	-32,77	24,00	0,80	Very hard, Yellowish grey, brownish grey, Lean clay with fragment (CL)	24,4	8	9	10	19	U12 24,00 - 24,40
5			9.80	Medium dense, yellowish grey, brownish grey, Clayey sand (SC)	26.4	9	10	12	22	U13 26,00 - 26,40
					28.4	10	12	14	26	U14 28.00 - 28.40
					30.4	15	20	34	54	U15 30,00 - 30,40
	-40,77	32,00			32.4	6	8	10	18	U16 32.00 - 32.40
6			7.20	Very stiff, bluish grey, brownish grey, Fat clay (CH)	34,4	8	10	12	22	U17 34.00 - 34.40
					36,4	9	11	13	24	U18 36.00 - 36.40
	-47.97	39.20			38.4	8	12	13	25	U19 38,00 - 38,40
8			3,80	Very stiff, brownish grey, Silty clay with sand (CL-ML)	40.4	7	10	11	21	U20 40.00 - 40.40
	-51,77	43,00			42,4	8	10	12	22	U21 42,00 - 42,40
9			7.00	Very stiff, brownish grey, bluish grey, Fat clay (CH)	44.4	4	6	8	14	U22 44,00 - 44,40
					46,4	5	8	8	16	U23 46.00 - 46.40
					48.4	7	9	10	19	U24 48,00 - 48,40
	-58,77	50,00			50,0	9	10	10	20	U25 49.60 - 50.00



Source: JICA Study Team

Figure 5.3.6 Boring Holes at Survey Point BH2

GEOTECHNICAL SECTION I - I



Source: JICA Study Team

Figure 5.3.7 Longitudinal Section of Two Boring Holes

Table 5.3.5 Laboratory Test Results

No.	TT No	Borehole	Sample No.	Depth (m) From - To	Percent passed sieve size (mm) 25	19	9.5	4.75	2.00	0.85	0.425	0.25	0.075	< 0.005	Natural moisture content w (%)	Atterberg Limits: Liquid limit W_L (%)	Plastic limit Wp (%)	Plasticity index Ip (%)	Consistency (B)	Bulk density (g/cm^3) Natural	Dry	Particle density Δ (g/cm^3)	Void ratio e_0	Porosity n (%)	Degree of saturation G (%)	Soil group	Description
1	2	BH1	U1	2.00 - 2.60						100.00	99.92	99.72	98.46	37.17	56.58	45.37	24.02	21.35	1.53	1.60	1.02	2.69	1.637	62.08	92.98	CL	Brownish grey, grey, Lean clay
2	2	BH1	U2	4.00 - 4.60						100.00	99.56	99.86	99.45	39.02	74.52	60.50	28.63	31.87	1.44	1.56	0.89	2.70	2.034	67.04	98.92	CH	Brownish grey, grey, Fat clay
3	2	BH1	U3	6.00 - 6.60					100.00	99.98	99.94	99.86	99.62	51.14	57.01	64.60	32.42	32.18	0.76	1.60	1.02	2.72	1.667	62.50	93.02	MH	Brownish grey, grey, Elastic silt
4	2	BH1	U4	8.00 - 8.50						100.00	99.98	99.84	99.46	38.67	52.50	58.42	28.70	29.72	0.80	1.63	1.07	2.69	1.514	60.22	93.28	CH	Brownish grey, grey, Fat clay
5	2	BH1	U5	10.00 - 10.60						100.00	99.98	99.84	98.94	41.32	80.12	71.35	34.65	36.70	1.24	1.50	0.83	2.70	2.253	69.26	96.02	MH	Brownish grey, grey, Elastic silt
6	2	BH1	U6	12.00 - 12.60					100.00	99.98	99.94	99.70	97.43	38.92	90.51	62.63	30.50	32.13	0.93	1.64	1.02	2.69	1.637	62.08	99.43	CH	Brownish grey, grey, Fat clay
7	2	BH2	U1	2.00 - 2.50						100.00	99.98	99.92	99.74	35.27	56.75	48.32	23.84	24.48	1.34	1.59	1.01	2.69	1.663	62.45	91.80	CL	Brownish grey, grey, Lean clay
8	2	BH2	U2	4.00 - 4.70					100.00	99.98	99.96	99.74	99.22	38.96	65.33	60.07	25.71	34.36	1.15	1.58	0.96	2.70	1.813	64.45	97.29	CH	Brownish grey, grey, Fat clay
9	2	BH2	U3	6.00 - 6.70						100.00	99.98	99.90	99.34	38.74	70.43	56.56	26.78	29.78	1.47	1.57	0.92	2.69	1.924	65.80	98.47	CH	Brownish grey, grey, Fat clay
10	2	BH2	U4	8.00 - 8.70						100.00	99.98	99.84	99.18	43.85	59.63	63.76	26.48	37.28	0.89	1.63	1.02	2.71	1.657	62.36	97.52	CH	Brownish grey, grey, Fat clay
11	2	BH2	U5	10.00 - 10.70							100.00	99.98	99.52	31.20	67.95	52.22	24.20	28.02	1.56	1.55	0.92	2.69	1.924	65.80	95.00	CH	Brownish grey, grey, Fat clay
Average value of layer 2									**100.00**	**99.99**	**99.97**	**99.84**	**99.13**	**39.48**	**63.76**	**58.53**	**27.81**	**30.71**	**1.17**	**1.59**	**0.97**	**2.70**	**1.778**	**64.00**	**96.72**	**CH**	**Brownish grey, grey, Fat clay**
12	3	BH1	U7	14.00 - 14.40					100.00	99.85	99.53	89.08	3.34									2.66				SP	Brownish grey, grey, Poorly graded sand
13	3	BH2	U6	12.00 - 12.40		100.00	88.97	82.07	74.50	70.69	67.27	60.77	27.67	5.32	23.24	28.60	18.36	10.24	0.48	2.02	1.64	2.65	0.616	38.12	99.98	SC	Bluish grey, grey, Clayey sand with gravel
Average value of layer 3						**100.00**	**88.97**	**82.07**	**87.25**	**85.27**	**83.40**	**64.93**	**15.51**	**5.32**	**23.24**	**28.60**	**18.36**	**10.24**	**0.48**	**2.02**	**1.64**	**2.66**	**0.619**	**38.23**	**99.70**	**SC**	**Bluish grey, brownish grey, Clayey sand with gravel**
14	4	BH1	U8	16.00 - 16.50				100.00	99.73	99.33	98.83	94.05	83.52	45.93	32.38	49.59	24.90	24.69	0.30	1.88	1.42	2.73	0.923	47.9979	95.71	CL	Brownish grey, yellowish grey, Lean clay with sand
15	4	BH1	U9	18.00 - 18.40					100.00	99.70	99.22	95.89	83.94	32.23	33.01	49.23	19.89	29.34	0.45	1.87	1.41	2.71	0.922	47.9709	97.03	CL	Brownish grey, yellowish grey, Lean clay with sand
16	4	BH1	U10	20.00 - 20.40							100.00	99.74	94.91	50.06	27.30	47.90	22.57	25.33	0.19	1.97	1.56	2.74	0.768	43.4389	97.40	CL	Brownish grey, yellowish grey, Lean clay
17	4	BH1	U11	22.00 - 22.60					100.00	99.94	99.64	96.07	78.22	30.30	27.46	41.49	19.78	21.71	0.35	1.95	1.53	2.70	0.765	43.3428	96.92	CL	Brownish grey, yellowish grey, Lean clay with sand
18	4	BH1	U12	24.00 - 24.40					100.00	99.92	99.88	99.70	98.10	37.43	28.66	54.00	25.61	28.39	0.11	1.90	1.48	2.72	0.838	45.593	93.03	CH	Brownish grey, yellowish grey, Fat clay
19	4	BH1	U13	26.00 - 26.40			100.00	96.39	86.81	85.95	83.49	78.36	50.12	17.15	25.53	33.93	17.32	16.61	0.49	1.97	1.57	2.67	0.701	41.2111	97.24	CL	Yellowish grey, Sandy Lean clay
20	4	BH2	U7	14.00 - 14.50					100.00	99.98	99.94	99.30	98.13	50.89	31.15	60.75	25.55	35.20	0.16	1.90	1.45	2.74	0.890	47.0899	95.90	CH	yellowish brown, yellowish grey, Fat clay
21	4	BH2	U8	16.00 - 16.40				100.00	99.99	99.59	99.03	84.39	52.95	19.34	27.23	35.15	21.39	13.76	0.42	1.89	1.49	2.68	0.799	44.4136	91.33	CL	Yellowish grey, Sandy Lean clay
22	4	BH2	U9	18.00 - 18.40					100.00	99.84	99.80	99.52	66.74	9.87	27.21	36.38	21.19	15.19	0.40	1.92	1.51	2.67	0.768	43.4389	94.60	CL	Yellowish grey, Sandy Lean clay
23	4	BH2	U10	20.00 - 20.40					100.00	99.94	99.90	99.42	80.27	14.53	23.71	27.59	21.46	6.13	0.37	1.91	1.54	2.65	0.721	41.8942	87.14	CL-ML	Yellowish grey, Silty clay with sand
24	4	BH2	U11	22.00 - 22.40					100.00	99.98	99.90	99.14	73.96	13.70	24.07	27.98	21.84	6.14	0.36	1.89	1.52	2.65	0.743	42.6277	85.85	CL-ML	Yellowish grey, Silty clay with sand
Average value of layer 4							**100.00**	**99.80**	**99.85**	**98.42**	**98.15**	**95.05**	**78.59**	**29.22**	**27.97**	**42.18**	**21.95**	**20.23**	**0.30**	**1.91**	**1.50**	**2.70**	**0.801**	**44.471**	**94.18**	**CL**	**Brownish grey, yellowish grey, Lean clay with sand**
25	5	BH2	U12	24.00 - 24.40					100.00	99.92	99.76	98.78	37.32	8.15	24.48	27.77	20.15	7.62	0.57	1.99	1.60	2.66	0.663	39.8677	98.14	SC	Yellowish grey, Clayey sand
26	5	BH2	U13	26.00 - 26.40							100.00	99.98	37.47	5.09	21.59	26.34	17.79	8.55	0.44	1.99	1.64	2.65	0.616	38.12	92.88	SC	Brownish grey, Clayey sand
27	5	BH2	U14	28.00 - 28.40							100.00	94.90	35.76	8.88	21.09	25.27	17.17	8.10	0.48	2.00	1.65	2.65	0.606	37.73	92.23	SC	Brownish grey, Clayey sand
28	5	BH2	U15	30.00 - 30.40					100.00	99.98	99.96	98.42	33.97	7.31	20.95	24.60	17.57	7.03	0.48	2.06	1.7	2.67	0.571	36.35	97.86	SC	Brownish grey, Clayey sand
Average value of layer 5									**100.00**	**99.95**	**99.93**	**98.02**	**36.13**	**7.36**	**22.03**	**26.00**	**18.17**	**7.83**	**0.49**	**2.01**	**1.65**	**2.66**	**0.611**	**38.01**	**95.46**	**SC**	**Yellowish grey, brownish grey, Clayey sand**
29	6	BH1	U14	28.00 - 28.40					100.00	99.28	99.08	98.76	97.52	66.63	25.92	53.27	23.58	29.69	0.08	2.00	1.59	2.75	0.730	42.1965	97.84	CH	Blue, yellowish grey, reddish brown, Fat clay

Source: JICA Study Team

Table 5.3.6 Laboratory Test Results

No.	TT No	Borehole	Sample No.	Depth (m) From - To	Percent passed sieve size (mm) 25	19	9.5	4.75	2.00	0.85	0.425	0.25	0.075	< 0.005	Natural moisture content w (%)	Atterberg Limits: Liquid limit W_L(%)	Plastic limit Wp(%)	Plasticity index Ip (%)	Consistency (B)	Bulk density (g/cm^3): Natural	Dry	Particle density Δ (g/cm^3)	Void ratio e_0	Porosity n (%)	Degree of saturation G (%)	Soil group	Description
30	6	BH1	U15	30.00 - 30.40					100.00	99.76	99.38	98.64	97.04	36.89	24.60	47.03	20.31	26.72	0.16	2.00	1.61	2.71	0.683	40.5823	97.61	CL	Blue, brownish grey, Lean clay
31	6	BH1	U16	32.00 - 32.40					100.00	99.70	99.50	98.88	95.93	40.54	23.54	46.19	20.85	25.34	0.11	2.03	1.64	2.72	0.659	39.7227	97.16	CL	Blue, brownish grey, Lean clay
32	6	BH1	U17	34.00 - 34.60							100.00	99.98	99.96	54.74	28.97	62.30	27.76	34.54	0.04	1.96	1.52	2.74	0.803	44.5369	98.85	CH	Blue, brownish grey, yellowish grey, Fat clay
33	6	BH1	U18	36.00 - 36.50							100.00	99.94	99.68	45.81	29.60	60.65	26.73	33.92	0.08	1.95	1.50	2.73	0.820	45.0549	98.55	CH	Blue, brownish grey, Fat clay
34	6	BH1	U19	38.00 - 38.40					100.00	99.96	99.92	96.52	85.65	30.40	29.27	51.86	24.59	27.27	0.17	1.93	1.49	2.70	0.812	44.8124	97.33	CH	Blue, brownish grey, Fat clay
35	6	BH2	U16	32.00 - 32.40					100.00	99.90	99.82	95.89	71.38	23.18	26.44	34.65	19.23	15.42	0.47	1.97	1.56	2.68	0.718	41.79	98.69	CL	Grey, brownish grey, Lean clay with sand
36	6	BH2	U17	34.00 - 34.40							100.00	99.98	99.96	47.05	31.25	63.12	28.89	34.23	0.07	1.92	1.46	2.72	0.863	46.32	98.49	CH	Grey, brownish grey, Fat clay
37	6	BH2	U18	36.00 - 36.40					100.00	99.90	99.82	97.22	83.12	24.55	21.22	40.15	19.89	20.26	0.07	2.06	1.7	2.69	0.582	36.79	98.08	CL	Blue, Sandy lean clay
38	6	BH2	U19	38.00 - 38.40					100.00	99.98	99.88	97.14	68.43	21.44	22.92	40.84	23.01	17.83	<0	2.03	1.65	2.68	0.624	38.42	98.44	CL	Blue, Sandy lean clay
Average value of layer 6									**100.00**	**99.78**	**99.74**	**98.30**	**87.87**	**39.12**	**26.37**	**50.01**	**23.48**	**26.52**	**0.11**	**1.99**	**1.57**	**2.71**	**0.725**	**42.04**	**98.63**	**CH**	**Bluish grey, brownish grey, Fat clay**
39	7	BH1	D20	40.00 - 40.45					100.00	99.87	96.54	34.19	8.81			21.23	16.70	4.53				2.65				SP-SC	Grey, yellowish grey, Poorly graded sand with silty clay
40	7	BH1	D21	42.00 - 42.45					100.00	99.79	95.32	36.81	8.78			18.98	14.36	4.62				2.66				SP-SC	Grey, bluish grey, Poorly graded sand with silty clay
Average value of layer 7									**100.00**	**99.83**	**95.43**	**35.46**	**8.80**			**20.11**	**15.53**	**4.58**				**2.66**				**SP-SC**	**Grey, bluish grey, yellowish grey, Poorly graded sand with silty clay**
41	8	BH1	U22	44.00 - 44.40					100.00	99.98	99.88	97.14	68.43	5.80	22.05	28.65	19.55	9.10	0.27	1.95	1.60	2.65	0.656	39.6135	89.07	CL	Grey, brownish grey, Sandy Lean clay
42	8	BH1	U23	46.00 - 46.25	100.00	83.17	76.73	73.92	72.62	71.41	70.52	69.81	66.08	17.81	21.99	44.27	21.20	23.07	0.03	2.02	1.66	2.69	0.620	38.2716	95.41	CL	Bluish grey, Sandy Lean clay
43	8	BH2	U20	40.00 - 40.40					100.00	99.98	99.96	99.88	82.32	9.72	23.93	27.91	22.39	5.52	0.28	1.90	1.53	2.65	0.732	42.26	86.63	CL-ML	Brownish grey, Silty clay with sand
44	8	BH2	U21	42.00 - 42.40						100.00	99.96	99.72	93.98	8.11	24.64	29.57	22.64	6.93	0.29	1.85	1.48	2.65	0.791	44.17	82.55	CL-ML	Brownish grey, Silty clay
Average value of layer 8					**100.00**	**83.17**	**76.73**	**73.92**	**98.87**	**92.84**	**92.58**	**91.59**	**77.70**	**10.36**	**23.15**	**32.60**	**21.45**	**11.16**	**0.15**	**1.93**	**1.57**	**2.66**	**0.697**	**41.071**	**88.36**	**CL**	**Grey, bluish grey, brownish grey, Sandy Lean clay**
45	9	BH2	U22	44.00 - 44.40						100.00	99.98	99.92	99.54	37.44	32.79	53.07	23.14	29.93	0.32	1.89	1.42	2.71	0.908	47.59	97.86	CH	Brownish grey, Fat clay
46	9	BH2	U23	46.00 - 46.40							100.00	99.92	99.54	31.22	29.84	46.45	21.99	24.46	0.32	1.94	1.49	2.70	0.812	44.81	99.22	CL	Brownish grey, Lean clay
47	9	BH2	U24	48.00 - 48.40						100.00	99.96	99.90	99.84	59.41	25.62	58.46	25.35	33.11	0.01	2.00	1.59	2.73	0.717	41.76	97.55	CH	Blue, Fat clay
48	9	BH2	U25	49.60 - 50.00							100.00	99.86	97.82	48.31	23.70	42.15	20.83	21.32	0.13	2.03	1.64	2.72	0.659	39.72	97.82	CL	Brownish grey, Lean clay
Average value of layer 9										**100.00**	**99.99**	**99.90**	**99.21**	**44.10**	**27.99**	**50.04**	**22.83**	**27.21**	**0.19**	**1.97**	**1.54**	**2.72**	**0.769**	**43.462**	**98.85**	**CH**	**Brownish grey, bluish grey, Fat clay**
49	10	BH1	U24	48.00 - 48.40					100.00	99.30	98.62	93.81	40.51	6.50	21.57	25.94	18.90	7.04	0.38	2.04	1.68	2.65	0.577	36.5885	99.06	SC	Bluish grey, Clayey sand
50	10	BH1	U25	49.60 - 50.00			100.00	98.87	95.82	91.03	86.81	73.02	45.07	5.55	25.02	30.12	20.60	9.52	0.46	1.99	1.59	2.65	0.667	40.012	99.40	SC	Bluish grey, Clayey sand
Average value of layer 10							**100.00**	**98.87**	**97.91**	**95.17**	**92.72**	**83.32**	**42.79**	**6.02**	**23.30**	**28.03**	**19.75**	**8.28**	**0.43**	**2.02**	**1.64**	**2.65**	**0.621**	**38.302**	**99.44**	**SC**	**Bluish grey, Clayey sand**

Source: JICA Study Team

Boring surveys had also been done by ‘previous study’ or soil survey for Duyen Hai CFPP. Boring surveys of this study and existed study are used to determine the design soil conditions of near shore location and offshore location.

Table 5.3.7 Design Soil Conditions at near Shore Location

Elevation	Layer	N-value	unit weight	cohesion C	Ø	C_c	C_v
m			kN/m^3	kPa	Degree		cm^2/day
Sea Bed	1 sand	5	18.5	-	25	-	-
- 3.0 m	2 clay	0	16.5	4+0.12Z	-	0.43	50
- 19 m	3 clay	14	15	36	-	-	-
- 27 m	4 sand	24	19	-	35	-	-
- 30 m	5 clay	19	19	50	-	-	-

Source: JICA Study Team

Table 5.3.8 Design Soil Conditions at Offshore Location

Elevation	Layer	N-value	Unit Weight	Cohesion C	Ø
m			kN/m^3	kPa	Degree
Sea Bed	2 clay	0	16.5	4+0.12Z	-
- 17 m	3 clay	14	15	36	-
- 23 m	4 sand	24	19	-	35
- 30 m	5 clay	19	19	50	-
- 40 m	6 sand	25	19	-	35

Source: JICA Study Team

5) Meteorological Conditions

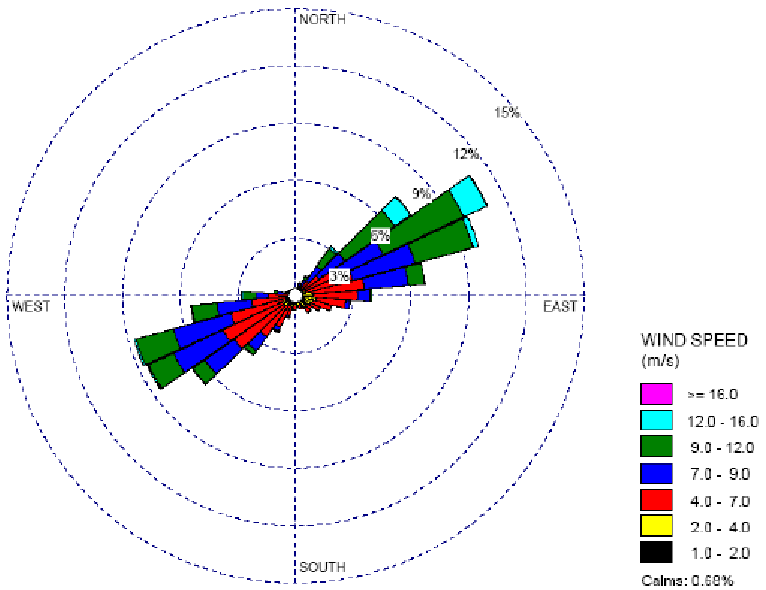
i) Wind

Table 5.3.9 Wind Data Observed near the Project Site from 1999 to 2008

Wind speed (m/s)	1 - 2	2 - 4	4 - 7	7 - 9	9 - 12	12 - 16	> 16
Frequency (%)	99.3	96.3	82.4	48.1	23.4	3.3	0.04

Source: JICA Study Team

According to this result, winds from west-southwest and east-northeast caused by monsoon are affected, and winds from other direction are not affected. The frequency of wind speed over 16 m/sec is very low. Therefore, it is expected that the effect on the facilities is not significant.



Source: "Preparatory Survey for Song Hau 1 Coal-Fired Power Plant Project and its Related Common Infrastructures (PPP Infrastructure Project)"

Figure 5.3.8 Offshore Wind Rose in the South from 1999 to 2008

According to statistical analysis of offshore wind for ten years, the maximum wind speed in the case of 100 years return period is 18.7 m/sec. and even ten years return period is 17.0 m/sec. It is expected that about 17 m/sec wind has frequently occurred at the project site.

Table 5.3.10 Maximum Wind Speed at Each Return Period

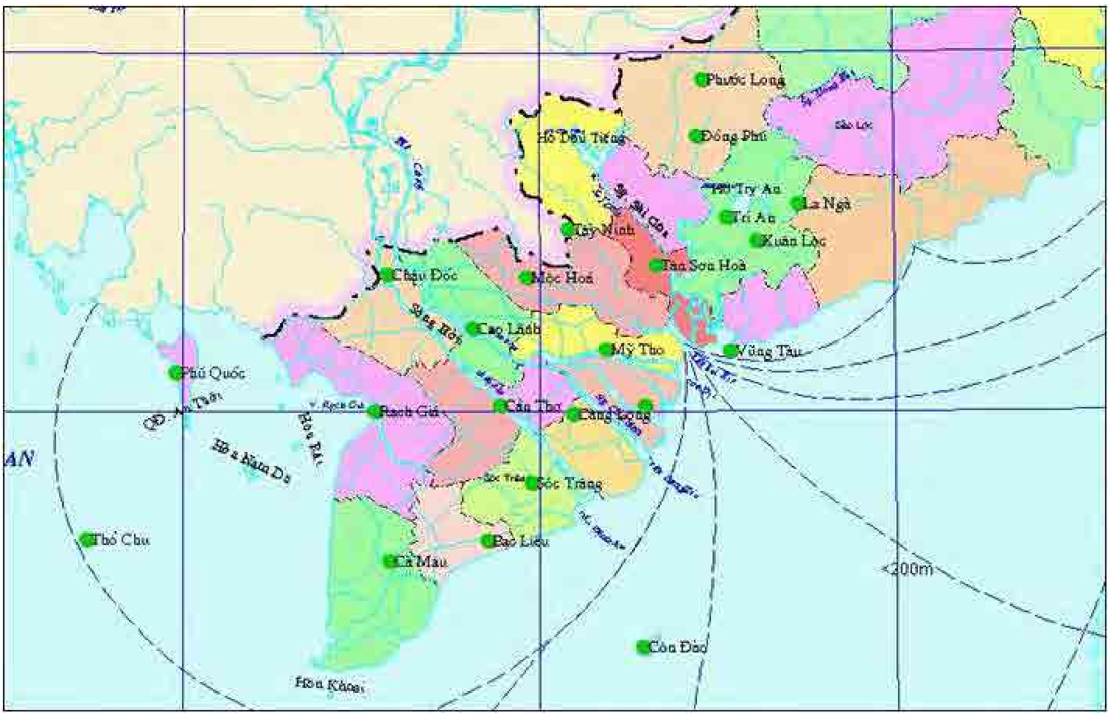
Return Period (year)	1	5	10	20	25	50	100
V max (m/s)	12.7	16.3	17.0	17.6	17.7	18.3	18.7

ii) Rainfall

The rainfall data in Southern Vietnam is recorded in each observation station as shown below. The average rainfall is about 1,300 mm to 2,300 mm. About 90% of it occurred in rainy season. The monthly average rainfall in rainy season is over 100 mm and the monthly average rainfall in August and September is about 250 mm to 350 mm.

Table 5.3.11 Monthly Average Rainfall in Southern Vietnam

Station/month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Yearly
Hà Tiên	9.7	9.6	36.3	133.6	224.1	237.5	271.6	289.9	259.6	274.8	133.5	45.5	1946
Rạch Giá	8.9	6.8	33.4	88.8	240.2	259.1	291.9	334.1	304.8	277.4	171.4	37.7	2054
Châu Đốc	6.5	4.5	25.0	80.2	157.7	114.2	134.2	146.8	160.3	252.1	135.3	46.9	1264
LongXuyên	8.3	2.6	11.7	66.5	147.2	151.6	209.4	174.4	213.8	260.3	130.7	41.8	1401
Vị Thanh	1.3	6.6	7.8	76.0	195.9	246.8	218.1	320.4	282.5	244.5	146.9	16.8	1764
Cần Thơ	8.9	2.3	9.7	42.8	170.1	195.2	211.7	209.1	250.5	271.4	146.0	32.3	1550
Vĩnh Long	9.1	0.1	9.2	30.4	139.2	171.0	180.6	175.9	214.1	273.2	131.0	30.5	1364
Cao Lãnh	9.5	4.7	9.8	44.7	168.3	139.1	157.0	166.0	247.1	258.0	129.4	22.0	1356
Tân Châu	11.3	7.2	7.8	65.9	110.4	96.0	140.2	112.8	160.3	253.1	202.8	20.0	1188
Mộc Hóa	13.0	4.2	14.1	48.2	187.7	181.6	184.4	168.1	268.7	312.1	150.3	39.9	1572
Tân An	6.9	2.3	7.2	35.6	187.1	22.2	203.9	187.2	245.5	260.8	136.5	40.3	1536
Mỹ Tho	5.0	2.5	4.5	38.5	148.6	187.8	185.7	170.8	233.0	267.0	103.6	35.1	1382

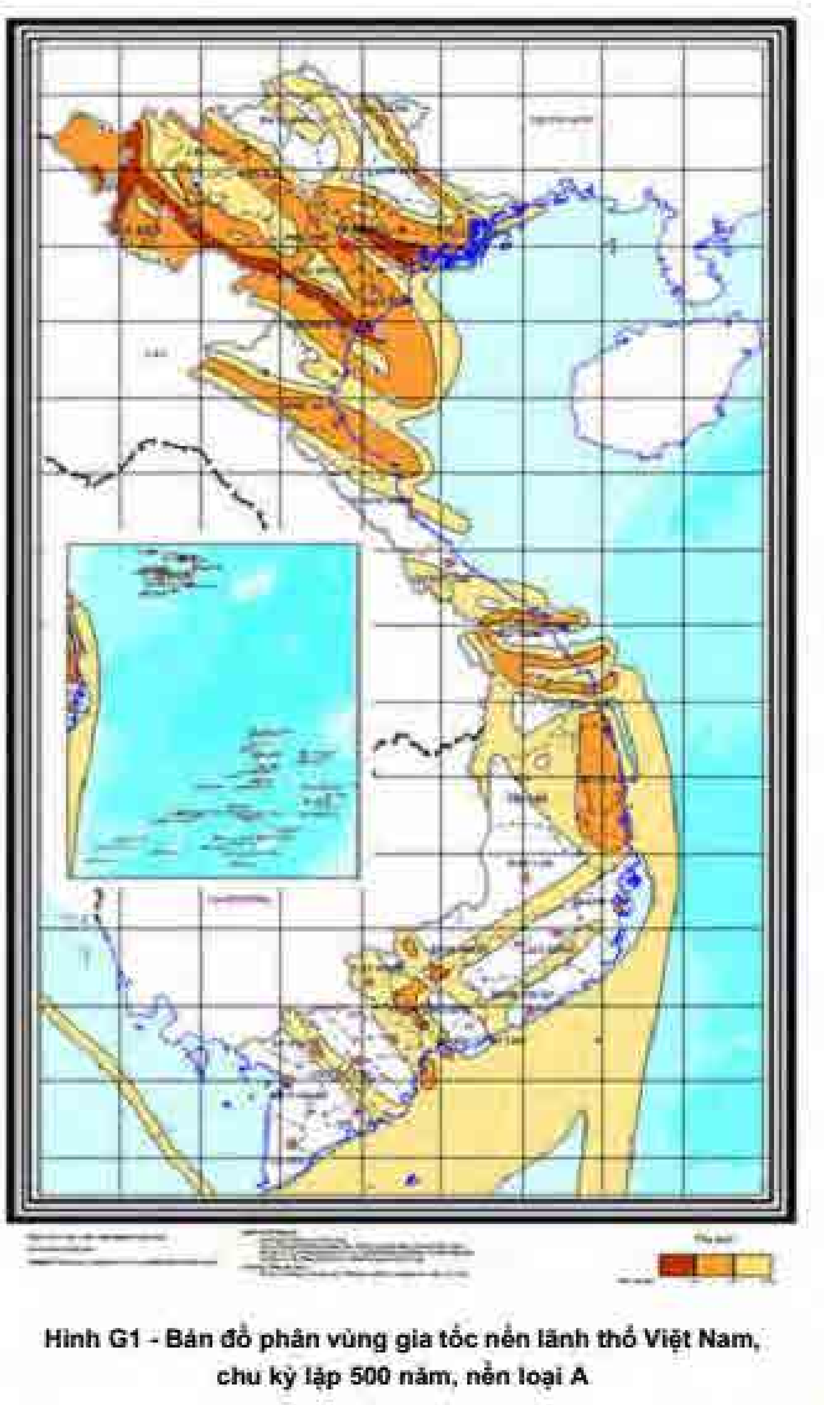


Source：Hydro Meteorological Data Center in Vietnam, HP：http://www.hymetdata.gov.vn

Figure 5.3.9 Rainfall Stations in Southern Vietnam

6) Earthquake

Seismic coefficient in Vietnam was defined by the Vietnamese design standard as shown in Figure 5.3.10. According to this figure, seismic coefficient at the site is 0.05 and under. No earthquake is considered in the design based on the technical criteria in Vietnam.



Source: TCVN 9386-2012

Figure 5.3.10 Seismic Coefficient in Vietnam

(2) Conditions for Use

1) Design Vessels

i) Coal Import Vessels and Their Dimensions

Design vessels for coal import vessels are determined as shown in Table 5.3.12. For the 1st Phase and the 2nd Phase, the design target is 100,000 DWT. For the 3rd Phase, the design target is 160,000 DWT.

Table 5.3.12 Coal Import Vessels and its Dimensions

Phase	Vessels (DWT)	L_{oa} (m)	Draft (m)	Beam (m)	L_{pp} (m)
1	70,000	230	14.5	32.3	218
2	100,000	255	15.5	39.5	242
3	160,000	280	17.5	45	267

Source: JICA Study Team

ii) Secondary Transport Vessels of Coal

Design vessels for secondary transport vessels of coal are determined as shown in Table 5.3.13. For the 1st ,2nd, and 3rd Phases, design target is 5,000 DWT to 10,000 DWT.

Table 5.3.13 Secondary Transport Vessels of Coal and its Dimensions

Vessels (DWT)	L_{oa} (m)	Draft (m)	Beam (m)	L_{pp} (m)
5,000	107	6.4	17	99
10,000	132	7.7	19.3	123

Source: JICA Study Team

2) Coal Handling Equipment

The design conditions of coal handling equipment are determined based on the specifications reported by the manufacturer. In this study, a 20% more of the load of coal handling equipment is applied in consideration with the difference of the manufacturer.

i) Unloader

Handling capacity	2,500 t/h
Total weight	16,640 kN
Rail gauge	25.0 m
Wheel base	22 m
Number of wheel	front: 12 wheels rear : 8 wheels
Wheel span	900 mm
Unit wheel load	Table 5.3.14.

Table 5.3.14 Unit Wheel Load of Unloader

		Unit front wheel load (kN/wheel)	Unit rear wheel load (kN/wheel)
Vertical load	Under operation (wind velocity 16 m/s)	500	550
	Downtime	670	700
Horizontal load	Under operation (wind velocity 16 m/s)	50	55
	Downtime	67	70

Source: JICA Study Team

ii) Ship Loader

Handling capacity	1,500 t/h
Total weight	4,600 kN
Rail gauge	14.0 m
Wheel base	8 m
Number of wheel	6 wheels x 2 arms
Wheel span	710 mm
Unit wheel load	Table 5.3.15.

Table 5.3.15 Unit Wheel Load of Ship Loader

		Maximum unit wheel load (kN/wheel)
Vertical load	Under operation (wind velocity 16 m/s)	260
	Downtime	280
Horizontal load	Under operation (wind velocity 16 m/s)	26
	Downtime	28

Source: JICA Study Team

iii) Belt Conveyor

Table 5.3.16 Dimensions of Belt Conveyor Considered in this Design Section

	Unloading Line (offshore side)	Loading Line (landside)
Handling capacity	5,500 t/h (2 line)	3,300 t/h (2 line)
Width of belt	2,200 mm	1,600 mm
Speed of belt	240 m/min	240 m/min
Weight of conveyor	21 kN/m	21 kN/m

Source: JICA Study Team

iv) Stacker and Reclaimer

Handling capacity	5,500/3,000 t/h
Coal stockpile height	16 m
Coal stockpile width	47 m
Rail span	8 m
Wheel base	10.1 m
Wheel formation	8 wheel / corner
Unit wheel load	250 kN/wheel

Total weight 8,820 kN (Main body 6,370 kN + Tripper 2,450 kN)

3) Load Conditions

i) Dead Load

Unit weight of super structure concrete is assumed as follows:

Reinforced concrete: 24 kN/m^3
Unreinforced concrete: 23 kN/m

ii) Vertical Load Conditions

Apron
On the berth : vertical load of 2.0 t/m^2
(unloading/loading equipment is considered separately)
Trestle
Management aisle : "A live load" in specification of highway bridge

iii) Other Load Conditions

Specific weight of coal

Coal mass : 7.8 kN/m^3
Coal powder : 9.8 kN/m^3

4) Other Constrained Conditions

i) Navigation of Fishing Boat

Fishing boat is considered for the determination of minimum under clearance of trestle of 4 m from sea surface.

ii) Buried Pipes and Cables

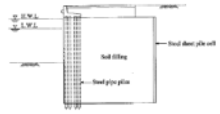
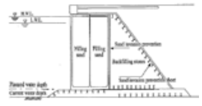
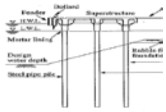
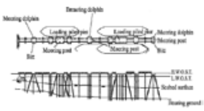
Buried pipes and cables are not considered in the design.

5.3.2. Coal Unloading Berth

(1) Selection of Type of Structure

Because of the deep water depth of -16 m to -19 m at berth front for larger size vessels, cell type, caisson type, jetty type, and dolphin type are the candidate type of berth structures. Comparing the soil conditions at the site, easiness of construction and cost efficiency, jetty type is considered as the most appropriate. Table 5.3.17 shows the comparison of four candidate type of structures for berth structure.

Table 5.3.17 Comparison of Four Candidate Type of Berth Structures

	Cell Type	Caisson Type	Jetty Type	Dolphin Type
Schematic structural figure				
For the case of soft soil conditoin	No necessity of soil improvement work A	Appropriate soil improvement work is necessary C	No necessity of soil improvement work A	No necessity of soil improvement work A
Installation of unloading equipment	Possible on the superstructure A	Possible on the superstructure A	Possible on the superstructure A	Another base structure is necessary. B
Easiness of construction	Large-scale temporary working site and equipment are necessary B	Large-scale temporary working site and equipment are necessary B	No need for large-scale working site A	No need for large-scale working site A
Cost efficiency	Steel type cell structure and comparatively expensive C	Conventional concrete and rock material work and not so expensive B	Steel pipe pile and concrete works and comparatively cost efficient A	Steel pipe pile and concrete works and most cost efficient A
Judge	Not applicable C	Not applicable C	Applicable A	Applicable B

Source: JICA Study Team

(2) Design Conditions

Design conditions of coal unloading berth are shown below.

1) Natural Conditions

Natural conditions are shown in “5.3.1 Design Conditions”. The design soil conditions at near shore location as shown in Table 5.3.7 was considered for unloading berth.

2) Conditions for Use

Conditions for use are shown in “5.3.1 Design Conditions”. Major issues are shown below.

i) Design Vessels

- For 1st and 2nd Phase :100,000 DWT
- For 3rd Phase :160,000 DWT

ii) Load Conditions of Coal Handling Equipment

Two unloaders are installed in each unloading berth.

iii) Vertical Load Conditions

Uniform vertical of 20 kN/m^2 is considered for the entire berth area.

(3) Dimensions of Structure

1) Berth Top Surface Level

Berth top surface level is determined by considering the local tide condition and size of design vessel. According to Table 5.3.18 by the Japanese design standard for port structure, which shows the relation between HWL and top surface level of berth, 0.5 m to 1.5 m are considered appropriate.

+4.71 m + 0.5 m~ + 4.71 m +1.5 m = +5.21 m~ +6.21 m

Based on this consideration, top surface level of +6.0 m (CDL) is employed.

Table 5.3.18 Threshold of Berth Top Surface Level by Considering the Local Tide Condition and Size of Design Vessel

	Tidal range 3.0m or more	Tidal range less than 3.0m
Wharf for large vessels (water depth of 4.5m or more)	+0.5–1.5m	+1.0–2.0m
Wharf for small vessels (water depth of less than 4.5m)	+0.3–1.0m	+0.5–1.5m

Source: Japanese design standard for port structure

2) Berth Length

In Section 5.2.2, berth length is determined as follows:

1st and 2nd Phases 100,000 DWT : 2 berths 300 m
3rd Phase 160,000 DWT : 4 berths 350 m

3) Berth Allocation

Berths are allocated on one side of jetty based on the unloader type in port planning.

4) Width of Berth

Total width of 30.0 m is employed by considering the unloader's rail span of 25 m, interval between sea side rail and front side end of berth of 3 m and interval between landside rail and back side of berth of 2.0 m.

Access road on the berth and installation space of belt conveyor is allocated within the rail span of unloader.

5) Water Depth in Front of the Berth

Water depth in front of the berth is planned as follows:

1st and 2nd Phase: 100,000 DWT, 16.0 m water depth
3rd Phase: 160,000 DWT, 19.0 m water depth

(4) Design Force

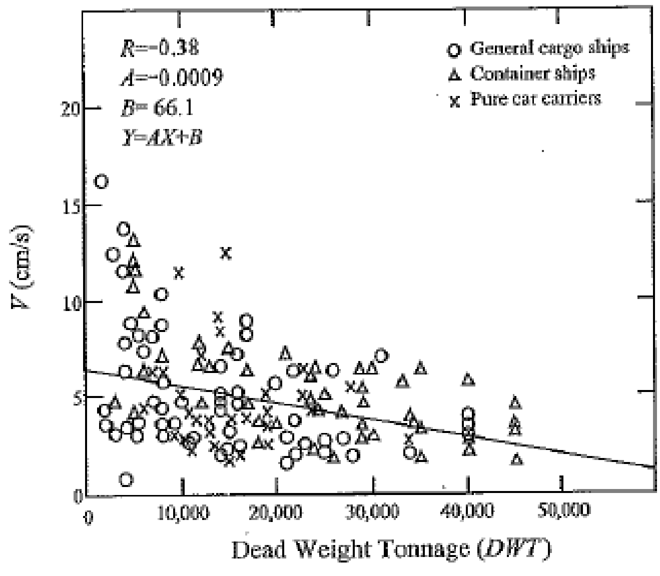
1) Wave, tide, and earthquake forces

Because the wave, tide, and earthquake forces are comparatively small with other dominant forces such as berthing of design vessels, these forces are not considered at this stage of work.

2) Berthing Forces

i) Berthing Velocity

Figure 5.3.11 shows the relation between the berthing velocity and DWT of the vessels. Berthing velocity of 5 cm/s, which is the maximum value for largest ship in the figure is selected as the design berthing velocity for 100,000 DWT vessel. Fender interval of 10 m is assumed.



Source: Japanese design standard for port structure

Figure 5.3.11 Relation between the Berthing Velocity and DWT of the Vessels

ii) Berthing Forces

Berthing forces is determined based on the Japanese design standard for port structure. The results are shown below.

For1st and 2nd Phase 158 kN/location (design vessel 100,000 DWT, berthing velocity 5 cm/s)

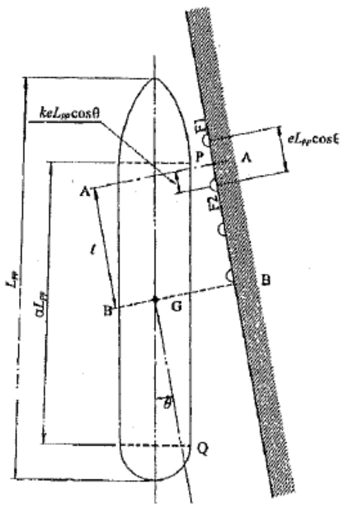
For 3rd Phase 251 kN/location (design vessel 160,000 DWT, berthing velocity 5 cm/s)

Table 5.3.19 Calculation of Berthing Energy for 100,000 DWT Vessels

Calculation of Berthing Energy

(shaded) Key-in Data

Type of Vessel		Bulk Carrier Vessel		
Deadweight Ton	DWT	100,000	ton	
Length (over all)	Loa	250.0	m	
Length (between perpendiculars)	Lpp	243.0	m	(Assumed)
Breadth	B	40.0	m	
Depth	D	20.0	m	
Draft (full)	d	14.5	m	
Displacement	Ws	117777	ton	(Assumed)
Berthing Angle	TH	5	degree	(Assumed)
Hydrodynamic coefficient	Cm	1.702		Cm=1+(pai/2Cb)(d/B)
Block coefficient	Cb	0.811		Cb=Ws/(LppXBXdX1.03)
Eccentricity coefficient	Ce	0.572		Ce =1/(1+(l/r)^2)
Radius of gyration	r	64.19	m	r=(0.19Cb+0.11)Lpp
Distance alongside the water line from the center of gravity of vessel to the berthing point	l	55.52 min(l1,l2)	m	l1=(0.5a+e(1-k))LppXcos(TH) l2=(0.5a-ek)LppXcos(TH)
Fender Spacing	Lf	10.00	m	(Assumed)
Coefficient of parallel side	a	0.50		
Coefficient of Fender interval	e	0.041		e=Lf/(LppXcosTH)
Coefficient of bertthing point	k	0.50		
Block coefficient	Cb	0.811		Cb=Ws/(LppXBXdX1.03)
Softness coefficient	Cs	1.0		
Berth configuration coefficient	Cc	1.0		
Berthing Velocity	V	0.05	m/sec	(Assumed)
Berthing Energy	E	143.3	kN-m	E=0.5XWsXV^2XCmXCeXCsXCc
Safety factor	Sf	1.10		(Assumed)
Abnormal Berthing Energy	Ea	157.7	kN-m	Ea = E × Sf



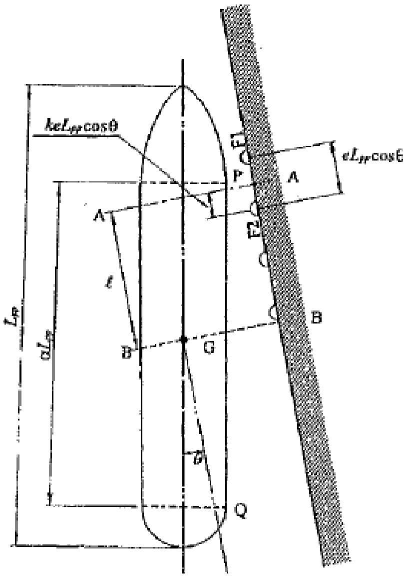
Source: JICA Study Team

Table 5.3.20 Calculation of Berthing Energy for 160,000 DWT Vessels

Calculation of Berthing Energy

[ ] Key-in Data

Type of Vessel		Bulk Carrier Vessel		
Deadweight Ton	DWT	160,000	ton	
Length (over all)	Loa	280.0	m	
Length (between perpendiculars)	Lpp	270.0	m	(Assumed)
Breadth	B	45.0	m	
Depth	D	24.0	m	
Draft (full)	d	17.5	m	
Displacement	Ws	183000	ton	(Assumed)
Berthing Angle	TH	5	degree	(Assumed)
Hydrodynamic coefficient	Cm	1.731		Cm=1+(pai/2Cb)(d/B)
Block coefficient	Cb	0.836		Cb=Ws/(LppXBXdX1.03)
Eccentricity coefficient	Ce	0.576		Ce =1/(1+(l/r)^2)
Radius of gyration	r	72.57	m	r=(0.19Cb+0.11)Lpp
Distance alongside the water line from the center of gravity of vessel to the berthing point	l	62.24 min(l1,l2)	m	l1=(0.5a+e(1-k))LppXcos(TH) l2=(0.5a-ek)LppXcos(TH)
Fender Spacing	Lf	10.00	m	(Assumed)
Coefficient of parallel side	a	0.50		
Coefficient of Fender interval	e	0.037		e=Lf/(LppXcosTH)
Coefficient of bertthing point	k	0.50		
Block coefficient	Cb	0.836		Cb=Ws/(LppXBXdX1.03)
Softness coefficient	Cs	1.0		
Berth configuration coefficient	Cc	1.0		
Berthing Velocity	V	0.05	m/sec	(Assumed)
Berthing Energy	E	228.1	kN-m	E=0.5XWsXV^2XCmXCeXCsXCc
Safety factor	Sf	1.10		(Assumed)
Abnormal Berthing Energy	Ea	250.9	kN-m	Ea = E × Sf



Source: JICA Study Team

3) Mooring Forces

Mooring forces are obtained as presented in Table 5.3.21. Bollard force of 1,000 kN for 100,000 DWT (about 54,000 GT) is selected from Table 5.3.21.

Table 5.3.21 Relationship between Gross Tonnage of Ship and Mooring Force

Gross tonnage of ship (t)	Tractive force acting on mooring post (kN)	Tractive force acting on bollard (kN)
Over 200 and not more than 500	150	150
Over 500 and not more than 1,000	250	250
Over 1,000 and not more than 2,000	350	250
Over 2,000 and not more than 3,000	350	350
Over 3,000 and not more than 5,000	500	350
Over 5,000 and not more than 10,000	700	500
Over 10,000 and not more than 20,000	1,000	700
Over 20,000 and not more than 50,000	1,500	1,000
Over 50,000 and not more than 100,000	2,000	1,000

Source: JICA Study Team

(5) Design Structures

Structure: Unloading berth is planned to install in harbor or at offshore. The conditions of target vessels, design depth or capacity of handling equipment are same in any case. Therefore, the same typical cross section of unloading berth is employed.

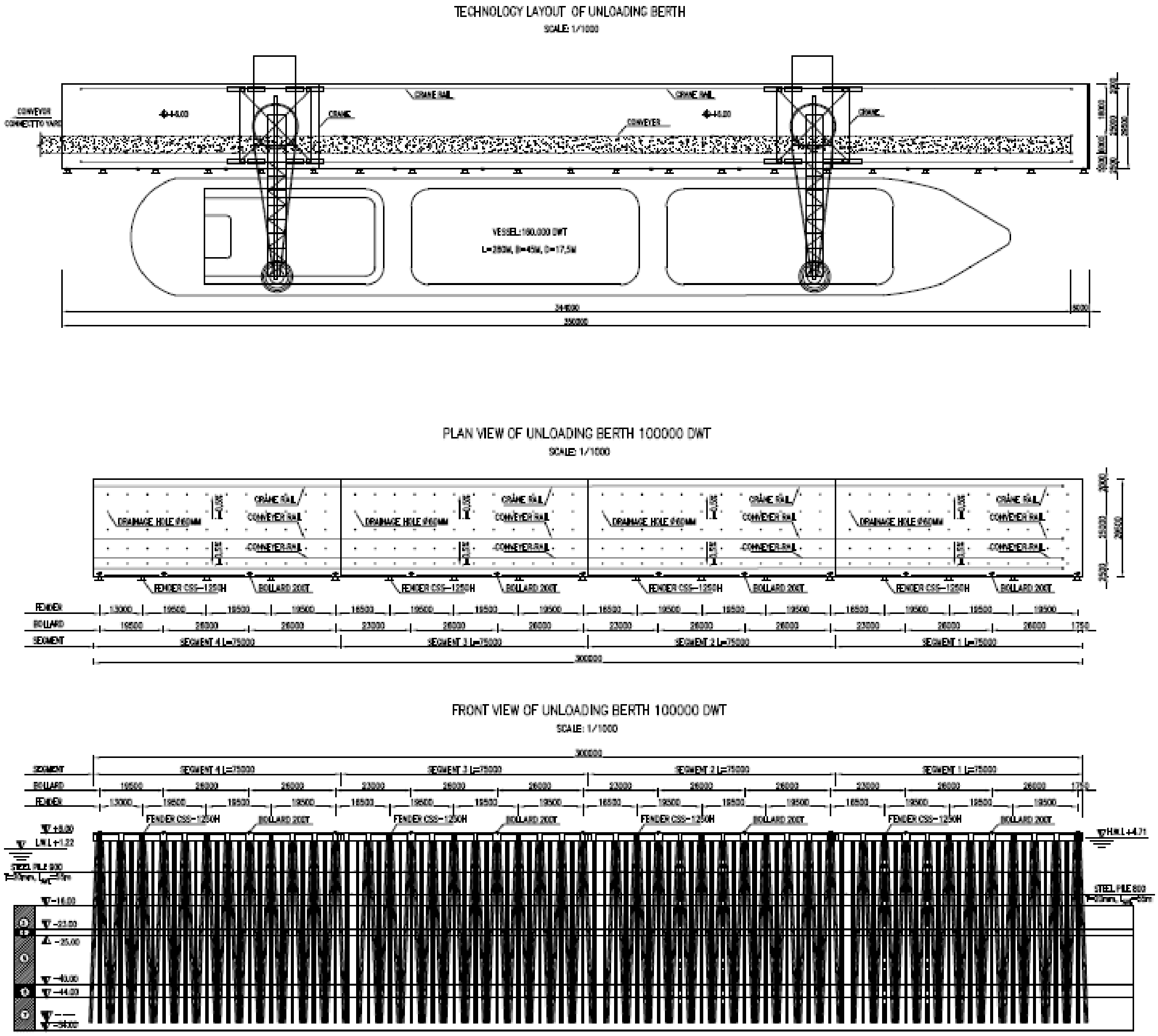
Location of pile: Two sets of pile casting are allocated to resist the strong horizontal berthing forces. Pile interval of 6.25 m to 6.5 m is determined by considering the use of RC beam. Supporting piles just underneath the rail for unloader are allocated because of heavy vertical load. The interval of the piles is 3.25 m. The piles are allocated at the intermediate RC beam under rail for unloader.

Type of pile: Steel pipe pile is selected by considering the necessity of long pile due to subsurface soft soil conditions. Corrosion protection is considered.

Superstructure: RC type structure is considered.

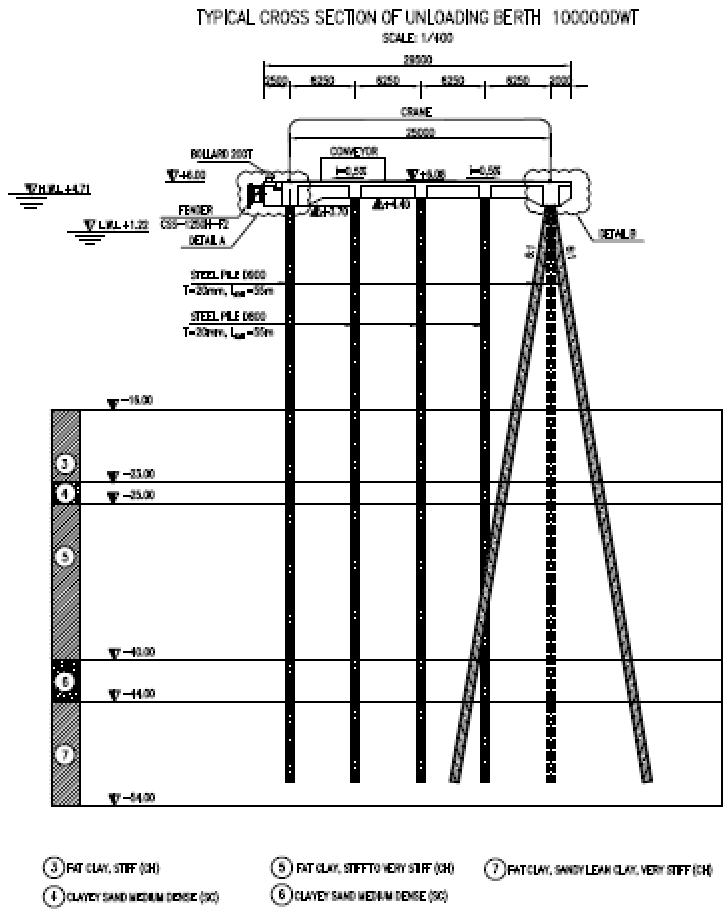
(6) Design Drawings

For 100,000 DWT berth



Source: JICA Study Team

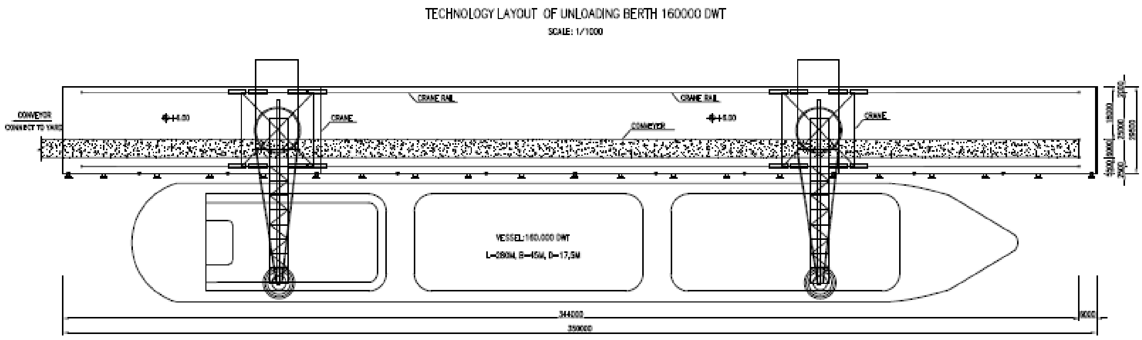
Figure 5.3.12 Front View and Side View of the Berth for 100,000 DWT

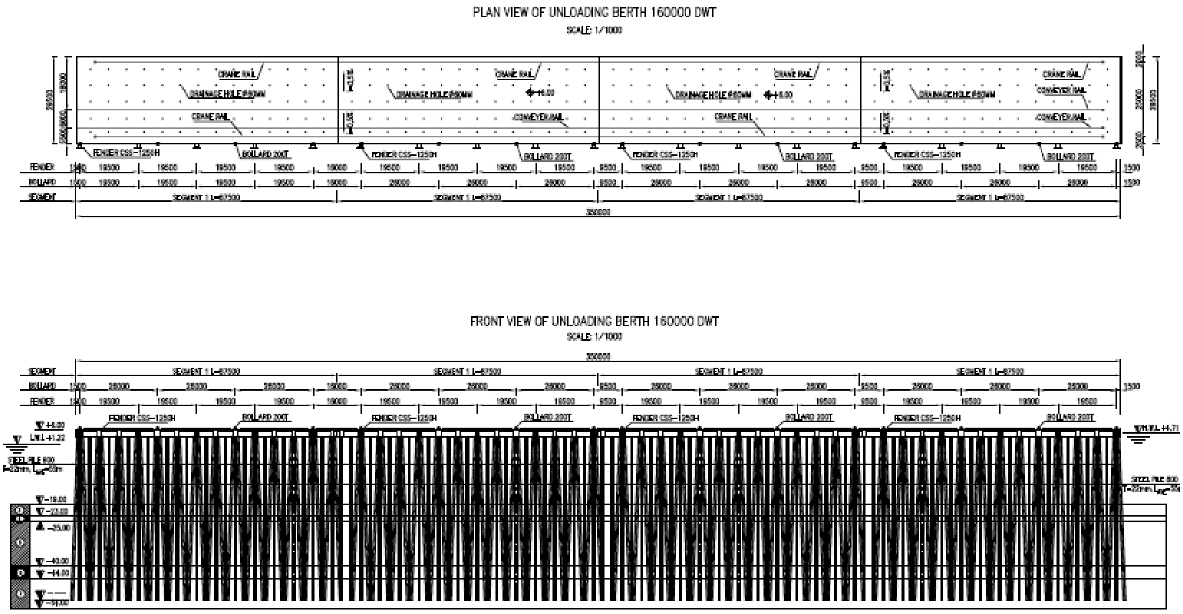


Source: JICA Study Team

Figure 5.3.13 Typical Cross Section of the Berth for 100,000 DWT

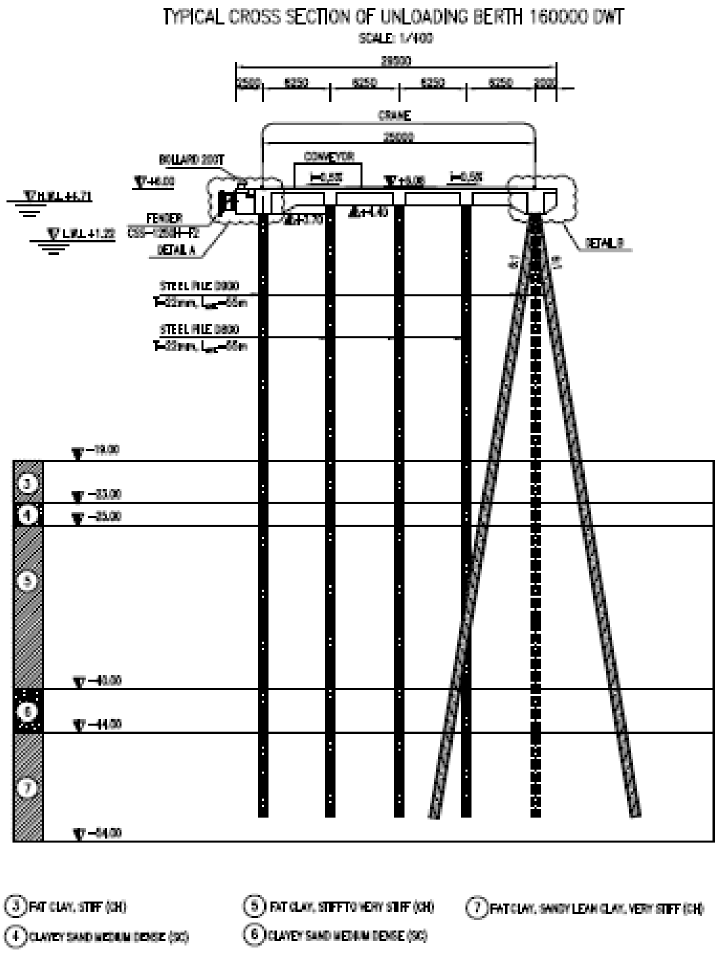
For 160,000 DWT berth





Source: JICA Study Team

Figure 5.3.14 Front View and Side View of the Berth for 160,000 DWT



Source: JICA Study Team

Figure 5.3.15 Typical Cross Section of the Berth for 160,000 DWT

5.3.3. Coal Loading Berth

(1) Selection of Type of Structure

Jetty type structure for the coal loading berth same as the coal unloading berth is selected.

(2) Design Conditions

1) Design Condition for the Facility

i) Natural Conditions

Natural conditions are shown in "5.3.1 Design Conditions". The design soil conditions at near shore location shown in Table 5.3.7 was considered for loading berth.

ii) Conditions for Use

Conditions for use and major items are shown below.

Uniform vertical load of 20 kN/m2 is considered for the entire area of berth

Around 5,000 DWT and 10,000 DWT barge are considered to be used in this planning. However, the specifications of the barges are not clear because the barges are planned to be newly built. Therefore, specifications of 5,000 DWT and 10,000 DWT vessels are considered for this design. In the stage of the basic design and detailed design, it is necessary to determine the specifications of the barges.

(3) Dimensions of Structure

i) Berth Top Surface Level

Berth top surface level of +6.0 m (CDL), same value of unloading berth, is selected by considering the tide conditions and design vessel size.

ii) Berth Length

Berth length is determined using similar procedure for unloading berth design. About 160 m is selected for berth length based on this consideration.

iii) Berth Allocation

Berths are allocated on both side of the jetty based on the port planning. A ship loader is also allocated at each berth.

iv) Width of Berth

Total width of 40.0 m is determined by considering the loader's rail span of 14.0 m, the distance between two loaders of 7.0 m, and interval between rail and side end of berth of 2.5 m for both side. Access road on the berth and installation of conveyor belt are allocated within the rail span of loader.

v) Water Depth in Front of the Berth

Water depth in front of the berth is 9.0 m.

(4) Design Forces

1) Berthing Forces

i) Berthing Velocity

According to Figure 5.3.5, berthing velocity of targeted ship of 10,000 DWT is averagely at 5.0 cm/s, but 8.0 cm/s is selected by considering the variation of the data. Fender allocation interval of 10 m is also assumed.

ii) Berthing Force

Berthing force is determined based on the Japanese design standard for port structure. A 52 kN/location is obtained for the design ship of 10,000 DWT.

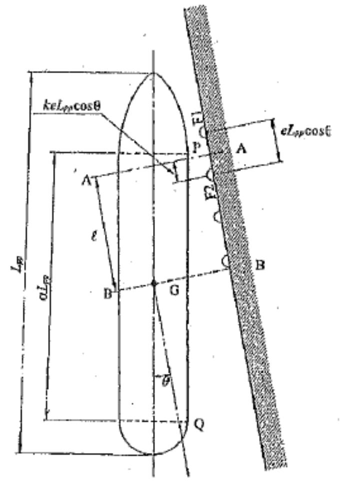
2) Mooring Force

Mooring force is obtained in Table 5.3.21. Bollard force of 500 kN/location is considered. Bollard interval of 10 m is selected.

Table 5.3.22 Calculation of Berthing Energy for 10,000 DWT Vessels

Key-in Data

Type of Vessel		Bulk Carrier Vessel		
Deadweight Ton	DWT	10,000	ton	
Length (over all)	Loa	132.0	m	
Length (between perpendiculars)	Lpp	123.7	m	(Assumed)
Breadth	B	19.3	m	
Depth	D	10.6	m	
Draft (full)	d	7.7	m	
Displacement	Ws	13337	ton	(Assumed)
Berthing Angle	TH	5	degree	(Assumed)
Hydrodynamic coefficient	Cm	1.890		Cm=1+(pai/2Cb)(d/B)
Block coefficient	Cb	0.704		Cb=Ws/(LppXBXdX1.03)
Eccentricity coefficient	Ce	0.577		Ce =1/(1+(l/r)^2)
Radius of gyration	r	30.16	m	r=(0.19Cb+0.11)Lpp
Distance alongside the water line from the center of gravity of vessel to the berthing point	l	25.81 min(l1,l2)	m	l1=(0.5a+e(1-k))LppXcos(TH) l2=(0.5a-ek)LppXcos(TH)
Fender Spacing	Lf	10.00	m	(Assumed)
Coefficient of parallel side	a	0.50		
Coefficient of Fender interval	e	0.081		e=Lf/(LppXcosTH)
Coefficient of bertthing point	k	0.50		
Block coefficient	Cb	0.704		Cb=Ws/(LppXBXdX1.03)
Softness coefficient	Cs	1.0		
Berth configuration coefficient	Cc	1.0		
Berthing Velocity	V	0.08	m/sec	(Assumed)
Berthing Energy	E	46.6	kN-m	E=0.5XWsXV^2XCmXCeXCsXCc
Safety factor	Sf	1.10		(Assumed)
Abnormal Berthing Energy	Ea	51.2	kN-m	Ea = E × Sf



Source: JICA Study Team

(5) Design Structure

Layout: Coal loading berth is planned to be installed in the harbor

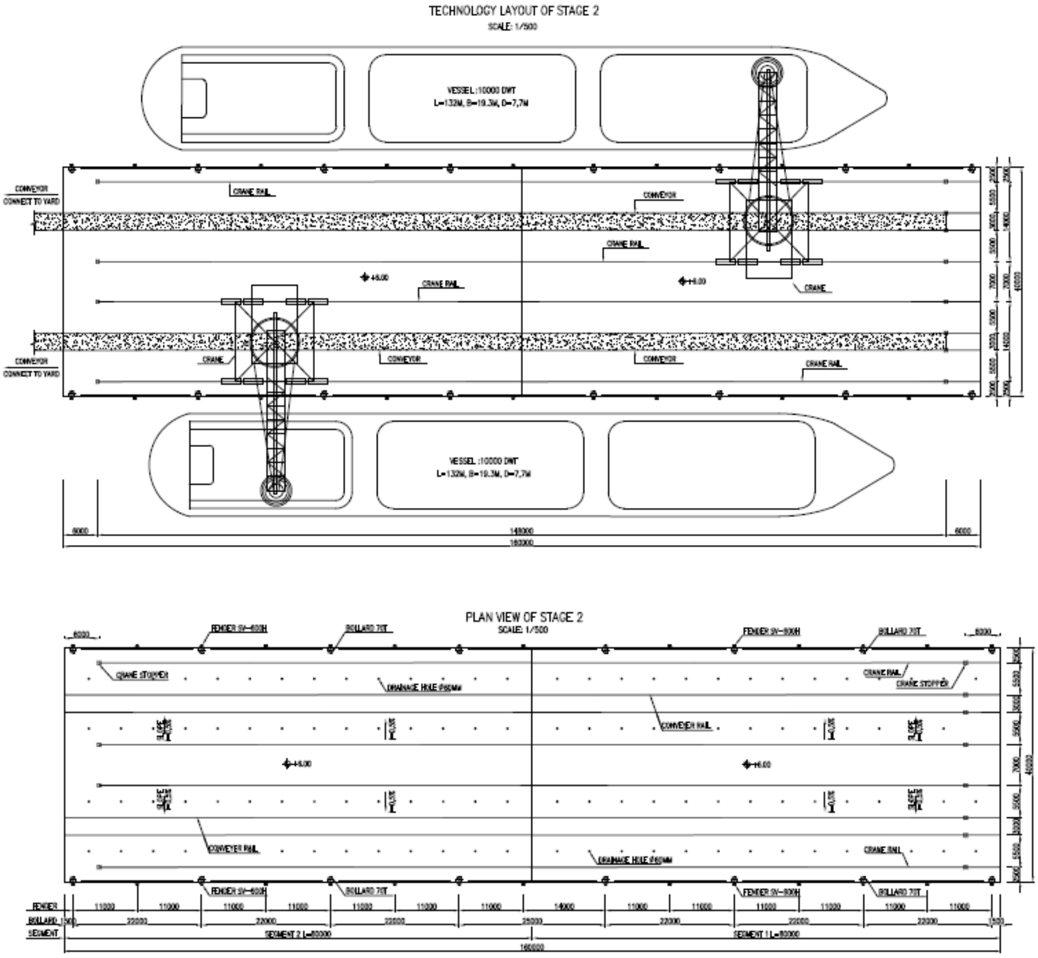
Location of pile: Two sets of pile casting are allocated at the center to resist the horizontal berthing forces. Supporting piles just underneath the rail for loader are allocated. Pile interval of 7 m is selected by considering the dimensions of rail span.

Type of pile: Steel pipe pile is employed by considering the necessity of long pile due to subsurface soft soil conditions. Corrosion protection is considered.

Superstructure: RC type structure is selected.

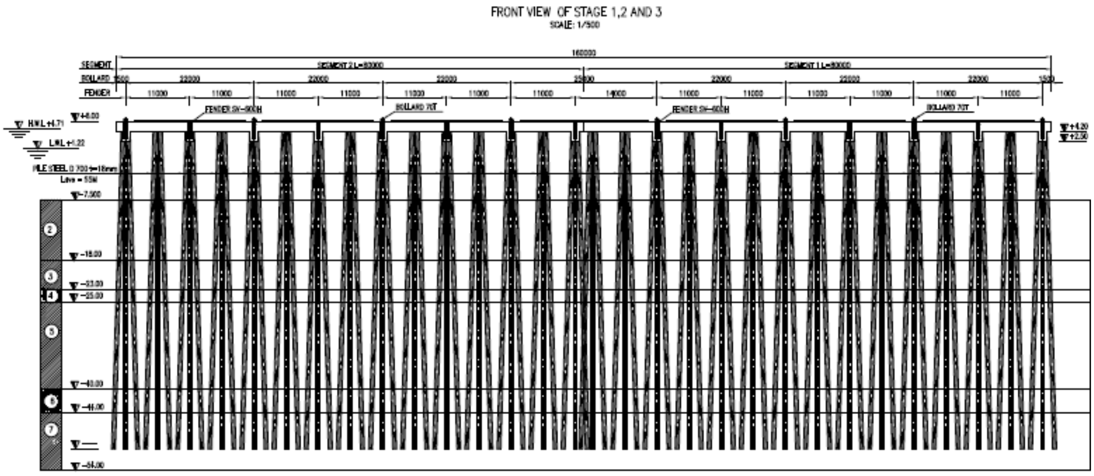
(6) Design Drawings

For 10,000 DWT berth



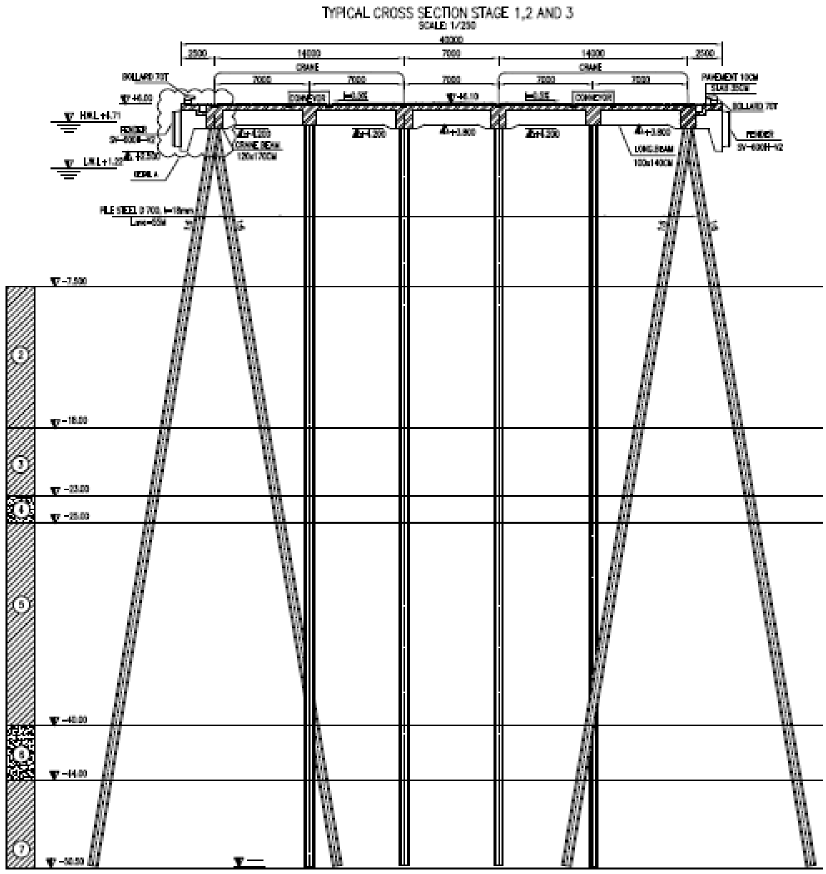
Source: JICA Study Team

Figure 5.3.16 Layout of Berth for 10,000 DWT



Source: JICA Study Team

Figure 5.3.17 Front View of the Berth for 10,000 DWT



Source: JICA Study Team

Figure 5.3.18 Typical Cross Section of the Berth for 10,000 DWT

5.3.4. Breakwater and Revetment

(1) Breakwater

Breakwater is studied in the case that it is necessary to install the breakwater in offshore. Therefore, typical cross section in offshore is considered in this section.

Selection of type of structure

Gravity-type (caisson type, rubble mound type), pile type, and cell type are selected for comparison.

1) Design Conditions

i) Natural Conditions

Natural conditions are shown in "Section 5.3.1 Design Conditions". The design soil conditions in offshore location shown in Table 5.3.8 were considered for the breakwater.

ii) Conditions for Use

No functions other than to protect wave attack is considered.

2) Dimensions of Structure

i) Functions

Expected function of the breakwater is to protect the overtopping of wave by ordinal high wave condition of H1/3=2.0 m.

ii) Design Wave Forces

Return period of 50 years is considered for the structural design.

iii) Crown Height

Crown height is determined to protect the overtopping at ordinal high wave condition of H1/3=2.0 m and overtopping of wave at extreme conditon are allowed as follows:

HWL+0.6H = +4.71 m + 0.6 x 2.0 m = +5.91 m = +6.0 m

3) Design force

Return period of 50 years is considered for the structural design with HWL condition. Design wave force by Goda's formula is selected.

Wave direction of $\beta=0°$ is considered as the most dangerous condition.

Vertically considered area of wave force

Gravity-type breakwater: Wave forces from top surface of base rubble mound to the top surface of the structure are considered.

Pile type breakwater：Wave forces from top to bottom (-6.0 m is assumed) of the curtain structure are considered. Lower part of the breakwater is vacant of structure to protect from wave entering.

Cell type breakwater: Wave force reduction factor,shown below, for Goda's formula obtained by hydraulic experiment for similar type of structure in Japan is applied.

4) Comparison of Candidate Types of Structures

i) Gravity Type Breakwater (Caisson type)

Main structure body: RC type Caisson (14 m x 18 m x 20 m)
Superstructure: unreinforced concrete from +2.0 m to +6.0 m
Base rubble mound: top surface level of -12 m (thickness of 3.0 m) and baring capacity of 600 kN/m^2 is considered.
Soil improvement work: SCP from 30 m to -15 m to secure the baring capacity of 300 kN/m^2 and against circular slip is considered.
Friction increasing rubber mat: Friction coefficient of 0.7 between rubble mound surface and caisson bottom is considered

ii) Rubble Mound Type Breakwater

Wave dissipating block is considered to resist rather high wave conditions.
Superstructure: cast in place concrete works on the top is considered.
Soil improvement work: SCP from 30 m to -15 m to secure the baring capacity of 300 kN/m^2 and against circular slip is considered.
Sub surface armor concrete block: Concrete block under the wave dissipating block to protect the leakage of core rubble is considered.
Slope: Instruction value of 3/4 for wave dissipating block is selected

iii) Pile and Curtain Wall Type Breakwater

Curtain wall: Curtain wall from -6.0 m to +6.0 m, allowing the part of wave behind the breakwater, is considered.
Scour protection: scour protection work by rubble mound with thickness of 1.0 m is considered at the bottom of the pile.
Soil improvement work: No necessity
Type of pile: Steel pipe pile is selected by considering the diameter, length, and necessity of slant pile.

iv) Embedded Circular Steel Cell Type Breakwater

Type of pile: Steel pipe pile is selected by considering the diameter of 20 m, length and necessity of slant pile of 15 m.

Main structure of embedded steel cell: diameter 20 m, height 26.5 m (-3.5 m~-30 m)

Superstructure: cap concrete thickness 1.0 m and unreinforced concrete from -4.5 m to + 6.0 m

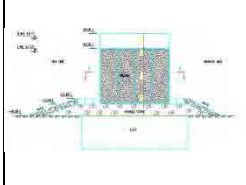
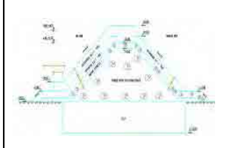
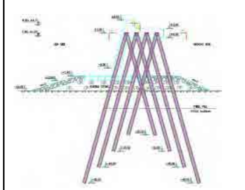
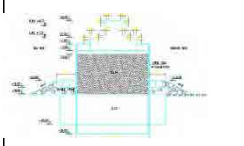
Soil improvement work: SCP from -28 m to -15 m

Score protection: score protection work by rubble stone with thickness of 3.0 m (-15.0 m to -12.0 m) abound the cell.

5) Comparison of the Types of Structures

By comparing the easiness and reliability of construction and cost efficiency, Caisson type breakwater is considered most appropriate.

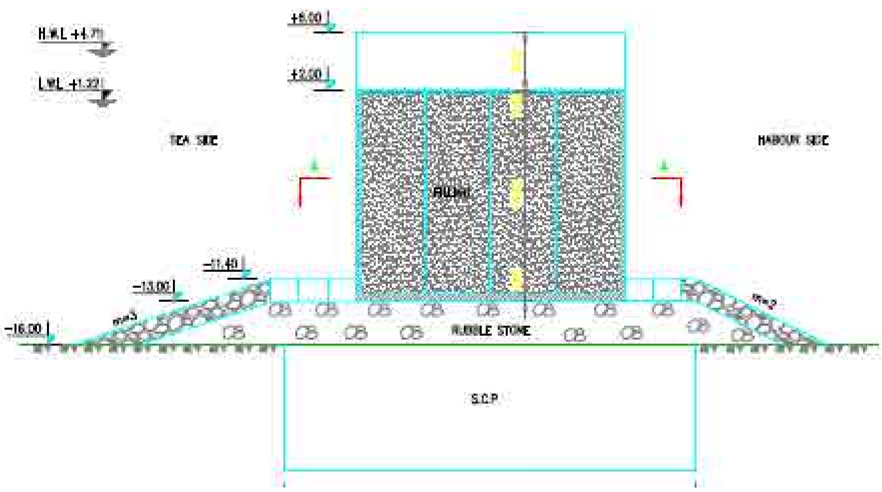
Table 5.3.23 Comparison of the Four Types of Breakwater Structures

	Gravity Type (Caisson)	Rubble Mound Type (wave dissipating block)	Pile and Curtain Wall Type	Embedded Circular Cell Type
Schematic structure				
For the case of soft soil condition	Necessary B	Necessary B	Not necessary A	Necessary B
Effect of surrounding sea environment	Cross section is not so large and impact is not big, but should be considered. B	Large-scale cross section and impact should be considered C	Relatively small impact A	Cross section is not so large and impact is not big, but should be considered. B
Easiness of construction	Large temporary construction yard is necessary A	Temporary construction yard for block is necessary A	Temporary construction yard is not necessary. B	Temporary construction yard for steel cell fabrication is necessary. Special equipment at site is necessary. C
Cost efficiency	1 A	2 B	3 C	4 C

Durability and past record of construction	Durable concrete structure many past construction record A	Rock and concrete material are durable many past construction record. A	Corrosion protection of steel is necessary. Little past record of similar large-scale structure. C	Corrosion protection of steel cell is necessary. Very little past record of construction. B
Judgment	Appropriate A	Appropriate B	Inappropriate C	Inappropriate C

6) Anticipated Cross Section

For gravity type (Caisson)



Source: JICA Study Team

Figure 5.3.19 Cross Section of the Gravity Type (Caisson) Breakwater

(2) Revetment

The cross section of the revetment in the case of reclamation of the sea for coal stock yard in the 3rd Phase is studied.

1) Selection of Type of Structure

Because the vertical load of coal stock yard is big, circular slip of the ground should be carefully considered for the selection of the type of revetment structure.

2) Design Conditions

i) Natural Conditions

Natural conditions are shown in “Section 5.3.1 Design Conditions”. The design soil conditions at near shore location shown in Table 5.3.7 was considered for revetment.

ii) Conditions for use (vertical load)

Road area of width of 20 m from the shoulder of revetment: 20 kN/m^2
Coal stock yard: 100 kN/m^2

3) Dimensions

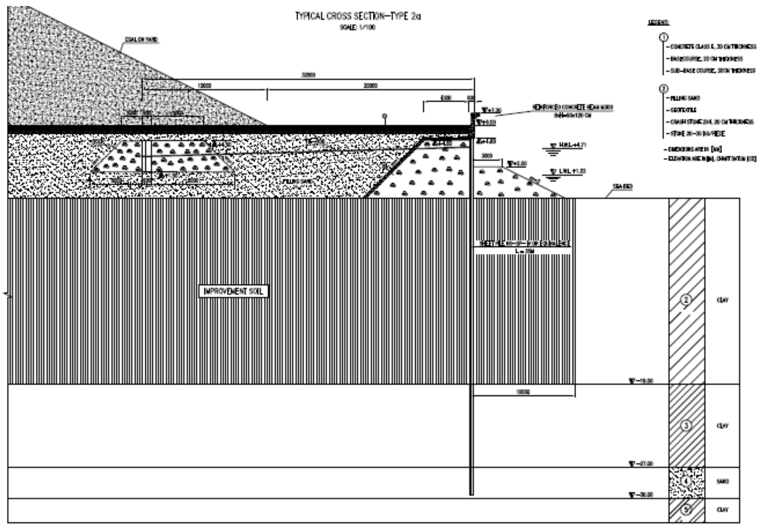
Crown height: +6.0 m
Water depth in front of the revetment： -2.0 m
Yard area layout plan：Based on the yard area planning, normal line of revetment is 500 m offshore from the coastal line.
Yard length: 1,600 m

4) Design Structure

The stability of circular slip is not ensured in the current soil condition. The sheet pile structure is employed and soil improvement under the revetment is conducted. The safety factor of circular slip of 2.13 is ordinary ensured in the case. The cross section of sheet pile is No. 4 and anchor plate is employed.

5) Design Drawings

Revetment



Source：JICA Study Team

Figure 5.3.20 Typical Cross Section of Revetment

5.3.5. Trestle

The typical cross section of trestle is studied in the condition that trestle is allocated until offshore is at a depth of -15.0 m.

(1) Trestle

1) Design Conditions

i) Natural Conditions

Natural conditions are shown in "Section 5.3.1 Design Conditions". The design soil conditions in the offshore location shown in Table 5.3.8 was considered for trestle.

ii) Conditions for Use

Belt conveyor: belt conveyors with four lanes at the 3rd Phase, with three lanes at the 2nd Phase and with two lanes at the 1st Phase are considered for transfer of import coal to coal stock yard. The width of belt conveyor is 2200 mm.

Access road: One lane access road for management purpose is considered. Width of the access road is 4.0 m. Live load of small vehicle is applied.

2) Selection of Type of Structure

Bridge type is selected by considering the length, water depth, waves, and the impact on sea environment.

PC hollow slab girder is selected for the access road and steel truss bridge is employed for the belt conveyor. The truss structure of the belt conveyor will be studied in more detail at the determination of conveyor structure. Steel pile for bridge pier is selected because the load of bridge pier is not so large and long pile is expected. Covers for belt conveyor are considered to protect the environment.

3) Dimensions

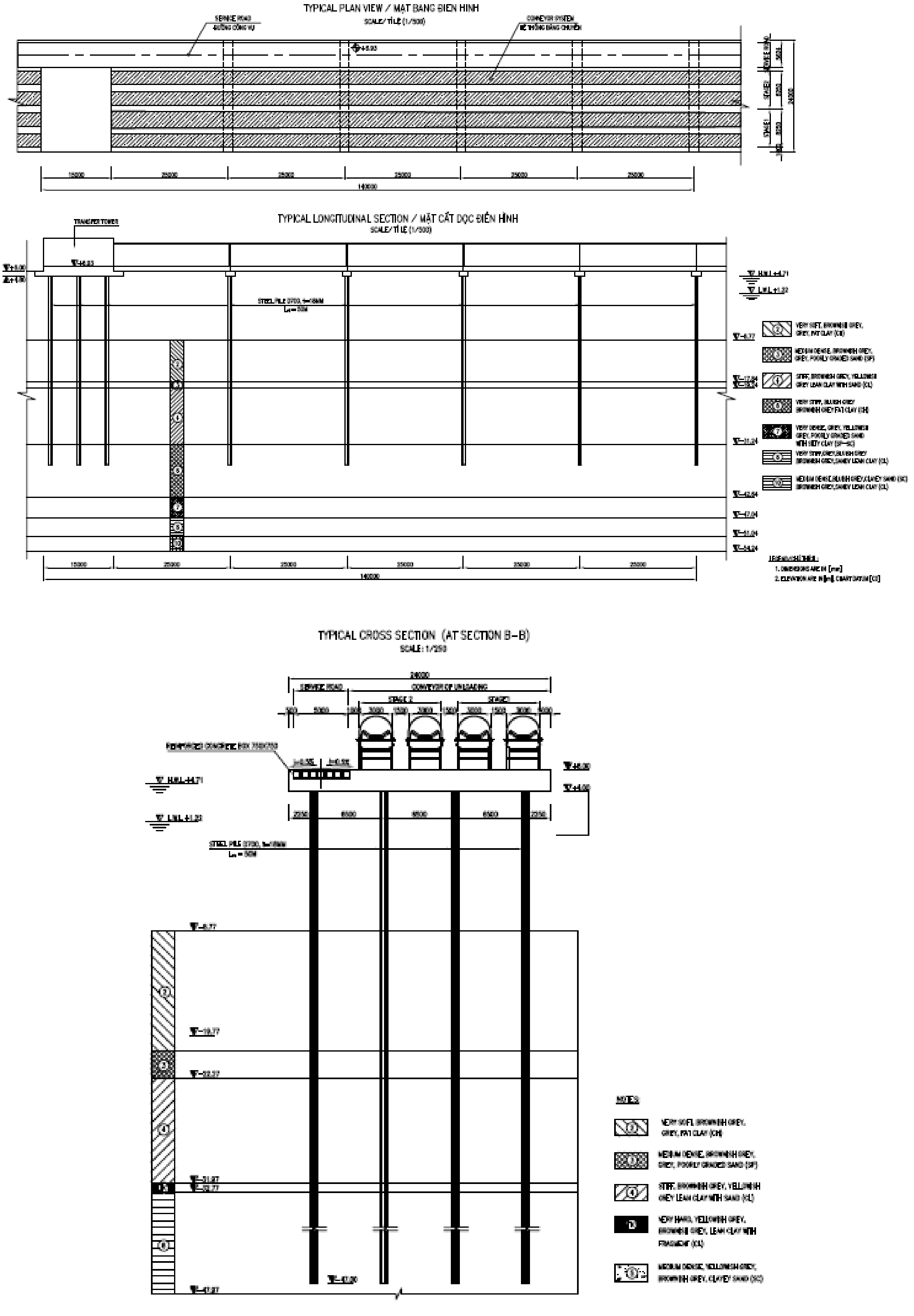
Width: The width of 24.0 m is determined by considering the access road for management and four lanes belt conveyor. The distance between each lane is 4.2 m.

Span of the bridge: The span of 25 m is determined by considering the balance with dead load of superstructure.

Top surface elevation: The elevation of 10 m is determined by considering the extreme wave conditions at the time of HWL. In the case that the trestle is installed along existed breakwater, the elevation of 10 m is employed in consideration with the effect of waves. The transfer switch for belt conveyor is installed appropriately in the trestle.

4) Design drawings

For trestle



Source：JICA Study Team

Figure 5.3.21 Layout, side view and typical cross section of trestle

5.3.6. Countermeasure Structure against Channel Sedimentation (Training Dike)

Training dike is allocated at head of the existing breakwater to protect the channel. The cross sections at water depth of -5 m and -10 m which are typical locations are studied in this section because the length of the training dike is determined by the simulation of channel deposition.

(1) Selection of Structure Type

The function of training dike is to reduce the volume of channel sedimentation. Therefore, the type of structure is determined by considering the stability of structure and its economy. As a result, rubble mound type is applied. Settlement of soil is permissible.

(2) Design Conditions

Wave: waves at water depth of -5.0 m and -10.0 m are considered.

Tidal current: it is not considered

Soil: soil improvement is considered to ensure stability of slip circular, because the surface of the soil is in soft soil condition. The design soil conditions in offshore location shown in Table 5.3.8 was considered.

(3) Dimensions

Crown height: Complete interruption of soil sedimentation is considered in the numerical simulation results. Therefore, the height of +5.0 m on the sea surface is determined to have a margin of HHWL.

Slope gradient: 1:4/3 is considered to keep the stability of structures.

(4) Design Results

Weight of block: 12 t/block

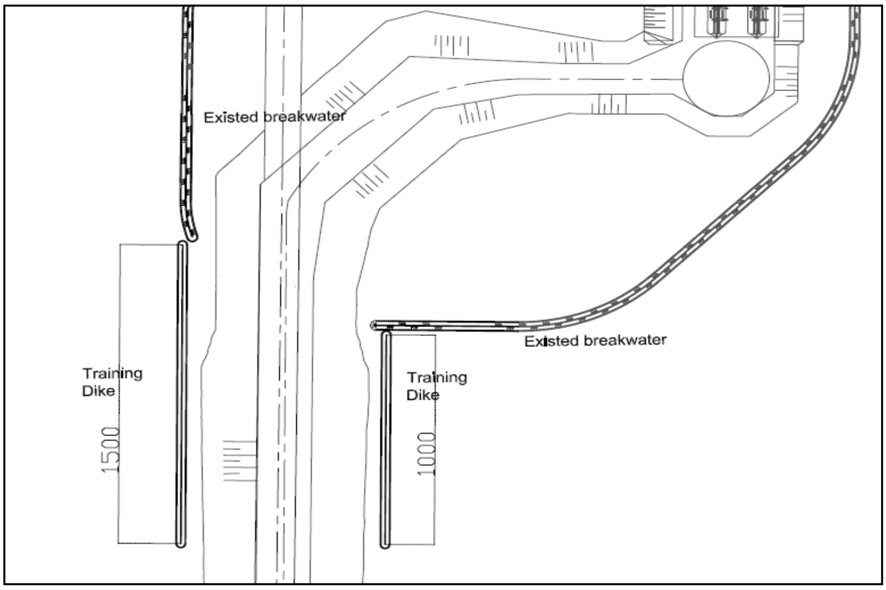
Weight of covered stone: 1.2 t/stone

Weight of rubble: 200 to 300 kg/rubble

Soil improvement: sand displacement t=5 m

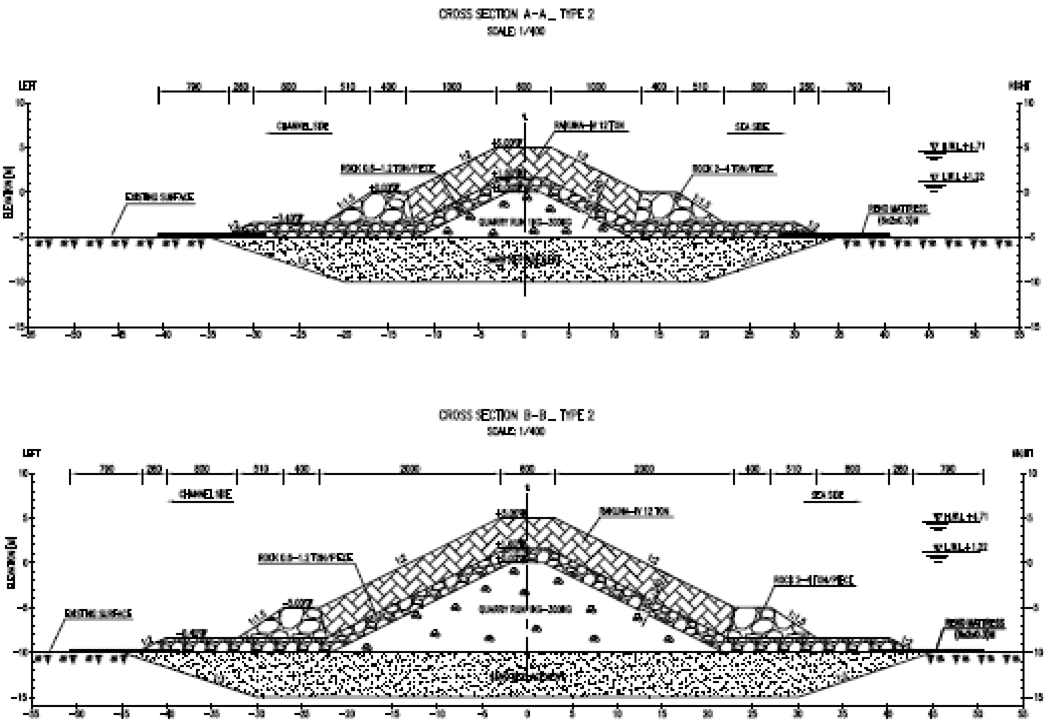
(5) Drawing

General layout



Source：JICA Study Team

Figure 5.3.22 Layout of the Training Dike



Source：JICA Study Team

Figure 5.3.23 Typical Cross Section of the Training Dike

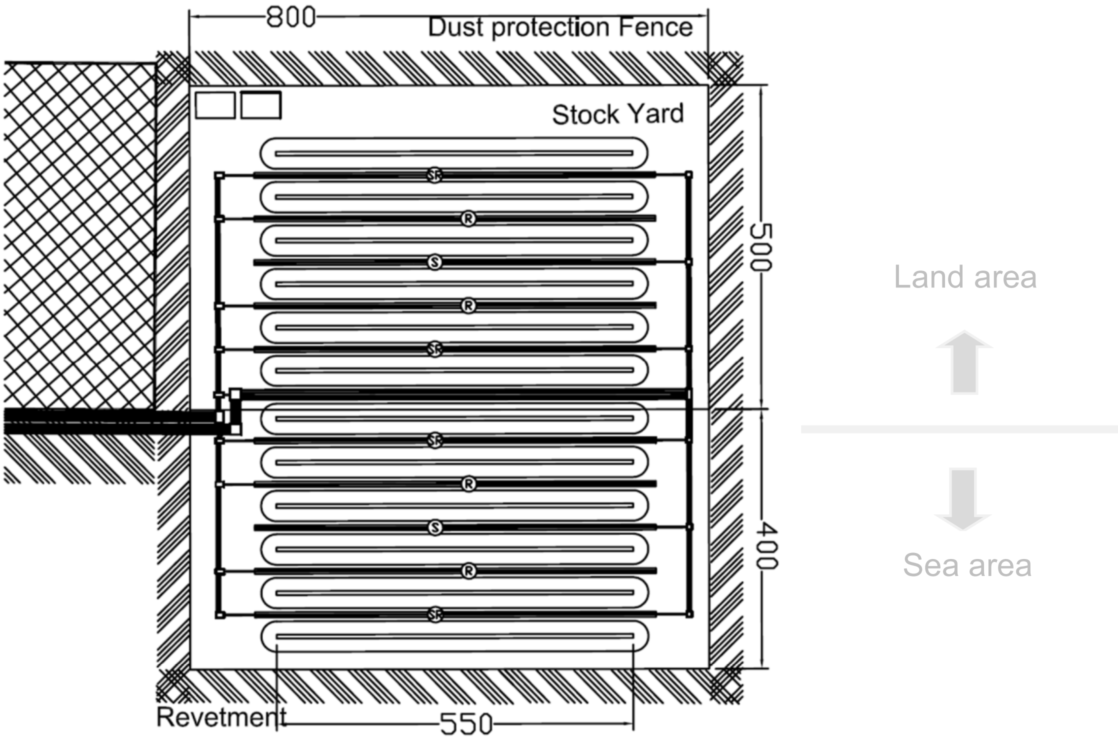
5.3.7. Coal Stock Yard

(1) Selection of Structure Type

The developed plan from the 1st Phase to the 3rd Phase is considered. Required area of stock yard is as follows:

1st Phase: 22 ha
2nd Phase: 18 ha
3rd Phase: 32 ha

The layout of stock yard is shown in Figure 5.3.24. At the 3rd Phase, reclamation work is considered to expand a part of the stock yard.



Source：JICA Study Team

Figure 5.3.24 Layout of Planned Coal Stock Yard

Designed structures and facilities are shown below.

i) Reclamation
ii) Base of stacker reclaimer
iii) Soil improvement
iv) Pavement
v) Dust protection fence
vi) Other facilities such as utility of drainage or water treatment

(2) Design Conditions

1) Natural Conditions

Land elevation: current average elevation is +3.0 m, land reclamation by +6.0 m

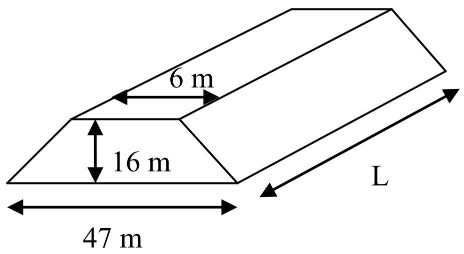
Soil conditions: The design conditions of near shore location at the coastal area as shown in Table 5.3.7 are applied.

2) Conditions for Use

Current average elevation at the site is around +2.0 m to +3.0 m.The elevation after land reclamation is +6.0 m by considering overtopping wave.

The typical cross section of coal stockpile is determined by considering the past examples and capacity of stacker reclaimer as follows:

Cross section of coal stockpile: trapezoid
Slope gradient: 40°
Height of coal stockpile: 16.0 m
Width of top surface: 6.0 m
Width of bottom: 47.0 m



Source：JICA Study Team

Figure 5.3.25 Dimensions of Coal Stockpile

3) Structure Results

i) Reclamation

The stock yard elevation of +6.0 m, which is slightly higher than the current elevation is determined by considering the wave or drainage. An average of 3.0 m height of the reclamation is considered.

ii) Basement of Rail for Stacker Reclaimer

The beams under the ground supported by steel pile are considered as basement of rail for stacker reclaimer. The grid span of 10 m connecting both sides of the beams was considered to ensure the rail span. The height of basement is 1.2 m higher than the coal stock yard to protect rail from sedimentation by coal.

iii) Soil Improvement

About 120 kN/m^2 weight from the height of coal stockpile of 16.0 m is expected. Ground settlement should be considered due to the weight and about 20 m thickness of soft silt layer at the site. In the case of no consideration of soil improvement, a maximum of about 1.75 m consolidation settlement of clay soil layer is expected. To prevent from settlement, soil improvement is applied. Pre-loading method with PVD is expected and selected as most cost efficient. Square configuration of PVD with 1.3 m interval is determined. The surcharge height of 14 m is considered and over 90% of final volume of consolidation settlement is expected in eight months.

iv) Pavement

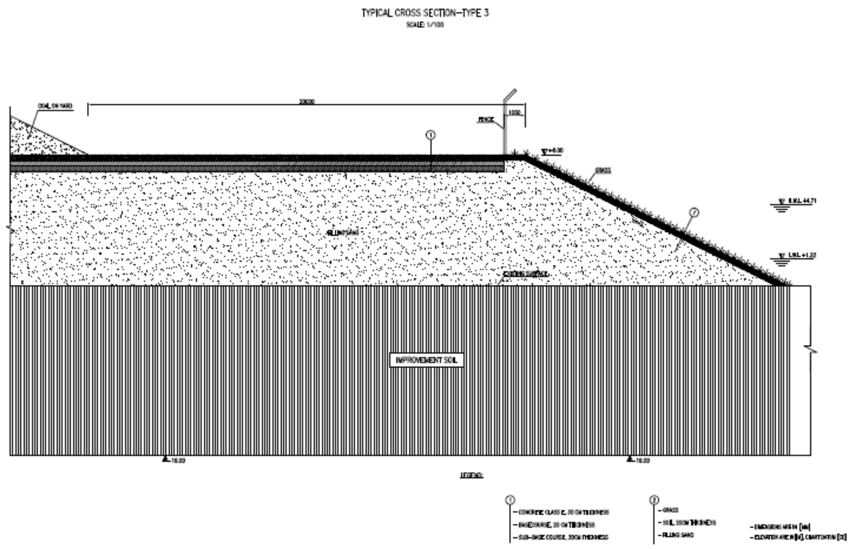
Wheel loader, reclaimer, or bulldozer for transfer of coal stockpile is considered for the design of pavement. Concrete slab of 0.3 kN/cm^2 with thickness of 30 cm, upper road bed with thickness of 20 cm and lower road bed with thickness of 30 cm for capacity of wheel loader of 2.0 m^3 are considered. About 2% gradient is selected to drain water from sprinkler for dust or fire protection.

v) Dust Protection Fence

The dimensions of dust protection fence are expected therefore, the height of the fence is 8 m and the height of the base is 2.0 m, which are same as the Chubu Coal Center in Japan. PC piles, L=20 m, Ø=300 m and t=60 mm, are considered as the base of the fence. The dust protection fence is planned to be installed at the border of coal stock yard on landside until the 2nd Phase.

4) Design Drawings

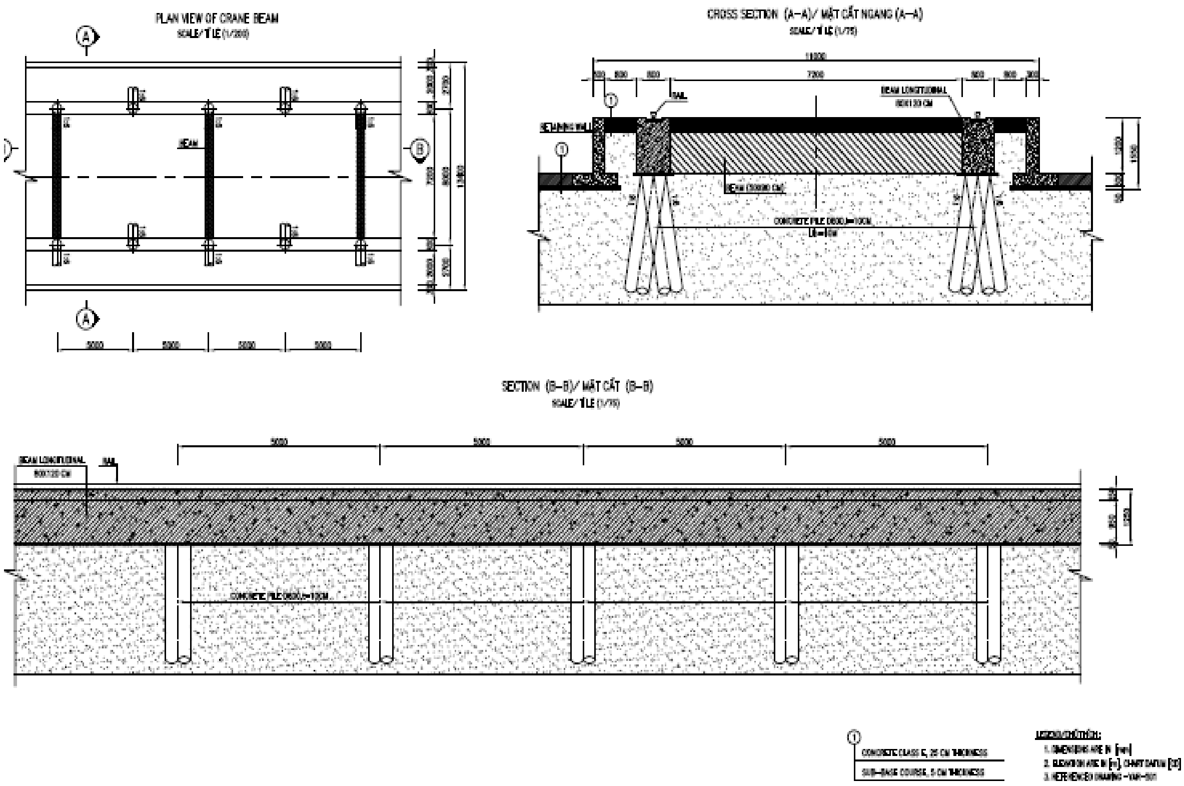
i) Reclamation slope on the landside



Source: JICA Study Team

Figure 5.3.26 Typical Cross Section of Reclamation Slope on the Land Side

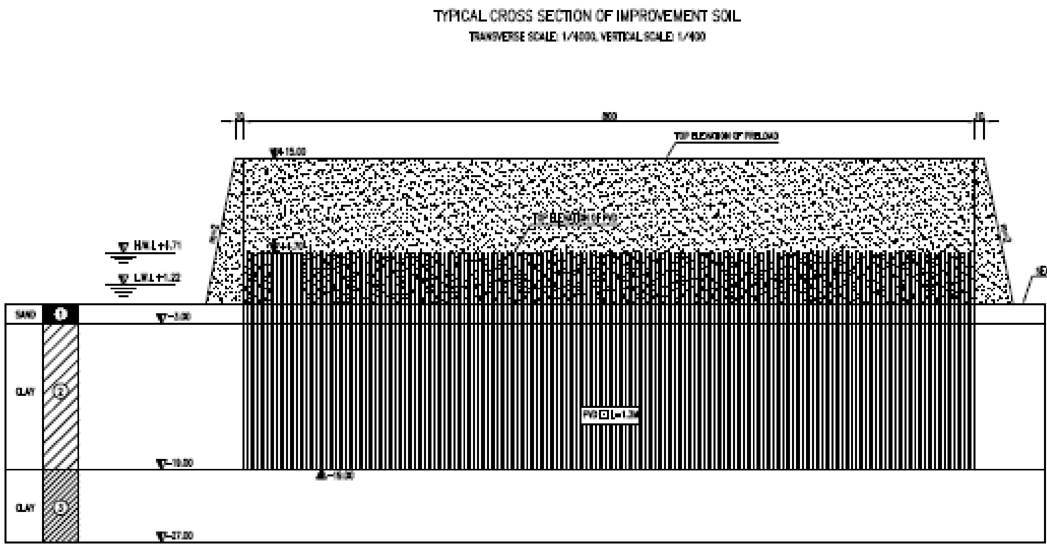
ii) Basement for stacker reclaimer



Source: JICA Study Team

Figure 5.3.27 Drawings of Basement for Stacker Reclaimer

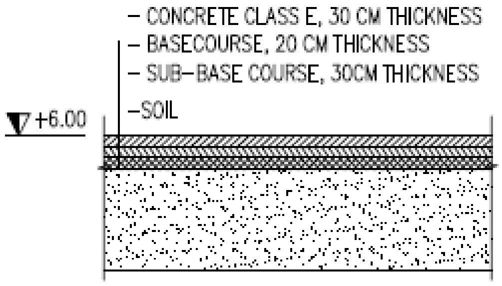
iii) Soil improvement of the coal stock yard



Source: JICA Study Team

Figure 5.3.28 Cross Section of Soil Improvement

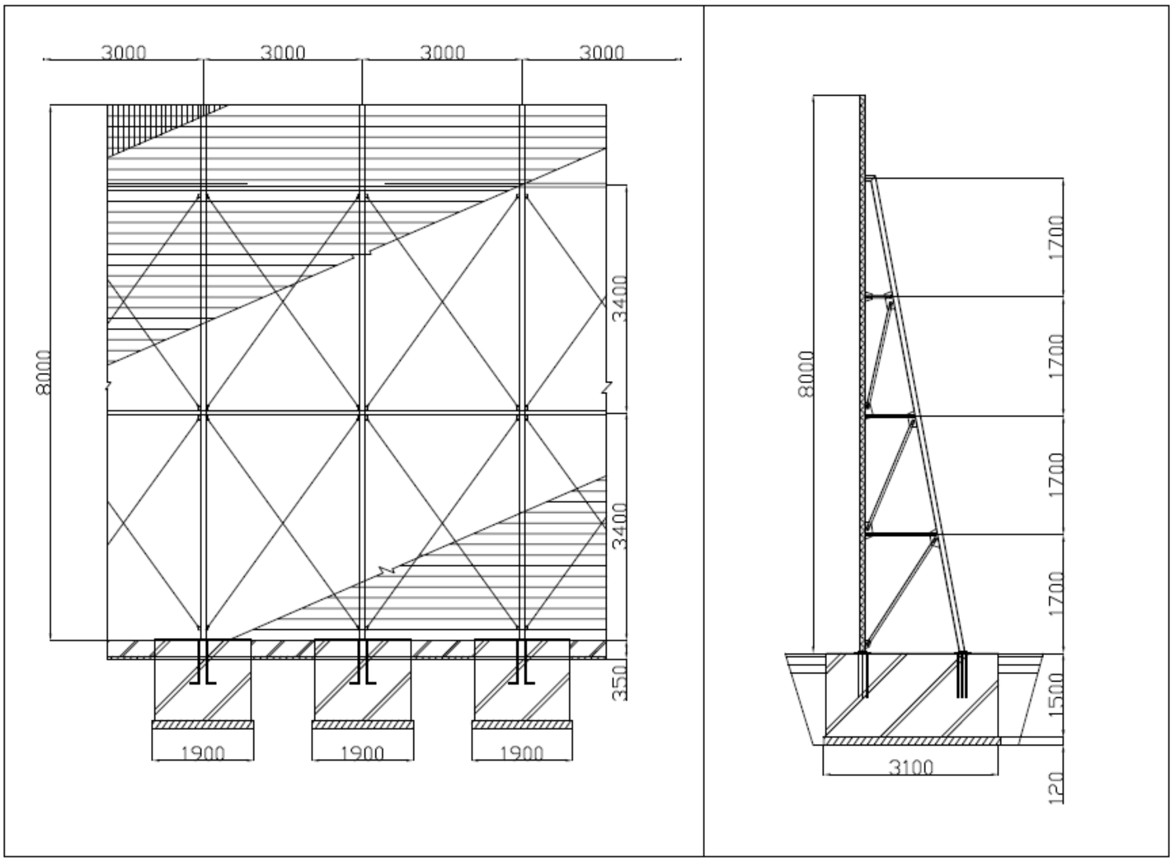
iv) Pavement



Source: JICA Study Team

Figure 5.3.29 Cross Section of Pavement

v) Dust protection fence



Source: JICA Study Team

Figure 5.3.30 General Layout of Dust Protection Fence

5.3.8. Navigational Channel and Aids for Navigation

(1) Navigation Channel

1) Dimensions of Channel

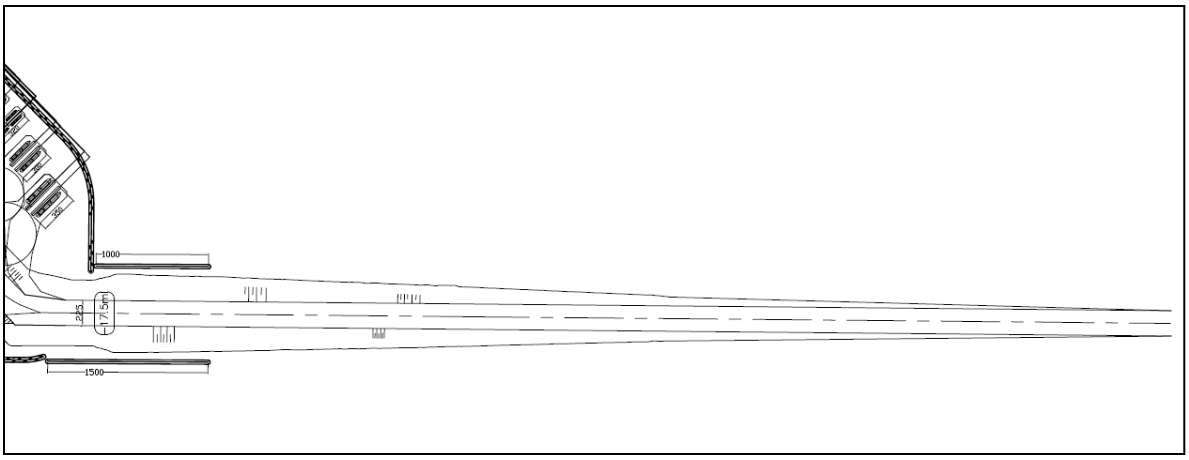
Dimensions of the navigational channel are determined in "Section 5.2.2" as follows:

For import vessels

Channel width:	1st and 2nd Phases	200 m
	3rd Phase	225 m
Channel water depth:	1st and 2nd Phases	-14.5 m
	3rd Phase	-17.5 m
Channel direction:	Center line of the channel is on a parallel with approach channel for the Hau River Bypass Canal. The center line is shifted toward 65 m north to maintain the stability of the southern side breakwater for the Hau River Bypass Canal. The northern breakwater of 130 m and the southern breakwater of 220 m for Duyen Hai Port should be removed with the expansion of the channel. Although calmness of the port is not maintained due to the removal of the breakwater, enough calmness of the port is ensured by the installation of the training dike, which is allocated along the channel from head of the breakwater.	

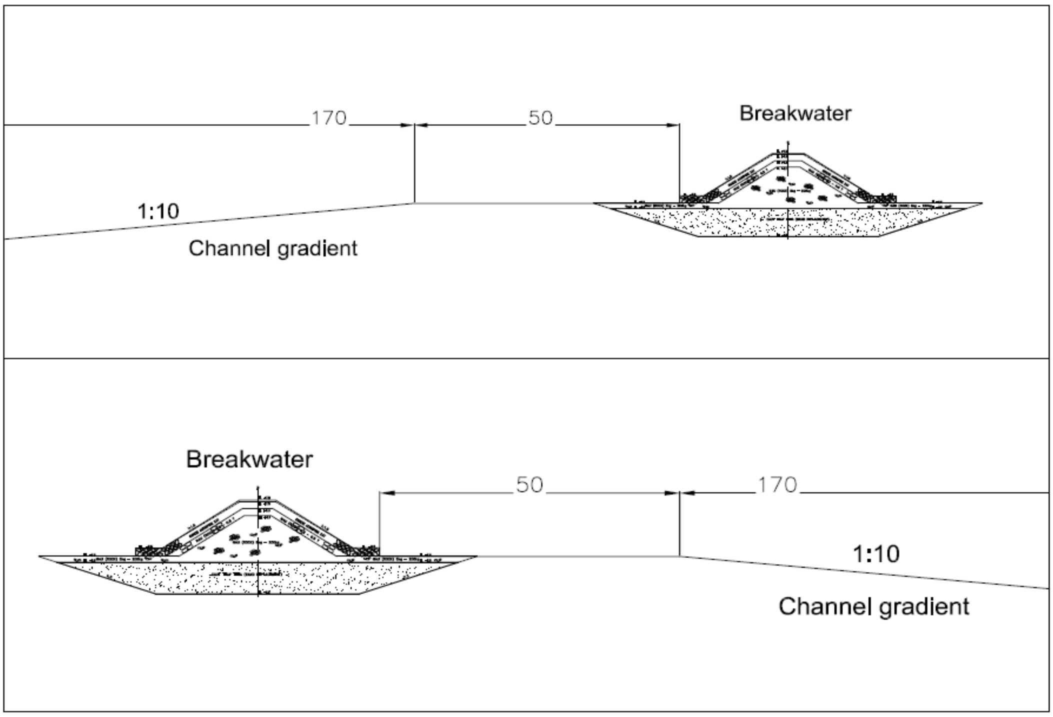
2) Cross Section of Channel

Slope gradient of 1:10 for the channel is determined by considering the soft soil condition.



Source：JICA Study Team

Figure 5.3.31 Layout of Approach Channel



Source：JICA Study Team

Figure 5.3.32 Relationship between Channel Gradient and Existing Breakwater

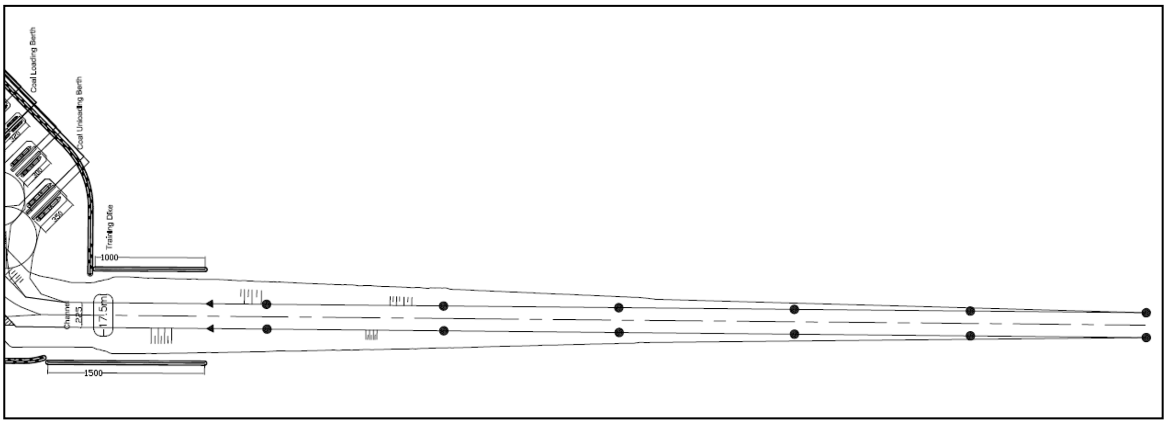
(2) Aids for Navigation

1) Structural Type

Channel beacon marker buoy, fixed type beacon light for berth.

2) Installation of Channel Beacon Marker Buoy

Since the straight channel from the channel entrance to the port entrance is designed, installation of marker buoy at both sides of the channel from the entrance to the mouth of port with 1 nautical mile interval is necessary.



Source：JICA Study Team

Figure 5.3.33 Layout of Channel Beacon Marker Buoy

5.3.9. Basement of Facilities on Landside

(1) Structure

PC concrete piles are expected as basement of facilities on landside such as belt conveyors or buildings.

5.4. Outline of Execution Plan and Schedule of Construction Works

5.4.1. Outline of the Work Items

This project is recommended to be divided into three phases as mentioned above. Construction of the facilities will be divided into three stages, namely, the 1st Phase, 2nd Phase, and 3rd Phase, according to the phasing of the project.

The outlines of work items by phase of the facilities to be constructed, coal handling equipment to be installed, and buildings to be constructed in the CTT Project are given in Table 5.4.1, Table 5.4.2, and Table 5.4.3, respectively.

Table 5.4.1 Outline of Facilities to be Constructed

No.	Facility's Name	Unit	Quantity		
			1st Phase	2nd Phase	3rd Phase
1	Construction of Coal Unloading Berth	Berth	2	3	4
2	Construction of Coal Loading Berth	Berth	2	4	7
3	Earthworks of the Coal Storage Yard	ha	22	40	72
4	Revetment	m	2,054	3,400	5,000
5	Dredging and Disposal Works	million m^3	19	21	37
6	Channel Protection Work	km	2.5	2.5	2.5

Source: JICA Study Team

Table 5.4.2 Outline of Coal Handling Equipment to be Installed

No.	Facility's Name	Unit	Quantity		
			1st Phase	2nd Phase	3rd Phase
1	Coal Unloading Machine	Set	4	6	8
2	Coal Loading Machine	Set	2	4	7
3	Stacker Reclaimer	Set	3	5	10
4	Belt Conveyor	km	22.7	31.5	51.6

Source: JICA Study Team

Table 5.4.3 Outline of Buildings to be Constructed

No.	Facility's Name	Unit	Quantity		
			1st Phase	2nd Phase	3rd Phase e
1	Administration Building	L.S.	1	1	2

2	Maintenance Shop	L.S.	1	1	2
3	Sub-Station	L.S.	1	1	2
4	Wind Protection Wall	km	1.8	1.8	1.8
5	Security Fence	km	2.6	2.6	4.2

Source: JICA Study Team

5.4.2. General Conditions of the Site

Location, access, natural conditions and social conditions are studied in this section. These conditions will be used for estimation of the work method, procedure, equipment to be used, and activity ratio of each work item.

(1) Project Site Location and Accessibility to the Site

The project site is located in the estuary of the Mekong River and divided into the northeast side of the Duyen Hai Coal Power Plant and the harbor area of the power plant which will be connected by belt conveyor. The coal storage yard and necessary buildings will be constructed in the area at the northeast side of the Duyen Hai Coal Power Plant. The coal unloading berth and loading berth will be constructed in the existing harbor.

Land transportation and water transportation are possible to be used as access to the site. However, the water depth in front of the sea is too shallow to be used for water transportation until construction of the Hau River Bypass Canal is completed.

The location of the project site is shown in Figure 5.4.1.

Source: JICA Study Team

Figure 5.4.1 Project Site Location

(2) Natural Conditions and Social Conditions

The project site is located in the shoreline area of the estuary of the Mekong River. The main natural conditions of the site are summarized below.

No.	Item	Condition
1	Climate	Monsoon climate
2	Rainfall	Annual rainfall is 2,106 mm
3	Wind	Annual average wind velocity is 6.79 m/s
4	Wave	Significant wave height higher than 1.5 m is 68%
5	Existing ground	Subsurface ground is soft silt layer with 12 m

Source: JICA Study Team

5.4.3. Availability of Materials and Equipment

Availability of materials and equipment is important for consideration of the execution plan and construction schedule. It will affect the construction cost also. In this study, available materials and equipment from local sources will be applied as much as possible and imported materials and equipment will be applied only when they are difficult to be obtained from local sources with suitable quantity and quality.

(1) Availability of Materials

Considering the preliminary design of the structures, the main materials to be used and their expected source are studied and listed below.

No.	Material	Facility	Source
1	Concrete	Berth and yard	Near site or on site
2	Stone	Revetment	South Vietnam
3	Reclamation sand	Coal storage yard	Mekong River
4	Rebar	Berth and yard	South Vietnam
5	Foundation pile	Berth	South Vietnam
6	Steel structure	Berth	South Vietnam
7	PVD	Coal storage yard	Vietnam or imported

Source: JICA Study Team

(2) Availability of Equipment

Considering the preliminary design of the structures, the main equipment to be used and their expected source are studied and listed below.

No.	Equipment	Work Item	Source
1	Piling barge	Piling	Vietnam
2	Crane barge (50 t class)	Berth superstructure	Vietnam

3	Material barge (1,000 t)	Berth superstructure	Vietnam
4	Sand pump barge (200 m^3/h)	Reclamation	Vietnam
5	Excavator (0.7 m^3 class)	Earthworks	Vietnam
6	PVD machine (30 m)	Soil improvement	Vietnam or imported
7	Dump truck (20 t)	Earthworks	Vietnam
8	Mobile crane (50 t)	Building works	Vietnam
9	Dredger (5,000-30,000 m^3/day)	Dredging work	Vietnam or imported

Source: JICA Study Team

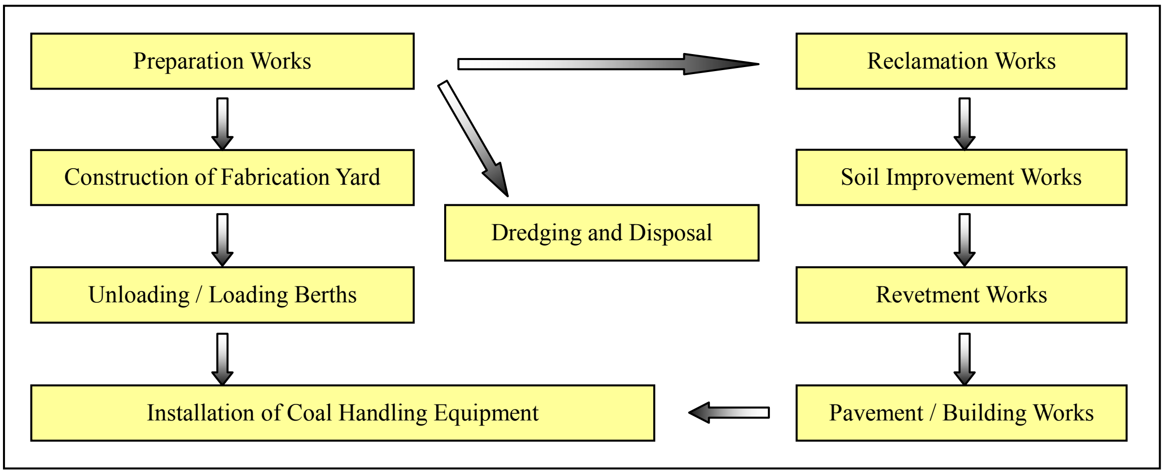
5.4.4. Preliminary Execution Plan

Preliminary construction method is studied considering the following tentative conditions. The purpose of studying the preliminary execution plan is to calculate the tentative construction schedule and construction cost.

- Experienced contractor will implement the works.
- Popular and reasonable work method in Vietnam will be applied.
- Popular and reasonable work progress will be expected.

(1) Overall Execution Flow

The tentative overall execution flow of the construction is shown in Figure 5.4.2.



Source: JICA Study Team

Figure 5.4.2 Overall Execution Flow

(2) Execution Plan for Preparation Works and Temporary Works

Prior to the commencement of construction works, necessary preparation works such as general survey works, installation of fence and gate, construction of office, obtaining permissions and preparation of the method statement and drawings shall be carried out. Fabrication yard for the concrete block and splicing piles shall be prepared as well.

(3) Execution Plan for Construction of Coal Unloading/Loading Berths

The coal unloading berth and loading berth will be constructed in the harbor of the Duyen Hai Coal Power Plant. Driving of foundation piles will be carried out by piling barge with hammer. Pile materials will be transported by material barges after splicing at the temporary yard.

After completion of the piling works, concrete superstructure will be constructed. Supporting work, form work, and rebar work will be carried out by manpower with support of crane barge, and concrete will be placed by concrete pump truck located on the existing breakwater. Ready-mix concrete will be produced at the batching plant located at the temporary yard and transported by agitator truck. To implement this work, the top of the breakwater will be arranged as an access road prior to the commencement of the work.

(4) Execution Plan for Dredging and Disposal

New channel, berth pocket, and turning basin will be dredged up to the required depth. Trailer suction hopper dredger (TSD), cutter suction dredger (CSD), and grab dredger (GD) may be used. TSD and CSD are suitable for dredging of the channel and GD is suitable for excavation of the berth pocket.

Dredged materials will be transported by barge or pipeline and disposed to the provided disposal area. In this study, an offshore dumping area is tentatively applied considering the volume of the dredged materials.

(5) Execution Plan for Reclamation Works

The existing ground elevation is too low for the coal storage yard. Therefore, reclamation will be necessary. Prior to filling sand, surface soil including organic materials and garbage will be removed by backhoe and dump truck.

Reclamation sand will be transported by barge, and the reclamation area will be filled with the reclamation sand by sand pump barge. L-type wall will be constructed at the edge of the reclamation area to protect sand outflow. Sand will be pumped up mixed with water. Therefore, environmental impact by the extra water needs to be protected by spillway and/or silt protector.

(6) Execution Plan for Soil Improvement Works

PVD method will be applied for soil improvement at the coal storage yard. The necessary work items for soil improvement by PVD method are as follows:

(a) Installation of the pump well, monitoring well, and monitoring plate for settlement;
(b) Installation and leveling of sand mat (horizontal drain) by bulldozer and dump truck;
(c) Installation of PVD by PVD machine;
(d) Installation of surcharge soil;
(e) Monitoring and measuring during the surcharge period; and

(f) Removal of surcharge soil.

(7) Execution Plan for Revetment Works

The coal storage area will be located along the shoreline. To protect the coal storage yard from wave and erosion, the shoreline shall be covered by revetment. Rubble slope covered by concrete armor type will be applied to the revetment.

The necessary work items for construction of the revetment are as follows:

(a) Installation of geotextile sheet on the slope by manpower.
(b) Installation of filter stone to protect the geotextile sheet by backhoe.
(c) Installation of rubble stone by backhoe.
(d) Installation of concrete armor block on the rubble stone by backhoe.
Concrete armor block will be fabricated at the temporary yard and transported by truck.

(8) Execution Plan for Pavement/Building Works

After completion of the soil improvement works, foundation of the coal handling equipment, buildings, utilities, and pavement will be constructed at the filled and improved yard. Mobile crane will be used for the main equipment of the building works. Ready-mix concrete will be produced at the temporary yard and transported by agitator truck.

Foundation piles of the coal handling equipment and buildings will be installed by diesel hammer. Utilities such as power supply line, water supply line, drainage system, and foundation piles should be constructed or installed prior to the construction of the pavement.

5.4.5. Temporary Works

Temporary works are important items in order to estimate the construction period and the construction cost.

(1) Necessary Temporary Works

The necessary temporary works for this project are as follows:

(a) Installation of temporary security gate and fence;
(b) Construction of fabrication yard; and
(c) Construction of temporary dike for disposal of dredged materials.

The above works should be conducted prior to commencement of the related permanent works. Therefore, careful schedule control will be required for the smooth implementation of the construction project.

(2) Fabrication Yard

The following works will be conducted at the fabrication yard:

(a) Splicing of concrete foundation piles;
(b) Fabrication of concrete armor blocks;
(c) Production of ready-mix concrete;
(d) Cutting and bending rebars; and
(e) Stockpiling of materials such as stone, piles, and equipment.

The ground of the fabrication yard will be filled with sand and covered with gravel. Filled sand and gravel will be compacted thoroughly by roller in order for vehicles to move smoothly. The fabrication yard will be enclosed by security fence for safety of third parties.

5.4.6. Schedule of Construction Works

In this section, the tentative construction schedule of each stage based on the terminal development plan, preliminary design and preliminary execution plan is studied. The tentative construction schedule will be prepared based on the work quantity, workability ratio, and daily progress.

(1) Work Quantity of Each Facility

Work quantities are calculated based on the preliminary design.

(2) Work Activity Ratio

The following work activity ratios will be applied in consideration of site conditions:

No.	Work Item	Applied Activity Ratio
1	Offshore works	0.7
2	Onshore works	0.8
3	Fabrication works	0.9
4	Other works	0.8

(3) Tentative Construction Schedule

The tentative construction schedule of each stage considering the work quantities, activity ratios, and assumed daily progress are respectively shown in Figure 5.4.3, Figure 5.4.4, and Figure 5.4.5.

No.	WORKING ITEM	Unit	Qty	Productivity (/day)	Act Ratio	Duration (month)
1-1	**Coal Unloading Berth**	berth	2			
	Foundation Pile	nos	750	4	0.7	9
	Superstructure Concrete	m3	16,679	40	0.7	20
	Utility	L.S.	1			3
1-2	**Coal Loading Berth**	berth	2			
	Foundation Pile	nos	240	4	0.7	3
	Superstructure Concrete	m3	8,845	40	0.7	11
	Utility	L.S.	1			3
1-3	**Coal Storage Yard and Revetment**	ha	22			
	Reclamation	m3	1,271,200	8,000	0.8	7
	Soil Improvement	ha	22		0.8	18
	Revetment	m	2,054	10	0.8	9
	Underground Utilities	L.S.	1			6
	Pavement	ha	22	0.3	0.8	3
1-4	**Buildings**	L.S.	1			
	Administrative Building	L.S.	1			18
	Gate and Fence	m	2,600	10	0.8	11
	Wind Protection Wall	m	1,800	5	0.8	15
	Other Buildings	L.S.	1			18
1-5	**Coal Handling Equipment**	L.S.	1			
	Installation of Equipments	L.S.	1			6
1-6	**Dredging and Disposal**	m3	19,447,830			
	Dredging and Disposal	m3	19,447,830	30,000	0.7	31
1-7	**Channel Protection**	km	3			
	Sand Replacement	m3	662,500	5,000	0.7	6
	Stone work	m3	417,500	3,000	0.7	7
	Concrete Block	nos	33,000	80	0.7	20

Source: JICA Study Team

Figure 5.4.3 Tentative Construction Schedule of the 1st Phase

No.	WORKING ITEM	Unit	Q'ty	Productivity (/day)	Act Ratio	Year / Month
2-1	**Coal Unloading Berth**	berth	1			
	Foundation Pile	nos	440	2.0	0.7	10
	Superstructure Concrete	m3	8,340	40.0	0.7	10
	Utility	L.S.	1			3
2-2	**Coal Loading Berth**	berth	2			
	Foundation Pile	nos	240	2.0	0.7	6
	Superstructure Concrete	m3	8,845	40.0	0.7	11
	Utility	L.S.	1			3
2-3	**Coal Storage Yard and Revetment**	ha	18			
	Reclamation	m3	1,528,800	8,000.0	0.8	8
	Soil Improvement	ha	18		0.8	18
	Revetment	m	1,346	10.0	0.8	6
	Underground Utilities	L.S.	1			3
	Pavement	ha	18	0.3	0.8	3
2-5	**Coal Handling Equipment**	L.S.	1			
	Installation of Equipments	L.S.	1			3
2-6	**Dredging and Disposal**	m3	1,105,656			
	Dredging and Disposal	m3	1,105,656	5,000.0	0.7	11

Source: JICA Study Team

Figure 5.4.4 Tentative Construction Schedule of the 2nd Phase

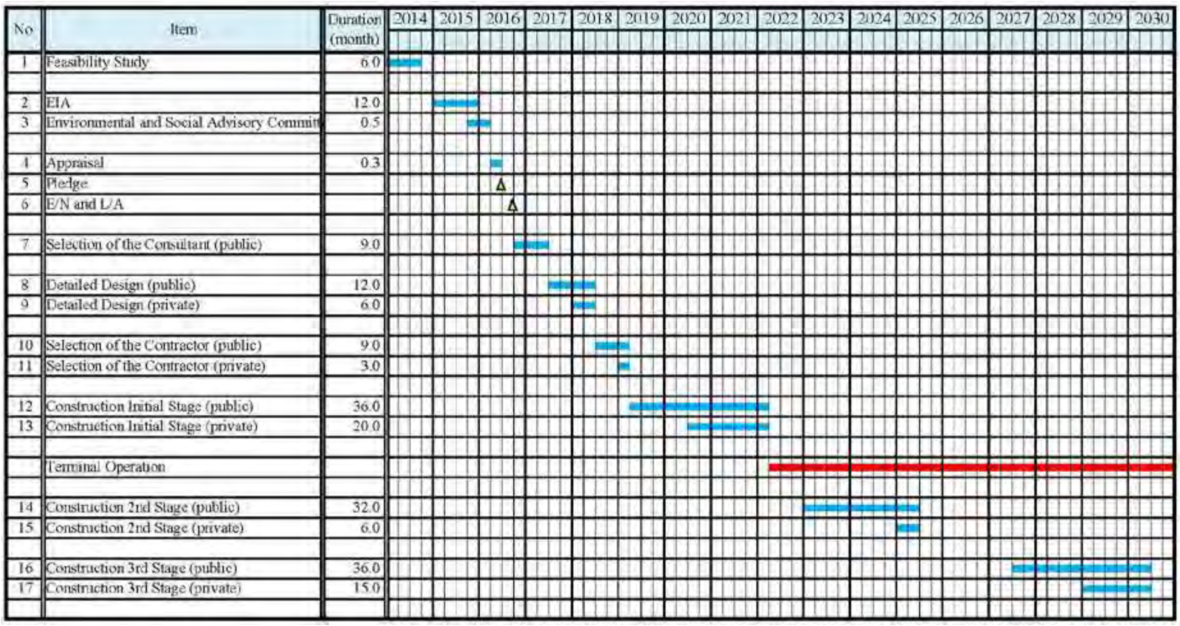
No.	WORKING ITEM	Unit	Qty	Productivity (/day)	Act Ratio	Year / Month
3-1	**Coal Unloading Berth**	berth	1			
	Foundation Pile	nos	440	2.0	0.7	10
	Superstructure Concrete	m3	8,340	40.0	0.7	10
	Utility	L.S.	1			3
3-2	**Coal Loading Berth**	berth	3			
	Foundation Pile	nos	360	2.0	0.7	9
	Superstructure Concrete	m3	13,268	40.0	0.7	16
	Utility	L.S.	1			3
3-3	**Coal Storage Yard and Revetment**	ha	32			
	Reclamation	m3	2,240,000	8,000.0	0.8	12
	Soil Improvement	ha	32		0.8	20
	Revetment	m	1,600	10.0	0.8	7
	Underground Utilities	L.S.	1			6
	Pavement	ha	32	0.3	0.8	4
3-4	**Buildings**	L.S.	1			
	Administrative Building	L.S.	1			12
	Gate and Fence	m	1,600	10.0	0.8	7
	Other Buildings	L.S.	1			12
3-5	**Coal Handling Equipment**	L.S.	1			
	Installation of Equipments	L.S.	1			4
3-6	**Dredging and Disposal**	m3	16,247,599			
	Dredging and Disposal	m3	16,247,599	30,000.0	0.7	26

Source: JICA Study Team

Figure 5.4.5 Tentative Construction Schedule of the 3rd Phase

(4) Tentative Project Schedule

Considering the development plan of the CTT Project and the construction schedule of each stage, the tentative project schedule is estimated as shown in Figure 5.4.6.



Source: JICA Study Team

Figure 5.4.6 Tentative Project Schedule

5.4.7. Construction Safety

Safety in any project is the most important and serious matter concerning all organizations and individuals involved. In this section, the necessary actions to analyze safety risks and recommended safety measures will be described.

(1) Necessary Actions to Analyze Safety Risks

- Safety risks will be evaluated based on multiple value of "possibility of the accident" by "scale of damage by the accident" in the Safety Risk Assessment.
- Safety risk with high score will be determined as an "important safety risk", which need to be monitored and be taken care.
- Detailed factors which realize the risk and countermeasures to avoid such factors shall be analyzed.

(2) Recommended Safety Measures

The following safety measures are recommended by the Consultant at the construction stage:

- Safety officer will be assigned (safety organization).
- Safety fence, safety path, safety stage, etc., will be installed (safety facilities).
- Helmets, safety boots, safety gloves, etc., will be used (PPG).
- Safety information should be shared among all concerned people (safety meeting).
- Third parties should check safety management at site (safety patrol).

- Near-miss study and case study should be carried out (safety training).
- Efficient measures in case an accident happens should be carried out (emergency network).

Chapter 6. Terminal Management

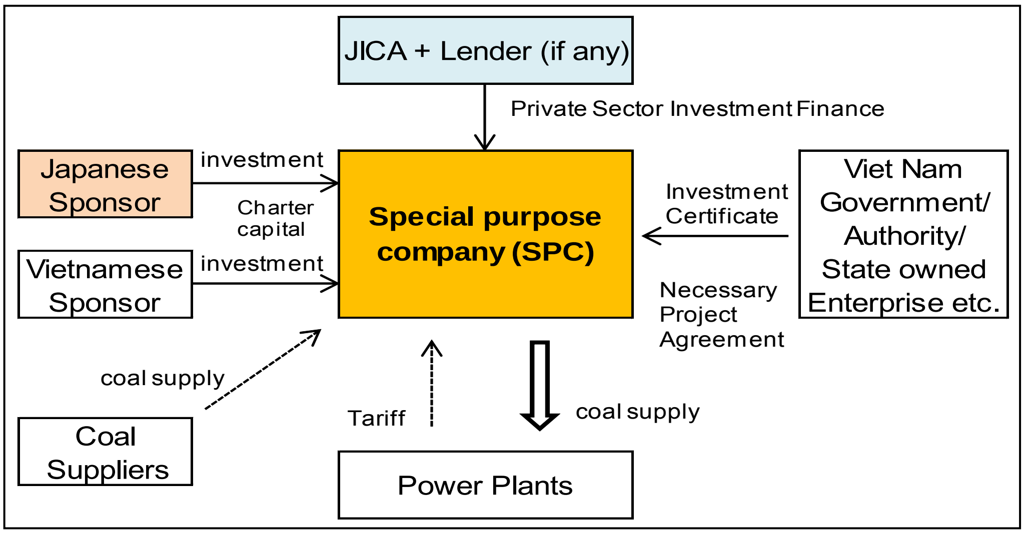
6.1. Terminal Management Organization

In order to make the project successful, it is important to clearly obtain project risk assignment between the government and the private sector. For this reason, it is expected that the lower part of infrastructure for unloading berth, loading berth, coal stock yard, etc., will be applied with Japanese official development assistance (ODA) as managed by the Vietnamese government, and that for the CTT Project including the upper part of infrastructure will be invested and operated by the private sector. It is also expected that the private sector can obtain enough profit for promoting the project.

It is necessary for the CTT Project, that a company manages the whole coal terminal operation of ship entry into port, coal unloading, conveyance to stock yard, coal storage control, loading coal to conveyer for delivery, and loading coal to barge for secondary transportation, in order to satisfy the users' demand timely.

For the CTT Project, it is desirable that a company participating in management of coal terminal, a company with experience in coal sale and transportation in Vietnam, and a company related to power generation in Vietnam, etc., take part as equity participants, concentrate on know-how of each company, and be in charge of corporate management. The Special Purpose Company (SPC), in which a Japanese company and Vietnamese firms invest in, will perform the construction management, and operation and maintenance of the coal terminal.

About the performance of each work, it is expected that capable companies will be selected for each work and the work will be performed under subcontract arrangement. For the organization of SPC, the scheme shown in Figure 6.1.1 is reviewed. Manpower planning for SPC, and the expected staff required for each work is described below.

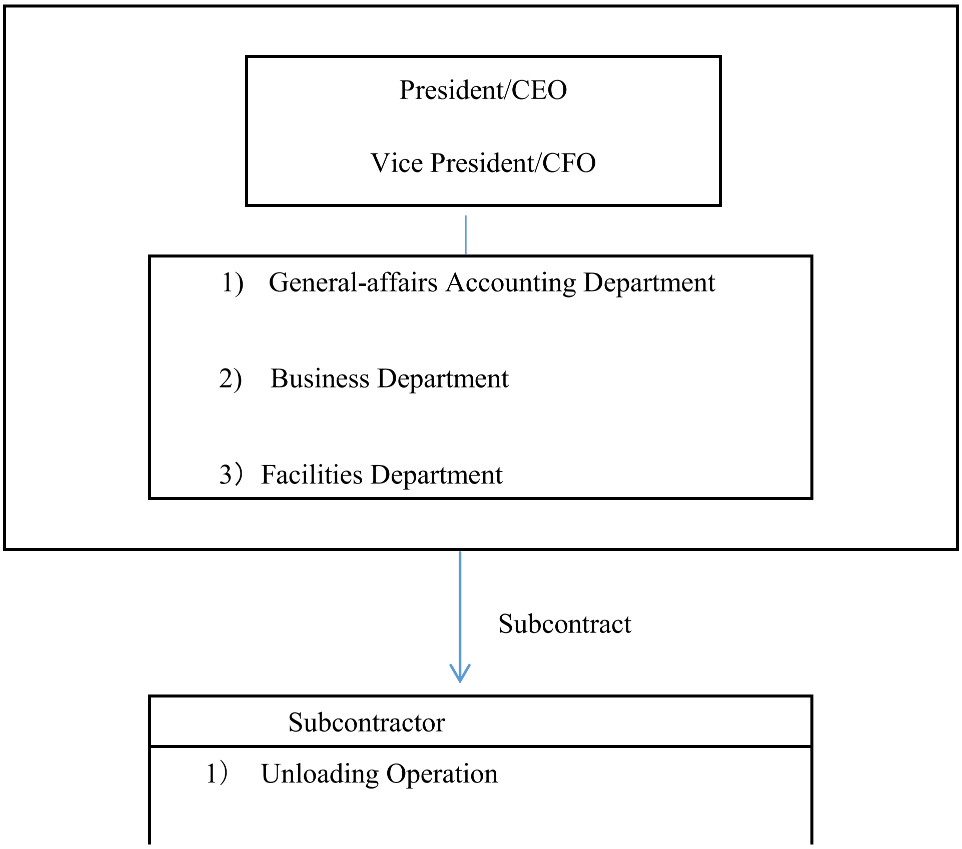


Source: JICA Study Team

Figure 6.1.1 Relation of SPC and Other Related Organizations and Firms

1) It is assumed to place three sections, namely, General-affairs Accounting Department, Business Department, and Facilities Department, under a president/chief executive officer (CEO) and a vice president/chief financial officer (CFO), as the management organization of SPC. In order to accumulate and share know-how of the whole management of CTT, a close liaison mechanism among the business department, and operation and maintenance management persons in charge is important. It is assumed that subcontractors will be used for the operation of unloading, coal stock yard and loading. It is expected that the staff of SPC will understand the whole project, lead the management of operation, and improve such if needed. For this reason, acquisition of know-how on the existing CTT becomes indispensable in this business promotion in Vietnam. It is very important to train specialists on CTT operation in Vietnam by the consultant with know-how on handling of imported coal and extensive experience in operation of a Japanese CTT, or to dispatch Vietnamese staff to a CTT in Japan for training.

1) General-affairs Accounting Department
   Responsible for general affairs relation, personnel relation, and accounting.
2) Business Department
   Responsible for storage and delivery, shipping schedule management, inventory control, subcontractor management, and business development.
3) Facilities Department
   Responsible for construction, and operation and maintenance of facilities, and IT-related works.



2） Coal Yard Operation

3） Ship Loading Operation

Source: JICA Study Team

Chart 6.1.2 SPC Organization and Subcontractor

2) The General-affairs Accounting Department performs general-affairs financial operation, and contract management of subcontracted companies.

(3) The Business Department performs storage and delivery, and inventory control for each customer, shipping schedule management of primary and secondary transport, management of subcontractors who perform the operation of unloading, yard and ship loading, fulfillment of contracts for customers, and business development. In order to grasp and share each customer's stock status and storage and delivery schedule timely, it is important to establish a suitable operation system.

1) Receipt and Delivery

For receipt and delivery operation, it is important to manage the shipping schedule, select the suitable facilities taking into account the efficiency of actual operation, operate them properly, and provide enough trainings for operators as mentioned later.

2) Yard Operation

For storage, operation taking account operational efficiency, safety, and attention to environmental aspects are important. As there will be several customers for this project and one customer will be using some kind of coal, it is necessary to make an inventory schedule of effective receipt and delivery without having to wrongly mix coal. As the imported sub-bituminous coal for this project is different from anthracite coal which has been used in Vietnam and has the nature of spontaneous combustion during long periods of storage, it is very important to avoid the occurrence of spontaneous combustion for storage management with sufficient knowledge. In order to avoid generation of heat, temperature control, spraying of water at appropriate areas, and taking weather conditions and coal specifications into consideration must be done. In addition to those, in case temperature is high, applying of press on coal, stock location change, spraying of water and pouring water, etc., must be done. It achieves a higher efficiency of operation and safety by maintaining a suitable shape of coal that can avoid disruption of coal pail by wind and rain. The effective use of limited storage space is also required. It is also necessary to consider environmental aspects by installing dust fences to suppress particulate scattering of coal, and recovery and recycle treatment facility of rain in the yard.

(4) For the construction stage, the Facilities Department will select, order, and install equipment that can satisfy the expected orders and demand of customers. After commencement of operation, the department will prepare the schedule and manage operation and maintenance.

1) For the construction stage, enough training of staff operating the equipment or workers will be provided before the start of CTT operation. It will be also investigated to carry out the training through cooperation with an existing coal terminal in Japan.

2) Operation of facilities is based on three shifts and for 24 hours. The managers are allocated with main equipment in order to perform proper work management. The work will be conducted after making the work plan in advance, considering the vessel, schedule for receiving and delivering coal.

3) For CTT equipment, unloading equipment of coal, belt conveyor from berth to coal stock yard, belt conveyor in stock yard, and stacker (for stacking coal), reclaimer (for loading coal to conveyor) and feeding conveyor to a berth and a ship loader (for loading coal to barge) are needed. Taking into account the users' demand, the space of the coal stock yard and the number of equipment will be selected, and the equipment will be installed.

In order to establish a highly-efficient management organization, it is important to hear the opinions of users and the personnel of concerned companies, and to reflect the results of hearing at the planning stage of equipment installation.

4) It is required that these facilities are stabilized in order to perform stable operation of unloading, coal stock, and loading, etc., for users. In order to satisfy this function, it is necessary to always maintain equipment operation in a good state. As equipment has the risk of breaking down, it is important to choose a suitable number of equipment so that operation can be complemented by other sound equipment at the time of failure. Maintenance will be done after planning both annual and middle-term maintenance. The necessary replacement parts will be purchased at the required time, and maintenance will be performed so that the service to customers may not be affected. IT apparatus-related installation, operation, and maintenance will be conducted appropriately. Information control of customers, CTT, and equipment data is performed properly.

i) Repair will be done suitably, looking at the operation condition of the equipment before commencement of daily works and also under operation. It is very important to also carry out preventive maintenance and a periodic check in order to secure the function of equipment.

Check and repair are planned to be carried out so that the actual operation of coal handling may not be affected.

ii) Parts with the possibility of failure should be equipped with replacement parts, and can be exchanged promptly at the time of failure. Since there are some which require a long time for delivery, advance purchase and storage of replacement parts are carried out appropriately.

Looking for cooperation with the maker side, it is necessary to prepare the system which can perform failure correspondence on a 24-hour basis. Furthermore, it is also important to select a maker who can respond and accepts such users' request.

iii) Efficient maintenance is carried out and it would be better to take into consideration excessive repair works and avoid it to save on maintenance costs. For example, it would be possible to simplify the maintenance method by reducing the frequency of check and maintenance of equipment that has lower influence on terminal operation and on failure of other facilities. It is also important to set up the period of the first stage, the middle, and the second half based on the lapsed time from installation, and to adopt a maintenance management method suitable for each period.

iv) For failed parts, the cause of failure will be analyzed, and check up to discover failure at an early stage and preventive maintenance will be applied. It is also important to propagate this approach to similar equipment to lower the rate of failure.

5) In case failure of equipment occurs and coal delivery is delayed, it is desirable to stock in a power station the minimum amount of coal to cover the user demand until such time that the failed equipment is repaired. Usually, in case there are replacement parts, the failure would be fixed and operation could restart in about one week or longer. A suitable amount of stock should be prepared taking into account the situation in Vietnam.

6) It is required to carry out terminal management after mastering special knowledge and skill on such. For this reason, close and positive liaison mechanism is built between makers and terminal operator, and it is also important at failure time of equipment to combine the method of agreement for the reservation of replacement parts and on-call contract for failure correspondence which receives the dispatch of a specialist on a 24-hour basis.

7) In failure developmental time, a terminal operator should understand the facts quickly and correctly and make judgment to minimize influence on terminal operation. When a phenomenon of failure is derived, it is required to take into consideration the influence on users' demand, give a role to operators of facilities and maker staff, and judge what function is suspended and substituted with what, and by when, and how the failed equipment will restart. The complement organization for assumed failure and trouble will be trained before the start-up of terminal, and the possibility of problem will be also actualized. From this training, the effect for minimizing the influence of a trouble under actual terminal operation could be expected.

(5) The education of workers is important for all jobs for project operation. Regarding such education, there is a method for understanding the equipment well through operation and maintenance management training by the maker, on-site inspection during construction, and operation and maintenance management manuals. Moreover, operation survey or training for coal handling at another coal center or power generation plant may be utilized. It is considered to use the support of a

consultant with abundant management experience in a coal center, from the test run of facilities to the beginning of actual terminal operation for smooth start-up.

It is also important to utilize IT systems in managing information including information on operation, maintenance plan, history, etc., and analyze such information rationally and utilize them in order to perform more efficient operation and maintenance management.

6.2. Running Cost of CTT Operation

(1) Personnel Expenses

1) Number of Employees

The required number of employees is calculated based on coal demand as referred to in Section 5.1.2. It is divided by direct labor cost and indirect labor cost.

The number of direct labor is calculated based on hearing information from existing coal transshipment terminals in Japan, and the required number of equipment to be installed in each phase.

The number of indirect labor is calculated based on hearing information from existing coal transshipment terminals in Japan and taking the volume of handling coal into consideration.

Table 6.2.1 Estimated Number of Direct Labor

Description	2020	2025	2030
	Phase 1	Phase 2	Phase3
Unloading	68	101	140
Stockyard Operation (Receiving)	16	26	40
Stockyard Operation (Supplying)	11	16	21
Loading Operation	10	18	26
Others	1	2	3
Grand Total / Shift	**106**	**163**	**230**
Grand Total / 3 Shifts	**318**	**489**	**690**

Source：JICA Study Team

Table 6.2.2 Estimated Number of Indirect Labor

Description		2020	2025	2030
		Phase 1	**Phase 2**	**Phase 3**
Director		1	1	1
Duputy Director		1	1	1
Admin Dept and Finance Dept	Manager	1	1	1
	Duputy Manager	1	1	1
	Staff	2	4	6
Marketing and Trading Dept	Manager	1	1	1
	Duputy Manager	1	1	1
	Staff	4	6	8
	Staff at scale station	1	1	1
Construction and Technical Dept	Manager	1	1	1
	Duputy Manager	1	1	1
	Staff	3	5	7
Technology Dept	IT staff	1	2	3
Total		**19**	**26**	**33**

Source：JICA Study Team

2) Unit Cost of Personnel Expenses

Unit cost of personnel expenses, as shown in Table 6.2.3 below, are calculated referring to the minimum wage in Vietnam, which is stipulated in Decree No. 182/2013/ND-CP dated 14 November 2013, and information from the Japan External Trade Organization (JETRO), and hearing information through a local study.

Social and health insurance fees, and unemployment insurance fees are calculated based on the ratio stipulated in Decision No. 1111/QD-BHXH dated 20 October 2011.

Table 6.2.3 Unit Cost of Personnel Expenses

Description	Basic salary/month (Unit:VND K)	Social Insurance - Health Insurance (Unit:VND K)							Bonus (Unit:VND K)	Total Labor Cost per Year (Unit:VND K)	Total Labor Cost per Year (Unit: USD K)
		Paid by Company				Paid by Staff					
		Social Insurance	Unemployment Insurance	Medical Treatment Fund (Health Insurance)	Labor Union	Social Insurance	Unemployment Insurance Fund	Medical Treatment Fund (Health Insurance)	(Month)		
		18%	1%	3%	2%	8%	1%	1.50%	1.5		
Indirect workforce											
Director	17,231	3,102	172	517	345	1379	172	258	25,847	282,248	13.4
Duputy Director	11,488	2068	115	345	230	919	115	172	17,231	188,165	9.0
Admin Dept and Finance Dept											
Manager	8,616	1551	86	258	172	689	86	129	12,923	141,124	6.7
Duputy Manager	5,744	1034	57	172	115	460	57	86	8,616	94,083	4.5
Staff	4,595	827	46	138	92	368	46	69	6,893	75,266	3.6
Marketing and Trading Dept											
Manager	8,616	1551	86	258	172	689	86	129	12,923	141,124	6.7
Duputy Manager	5,744	1034	57	172	115	460	57	86	8,616	94,083	4.5
Staff	4,595	827	46	138	92	368	46	69	6,893	75,266	3.6
Staff at scale station	4,595	827	46	138	92	368	46	69	6,893	75,266	3.6
Construction and Technical Dept											
Manager	8,616	1551	86	258	172	689	86	129	12,923	141,124	6.7
Duputy Manager	5,744	1034	57	172	115	460	57	86	8,616	94,083	4.5
Staff	4,595	827	46	138	92	368	46	69	6,893	75,266	3.6
Technology Dept											
Technology for load and unload facilities	4,595	827	46	138	92	368	46	69	6,893	74,163	3.5
IT staff	4,595	827	46	138	92	368	46	69	6,893	74,163	3.5
Direct workforce											
Equipment/Facility Operator	4,595	827	46	138	92	368	46	69	6,893	75,266	3.6
Staff works at coal storage and coal yard	4,595	827	46	138	92	368	46	69	6,893	75,266	3.6

Source：JICA Study Team

(2) Utilities Expenses

1) Usage of Electricity

The usage of electricity is calculated by the required amount of electricity consumption of equipment to be installed in each phase.

2) Electricity Cost

Electricity costs, as shown in Table 6.2.4, are calculated based on the tariff for "Production Sectors" stipulated in Decision no. 4887 dated 30 May 2014.

Table 6.2.4 Estimated Electricity Costs

No.	Price Applicable to Subjects	Electricity Selling Price (VND/kWh)
1	**Voltage of 110 kV or higher**	
	a) Off-peak hours	1,267
	b) Low-load hours	785
	c) Peak hours	2,263
2	Voltage level from 22 kV to less than 110 kV	
	a) Off-peak hours	1,283
	b) Low-load hours	815
	c) Peak hours	2,354
3	Voltage level from 6 kV to less than 22 kV	
	a) Off-peak hours	1,328
	b) Low-load hours	845
	c) Peak hours	2,429
4	Voltage level of less than 6 kV	
	a) Off-peak hours	1,388
	b) Low-load hours	890
	c) Peak hours	2,520

Source：Decision no. 4887/QD-BCT dated 30 May 2014

(3) Water Charge

The maximum and minimum rates of water charge are stipulated in Circular No. 88/2012/TT-BTC, as shown in Table 6.2.5 below; however, the tariff to be applied vary by province. Although the tariff in Tra Vinh Province is under investigation, this charge will not affect the results of the study. Therefore, detailed water charges are not calculated in this study.

Table 6.2.5 Maximum and Minimum Water Charges

Kind	Minimum Price (VND/m^3)	Maximum Price (VND/m^3)
Special urban areas, urban areas in Class 1	3,500	18,000
Urban areas in Class 2, Class 3, Class 4, Class 5	3,000	15,000
Clean water in rural areas	2,000	11,000

Source：Ministry of Finance's Circular No. 88/2012/TT-BTC dated 28 May 2012

(4) Depreciation Cost

Useful life is based on Circular No.: 45/2013/TT-BTC dated 25 April 2013 as shown in Table below. They are calculated by straight-line depreciation, with salvage value of zero.

Main Equipments:	**Item**	**Depreciation period**
Unloader	B-22	20 years
Belt Conveyor	B-18	12 years
Stacker-Reclaimer	B-18	12 years
Ship-Loader	B-22	20 years
Handling Machinery:		
Wheel Loader	D-7	10 years
Buldozer	D-7	10 years
Truck	D-7	10 years
Power Supply & Control System		
Electricity Supply System for unloader	A-3	15 years
Central Control System for unloader	A-3	15 years
Environmental Facilities:		
Dustproof Fence	I	25 years
Drain Water Treatment Facility:	B-18	12 years

Source: Ministry of Finance's Circular No. 45/2013/TT-BTC dated 25 April 2013

(5) Maintenance Cost for Coal Handling Equipment

It is assumed that 3% of purchased cost is the maintenance cost for coal handling equipment per year according to hearing information from equipment suppliers.

(6) Insurance Cost

The cost of property insurance or business interruption insurance for terminal assets is 0.6% of the upper infrastructure amount according to hearing information from existing CTTs in Japan and insurance company. This insurance compensates the damage of equipment and damage caused by equipment trouble.

(7) Land Usage Fee

1) As mentioned in Chapter 8, lower infrastructure should be prepared by the Vietnamese government otherwise this project will not be feasible for private investors. Therefore, lower infrastructure is prepared and owned by the Vietnamese government, and not by SPC.

2) The lower infrastructure is an asset of the Vietnamese government, and will have economic value after the project term. Therefore, necessary funding for the lower infrastructure, which is assumed to come from a JICA official development assistance (ODA) loan, should basically be prepared and borne by the Vietnamese government. However, it is assumed in this study that SPC will bear 50% of the funding cost, which is principal and interest of ODA loan, for the lower infrastructure as "Land Usage Fee" to the Vietnamese government. This issue should be further discussed with the Vietnamese government.

   Land acquisition and resettlement costs are not included. Such costs must be borne by the Vietnamese government.

3) Assumed Terms and Conditions of JICA ODA Loans

   i) Terms and conditions

      "General terms", "fixed interest", "Option 1" of "lower-middle-income countries as of 1 April 2014"

   ii) Interest rate: 0.8%

   iii) Repayment period: 20 years (Grace period is 6 years. Interest payment will be commenced from the 1st year of operation.)

   iv) ODA loan amount:

Initial Debt	(2020):	USD 574 million
Additional Debt 1	(2025):	USD 160 million
Additional Debt 2	(2030):	USD 457 million
Total	:	USD 1,198 million

(8) Maintenance Cost for the Lower Infrastructure

The lower infrastructure is supposed to be owned by the Vietnamese government; however, the study team assumed that 100% of the maintenance cost during the project term is borne by SPC, instead of the Vietnamese government.

(9) Other Expenses

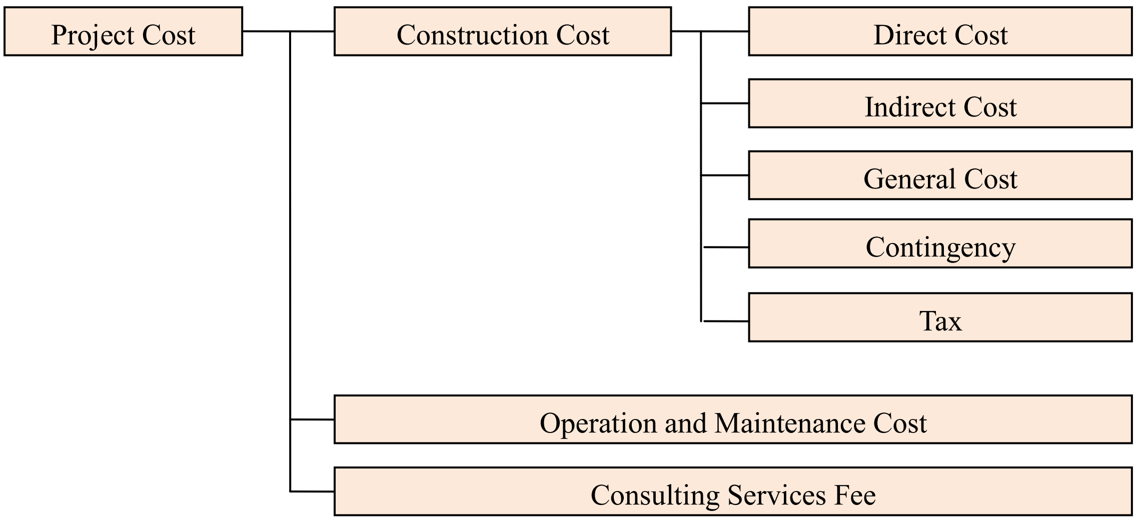
The study team estimated other costs such as incorporation fee, training fee, waste liquid treatment cost, security cost, consumable goods expenses, and cost for consulting services from the existing CTT, etc., based on hearing information.

Chapter 7. Approximate Project Initial Construction Cost and Running Cost

7.1. General Description

Construction cost for the initial phase (1st Phase), 2nd Phase, and 3rd Phase, and maintenance and operation cost will be studied and estimated in this section.

Generally, the project cost consists of construction cost, operation and maintenance cost, and consulting services fee, as shown in Figure 7.1.1. The construction cost consists of direct cost, indirect cost, and general cost. The direct cost consists of material cost, equipment cost, and manpower cost. Normally the indirect cost and general cost are shown as percentage of the direct cost.



Source: JICA Study Team

Figure 7.1.1 Breakdown of the Project Cost

7.1.1. General Conditions

The following general conditions will be applied in the estimation of the project cost:

- Normal market prices at the project site will be applied to unit prices.
- Price fluctuation will not be considered.
- Interest of the loaned money will not be considered.
- The consulting services consist of detailed design and construction supervision.
- The consulting services and construction will be carried out by experienced parties which have appropriate technical skills and experience.
- Normal and reasonable execution method and construction schedule as mentioned in Section 5 of this report will be applied.
- Applied exchange rate : JPY 102 = USD 1 = VND 21,000 (June 2014)

7.1.2. Construction Cost

Construction cost will be estimated based on the work quantity and unit price. In this section, construction cost of each stage will be estimated.

(1) Quantity of Facilities

The outlines of work items by phase of the facilities to be constructed, coal handling equipment to be installed, and buildings to be constructed in the CTT Project are given in Table 7.1.1, Table 7.1.2, and Table 7.1.3, respectively.

Table 7.1.1 Outline of Facilities to be Constructed

No.	Facility's Name	Unit	Quantity		
			1st Phase	2nd Phase	3rd Phase
1	Construction of Coal Unloading Berth	Berth	2	3	4
2	Construction of Coal Loading Berth	Berth	2	4	7
3	Earthworks of the Coal Storage Yard	ha	22	40	72
4	Revetment	m	2,000	3,400	5,000
5	Dredging and Disposal Works	million m^3	19	21	37
6	Channel Protection Work	km	2.5	2.5	2.5

Source: JICA Study Team

Table 7.1.2 Outline of Coal Handling Equipment to be Installed

No.	Facility's Name	Unit	Quantity		
			1st Phase	2nd Phase	3rd Phase
1	Coal Unloading Machine	Set	4	6	8
2	Coal Loading Machine	Set	2	4	7
3	Stacker Reclaimer	Set	3	5	10
4	Belt Conveyor	km	23	32	52

Source: JICA Study Team

Table 7.1.3 Outline of Buildings to be Constructed

No.	Facility's Name	Unit	Quantity		
			1st Phase	2nd Phase	3rd Phase
1	Administration Building	L.S.	1	1	2
2	Maintenance House	L.S.	1	1	2
3	Sub-Station	L.S.	1	1	2
4	Wind Protection Wall	km	2.6	2.6	4.2
5	Security Fence	km	2.6	2.6	4.2

Source: JICA Study Team

(2) Work Quantity of Each Facility

The required work quantities of each facility based on the preliminary design of the 1st Phase are shown below.

<Unloading Berth (per one berth)>

No.	Work Item	Description	Unit	Quantity
1	Foundation Pile	SPP	no.	375
2	Superstructure	RC concrete	m^3	8,300
3	Utility	Fender, bollard, etc.	L.S.	1.0

Source: JICA Study Team

<Loading Berth (per one berth)>

No.	Work Item	Description	Unit	Quantity
1	Foundation Pile	SPP	no.	240
2	Superstructure	RC concrete	m^3	4,400
3	Utility	Fender, bollard, etc.	L.S.	1.0

Source: JICA Study Team

<Coal storage Yard (per one ha)>

No.	Work Item	Description	Unit	Quantity
1	Reclamation	By sand	m^3	5,800
2	Soil improvement	PVD method	ha	1.0
3	Underground utilities	Drainage, etc.	L.S.	1.0
4	Pavement	Concrete	ha	1.0

Source: JICA Study Team

<Channel Protection (per km)>

No.	Work Item	description	Unit	Quantity
1	Ground Improvement	Sand replacement	m^3	316,000
2	Installation of Concrete Block	12 t	no.	16,600
3	Installation of Stone	Rubble and armor	m^3	259,000

Source: JICA Study Team

(3) Unit Price of the Work

The study team studied the normal market prices of the main materials, equipment, manpower and coal handling equipment at site. These unit prices will be applied for the estimation of the construction cost.

1) Material Cost

The applied unit prices of main materials are shown in Table 7.1.4. These unit prices include transportation fee to the site.

Table 7.1.4 Unit Prices of Main Materials

No.	Material	Description	Unit	Unit Price（USD）
1	Reclamation Sand	Black sand	m^3	10
2	Ready-mix Concrete	30 N/mm^2	m^3	80
3	Reinforcing Bar	D13	t	800
4	Steel Pipe Pile	D700-D900	t	2,000
5	Stone	Rubble	m^3	25

Source: JICA Study Team

2) Equipment Cost

The applied unit prices of main used equipment are shown in Table 7.1.5. These unit prices include fuel fee, operator's cost, mobilization and demobilization costs, and maintenance cost.

Table 7.1.5 Unit Prices of Main Equipment

No.	Equipment	Description	Unit	Unit Price（USD）
1	Backhoe	0.7 m^3 class	day	250
2	Crawler Crane	50 t	day	500
3	Piling Barge	40 m leader	day	2,000

Source: JICA Study Team

3) Manpower Cost

The applied unit prices of manpower are shown in Table 7.1.6. These unit prices include social insurance, allowances, and management cost of the subcontractor.

Table 7.1.6 Unit Prices of Manpower

No.	Manpower	Unit	Unit Price（USD）
1	General Worker	month	150
2	Skilled Worker	month	250
3	Site Supervisor	month	500

Source: JICA Study Team

4) Coal Handling Equipment

Coal handling equipment will be purchased from Vietnam and/or international supplier considering quality and price. In this study, the tentative cost will be applied to estimate the project cost.

The applied unit prices of coal handling equipment are shown in Table 7.1.7. These unit prices include transportation fee, installation fee, indirect cost, general cost, and design fee.

Table 7.1.7 Unit Price of Coal Handling Equipment

No.	Manpower	Description	Unit	Unit Price（USD）
1	Coal Unloader	2,500 t/h	set	15,440,000
		2,700 t/h		16,300,000
2	Ship Loader	1,500 t/h	set	4,200,000
		2,500 t/h		6,400,000
3	Stacker Reclaimer	5,500/3,000 t/h	set	6,440,000
		6,000/2,700 t/h		7,900,000

Source: JICA Study Team

(4) Construction Cost

The construction cost is estimated based on the above work quantities and unit prices.

1) Direct Cost

The direct cost calculated from the work quantities and unit prices are shown in Table 7.1.8.

Table 7.1.8 Direct Cost

Facility Name	Work Item	Unit	Quantity				Unit Price	Price			
			Initial Stage	2nd Stage	3rd Stage	Total	USD	Initial Stage	2nd Stage	3rd Stage	Total
Coal Unloading Berth											
	Berth No.	berth	2	1	1	4		**52,878,700**	**30,502,000**	**30,502,000**	**113,882,700**
	Foundation Pile SPP D900	nos	462	272	272	1,006	62,500	28,875,000	17,000,000	17,000,000	62,875,000
	Foundation Pile SPP D800	nos	288	168	168	624	62,500	18,000,000	10,500,000	10,500,000	39,000,000
	Superstructure Concrete	m3	16,679	8,340	8,340	33,359	300	5,003,700	2,502,000	2,502,000	10,007,700
	Utility	L.S.	2	1	1	4	500,000	1,000,000	500,000	500,000	2,000,000
Coal Loading Berth											
	Berth No.	berth	2	2	3	7		**13,253,500**	**13,253,500**	**19,880,400**	**46,387,400**
	Foundation Pile SPP D700	nos	240	240	360	840	42,500	10,200,000	10,200,000	15,300,000	35,700,000
	Superstructure Concrete	m3	8,845	8,845	13,268	30,958	300	2,653,500	2,653,500	3,980,400	9,287,400
	Utility	L.S.	2	2	3	7	200,000	400,000	400,000	600,000	1,400,000
Coal Storage Yard and Revetment											
	Area	ha	22	18	32	72		**49,531,400**	**45,152,850**	**72,084,250**	**166,768,500**
	Land Acquisition Cost	m2	260,000	180,000	320,000	760,000	4	1,040,000	720,000	1,280,000	3,040,000
	Reclamation	m3	1,271,200	1,528,800	2,240,000	5,040,000	12	15,254,400	18,345,600	26,880,000	60,480,000
	Soil Improvement	ha	22	18	32	72	500,000	11,000,000	9,000,000	16,000,000	36,000,000
	Revetment	m	2,054	1,346	1,600	5,000	3,000	6,162,000	4,038,000	4,800,000	15,000,000
	Underground Utilities	L.S.	1	1	1	3	2,000,000	2,000,000	2,000,000	2,000,000	6,000,000
	Foundation Pile PC D600	nos	748	498	1,246	2,492	1,000	748,000	498,000	1,246,000	2,492,000
	Superstructure Concrete	m3	9,308	6,205	15,513	31,026	250	2,327,000	1,551,250	3,878,250	7,756,500
	Pavement	ha	22	18	32	72	500,000	11,000,000	9,000,000	16,000,000	36,000,000
Dredging and Disposal											
	Dredging and Disposal	m3	19,447,830	1,105,656	16,247,599	36,801,085	10	**194,478,300**	**11,056,560**	**162,475,990**	**368,010,850**
Channel Protection											
	Total length	km	2.5	0	0	3		**47,212,500**	**0**	**0**	**47,212,500**
	Stone work	m3	417,500	0	0	417,500	30	12,525,000	0	0	12,525,000
	Concrete Block	nos	33,000	0	0	33,000	750	24,750,000	0	0	24,750,000
	Sand Replacement	m3	662,500	0	0	662,500	15	9,937,500	0	0	9,937,500
	Sub total							**357,354,400**	**99,964,910**	**284,942,640**	**742,261,950**
Coal Handling Equipment											
	Unloader	set	4	2	2	8	15,440,000	61,760,000	30,880,000	30,880,000	123,520,000
	Ship Loader	set	2	2	3	7	4,400,000	8,800,000	8,800,000	13,200,000	30,800,000
	Stacker Reclaimer	set	3	2	5	10	6,440,000	19,320,000	12,880,000	32,200,000	64,400,000
	Belt conveyer for unloading li	km	13.2	7.8	9.7	31	7,840,000	103,488,000	61,152,000	76,048,000	240,688,000
	Belt conveyer for loading line	km	9.5	1.0	10.4	21	4,834,000	45,923,000	4,834,000	50,273,600	101,030,600
	Other equipments	L.S.	1	0	1	2	2,000,000	2,000,000	0	2,000,000	4,000,000
	Sub total							**241,291,000**	**118,546,000**	**204,601,600**	**564,438,600**
Building and Fence											
	Office Building	L.S.	1	0	1	2	5,000,000	5,000,000	0	5,000,000	10,000,000
	Maintenance house	L.S.	1	0	1	2	2,000,000	2,000,000	0	2,000,000	4,000,000
	Warehouse	L.S.	1	0	1	2	1,000,000	1,000,000	0	1,000,000	2,000,000
	Sub-station	L.S.	0.32	0.55	0.14	1	41,500,000	13,114,000	22,700,500	5,685,500	41,500,000
	Security house	L.S.	3	1	2	6	100,000	300,000	100,000	200,000	600,000
	Rest house	L.S.	2	1	2	5	500,000	1,000,000	500,000	1,000,000	2,500,000
	Security fence and gate	m	2,600	0	1,600	4,200	200	520,000	0	320,000	840,000
	Dust protection wall	m	2,600	0	1,600	4,200	1,500	3,900,000	0	2,400,000	6,300,000
	Power supply system	L.S.	1	0	0	1	22,100,000	22,100,000	0	0	22,100,000
	Water supply system	L.S.	0.5	0.5	1	2	2,940,000	1,470,000	1,470,000	2,940,000	5,880,000
	Other utilities	L.S.	1	0	1	2	1,800,000	1,800,000	0	1,800,000	3,600,000
	Sub total							**52,204,000**	**24,770,500**	**22,345,500**	**99,320,000**
	Total							**650,849,400**	**243,281,410**	**511,889,740**	**1,406,020,550**

Note: The lower infrastructure is shown in blue-shaded area, and the upper infrastructure is shown in the gray-shaded area.

Source: JICA Study Team

2) Indirect Cost

The indirect cost consists of common temporary cost and site management cost. The common temporary cost includes the costs of temporary works, fence and gate, access road, common equipment, etc. Also, the site management cost includes the costs of management staff, office operation, accommodation, transportation, etc.

According to experience by the study team in Southeast Asia, 4.3% of the direct cost will be applied to the common temporary cost and 13.7% of the direct cost will be applied to the site management cost in this study.

3) General Cost

General cost includes costs of headquarters and/or branch of the contractor. According to experience of the study team in Southeast Asia, 9.4% of the direct cost will be applied to the general cost in this study.

4) Contingency

Contingency of 15% of the total of the direct cost, indirect cost, and general cost is applied.

5) Tax

Necessary tax of 10% of the total of the direct cost, indirect cost, general cost, and contingency is applied.

6) Estimated Construction Cost

The estimated construction cost including direct cost, indirect, general cost, contingency and tax is shown in Table 7.1.9. The estimated construction cost of the lower infrastructure, which is planned to be constructed by the public sector, and the upper infrastructure, which is planned to be constructed by the private sector, are shown in Table 7.1.10 and Table 7.1.11, respectively.

Table 7.1.9 Estimated Construction Cost of this Project

Work Item		Price (USD)			
		Initial Stage	2nd Stage	3rd Stage	Total
1	Civil Works	357,354,400	99,964,910	284,942,640	742,261,950
2	Building Works	52,204,000	24,770,500	22,345,500	99,320,000
3	Coal Handling Equipments	241,291,000	118,546,000	204,601,600	564,438,600
4	Sub total (Direct Cost 1+2+3)	**650,849,400**	**243,281,410**	**511,889,740**	**1,406,020,550**
5	Indirect Cost (18% of 1+2)	73,720,512	22,452,374	55,311,865	151,484,751
6	General Cost (9.4% of 1+2)	38,498,490	11,725,129	28,885,085	79,108,703
7	Sub total (4+5+6)	**763,068,402**	**277,458,912**	**596,086,690**	**1,636,614,004**
8	Contingency (15% of 7)	114,460,260	41,618,837	89,413,004	245,492,101
9	Tax (10% of 7+8)	87,752,866	31,907,775	68,549,969	188,210,610
TOTAL CONSTRUCTION COST (7+8+9)		**965,281,528**	**350,985,524**	**754,049,663**	**2,070,316,715**

Source: JICA Study Team

Table 7.1.10 Estimated Construction Cost of the Lower Infrastructure (Excluding Land Acquisition Cost)

Work Item		Price (USD)			
		Initial Stage	2nd Stage	3rd Stage	Total
1	Civil Works (excluding Land Acquisition Cost	356,314,400	99,244,910	283,662,640	739,221,950
2	Building Works	0	0	0	0
3	Coal Handling Equipments	0	0	0	0
4	Sub total (Direct Cost 1+2+3)	**356,314,400**	**99,244,910**	**283,662,640**	**739,221,950**
5	Indirect Cost (18% of 1+2)	64,136,592	17,864,084	51,059,275	133,059,951
6	General Cost (9.4% of 1+2)	33,493,554	9,329,022	26,664,288	69,486,863
7	Sub total (4+5+6)	**453,944,546**	**126,438,015**	**361,386,203**	**941,768,764**
8	Contingency (15% of 7)	68,091,682	18,965,702	54,207,931	141,265,315
9	Tax (10% of 7+8)	52,203,623	14,540,372	41,559,413	108,303,408
TOTAL CONSTRUCTION COST (7+8+9)		**574,239,850**	**159,944,089**	**457,153,547**	**1,191,337,487**

Source: JICA Study Team

Table 7.1.11 Estimated Construction Cost of the Upper Infrastructure

Work Item		Price (USD)			
		Initial Stage	2nd Stage	3rd Stage	Total
1	Civil Works	0	0	0	0
2	Building Works	52,204,000	24,770,500	22,345,500	99,320,000
3	Coal Handling Equipments	241,291,000	118,546,000	204,601,600	564,438,600
4	Sub total (Direct Cost 1+2+3)	**293,495,000**	**143,316,500**	**226,947,100**	**663,758,600**
5	Indirect Cost (18% of 1+2)	9,396,720	4,458,690	4,022,190	17,877,600
6	General Cost (9.4% of 1+2)	4,907,176	2,328,427	2,100,477	9,336,080
7	Sub total (4+5+6)	**307,798,896**	**150,103,617**	**233,069,767**	**690,972,280**
8	Contingency (15% of 7)	46,169,834	22,515,543	34,960,465	103,645,842
9	Tax (10% of 7+8)	35,396,873	17,261,916	26,803,023	79,461,812
TOTAL CONSTRUCTION COST (7+8+9)		**389,365,603**	**189,881,076**	**294,833,255**	**874,079,934**

Source: JICA Study Team

7.1.3. Maintenance and Operation Cost

Maintenance and operation cost which will incur after commencement of operation will be estimated in this section. This cost will be shown as an annual cost of each stage of the project.

(1) Work Item and Quantity

Maintenance and operation cost of this project may be divided into the following five items. Quantities, unit prices, and annual cost of each item are estimated as described below.

1) Maintenance Dredging

According to the results of the simulation study, the expected monthly maintenance dredging volume and necessary cost are calculated. Summary of the maintenance dredging volume and cost is shown in Table 7.1.12.

Table 7.1.12 Summary of Maintenance Dredging

Cost Factor	Quantity (m3/year)			Unit Price	Maintenance Cost (USD/year)		
	Initial Stage	2nd Stage	3rd Stage	(USD/m3)	Initial	2nd Stage	3rd Stage
Maintenance Dredging - scenario1 Yard CD	1,797,323	1,797,323	2,093,113	5	8,986,617	8,986,617	10,465,567

Source: JICA Study Team

2) Maintenance of Constructed Facilities

The expected annual maintenance cost of the civil constructed facilities is calculated as 0.5% of the construction cost excluding cost of dredging works. The calculated maintenance cost of the construction facilities is shown in Table 7.1.13.

Table 7.1.13 Maintenance Cost of Constructed Facilities

Cost Factor	Construction Cost (USD) except Dredging			Ratio (%)	Maintenance Cost (USD/year)		
	Initial Stage	2nd Stage	3rd Stage		Initial Stage	2nd Stage	3rd Stage
Cicil and Building Works - scenario1 Yard CD	215,080,100	328,758,950	473,571,100	0.5	1,075,401	1,643,795	2,367,856

Source: JICA Study Team

3) Maintenance of Coal Handling Equipment

The expected annual maintenance cost of coal handling equipment is calculated as 3.0% of the purchased cost. The calculated maintenance cost of the coal handling equipment is shown in Table 7.1.14.

Table 7.1.14 Maintenance Cost of Coal Handling Equipment

Cost Factor	Construction Cost (USD)			Ratio (%)	Maintenance Cost (USD/year)		
	Initial Stage	2nd Stage	3rd Stage		Initial Stage	2nd Stage	3rd Stage
Coal Handling Equipments - scenario1 Yard CD	241,291,000	359,837,000	564,438,600	3	7,238,730	10,795,110	16,933,158

Source: JICA Study Team

4) Operation Cost

The expected annual operation cost is shown in Table 7.1.15.

Table 7.1.15 Annual Operation Cost

Cost Factor	Operation Cost (USD/year)		
	Initial Stage	2nd Stage	3rd Stage
Operation Cost	5,186,589	9,080,691	16,550,591

Source: JICA Study Team

(2) stimated Maintenance Cost

The estimated maintenance cost in each stage is shown in Table 7.1.16. These costs include related tax.

Table 7.1.16 Summary of Maintenance Cost

Cost Factor	Operation and Maintenance Cost		
	2020-2024	2025-2030	2030-2050
Maintenance Dredging	8,986,617	8,986,617	10,465,567
Maintenance for Civil and Building Works	1,075,401	1,643,795	2,367,856
Maintenance for Coal Handling Equipments	7,238,730	10,795,110	16,933,158
Total	17,300,747	21,425,521	29,766,580

Source: JICA Study Team

7.1.4. Consulting Service Fee

The consulting services consist of design works and construction supervision works. According to current records of similar construction projects in North and South Vietnam, USD 15 million will be applied to the design cost and USD 15 million to the construction supervision cost at the 1st Phase, USD 5 million will be applied to the design cost and USD 5 million to the construction supervision cost at the 2nd Phase, and USD 10 million will be applied to the design cost and USD 10 to the construction supervision cost at the 3rd Phase in this study.

7.1.5. Project Cost

A summary of the project costs, as estimated in this section, are shown in Table 7.1.17.

Table 7.1.17 Summary of Project Costs

Cost Item	Unit	Price			
		Initial Stage	2nd Stage	3rd Stage	Total
Construction Cost	USD	965,281,528	350,985,524	754,049,663	2,070,316,715
Upper Infrastructure	USD	389,365,603	189,881,076	294,833,255	874,079,934
Lower Infrastructure	USD	574,239,850	159,944,089	457,153,547	1,191,337,487
Land Acquisition cost	USD	1,676,074	1,160,359	2,062,861	4,899,294
Maintenance Cost	USD/year	17,300,747	21,425,521	29,766,580	-
Operation Cost	USD/year	5,186,589	9,080,691	16,550,591	-
Consulting Service Fee	USD	30,000,000	10,000,000	20,000,000	60,000,000

Source: JICA Study Team

Chapter 8. Financial and Economic Analysis

8.1. Applicable Project Scheme

(1) Investment Structure of SPC

The Special Purpose Company (SPC) is assumed to be established as a joint venture (JV) under the Investment Law (Law on Investment No. 59/2005/QH11 of the National Assembly dated 29 November 2005.) Normally SPC is established under the Build-Operate-Transfer (BOT) Law or Public-Private Partnership (PPP) Law for infrastructure projects in Vietnam, however, the pilot PPP regulations are only effective for five years from the date of effectiveness, which was 15 January 2011, and these regulations will shortly be replaced by the PPP/BOT New Decree. The study team assumes to build SPC as a JV since it cannot be decided if the new decree is suitable for the project or not.

SPC is assumed to be established by investment from a Vietnamese company at 51% of shares and Japanese company at 49% of shares.

(2) Anticipated Role Sharing between the Public and Private Portions

In the current situation, cargo handling charge for coal is relatively low compared with container and electricity prices has kept low as a political decision by the Government of Vietnam, private sector can only expect their investment return in case most of the lower infrastructure such as coal loading/unloading jetty and coal storage yard are expected to be constructed by the public sector using official development assistance (ODA) yen loan.

The study team analyzed Case 1, Case 2, and Case 3 below, and set Case 2 as the base case. Case 1 was assumed to obtain ODA funding for a part of the upper infrastructure, however, it is difficult to find any reason to apply ODA to fund only a part of the equipment. Case 3 is not included in the analysis since an offshore-type terminal plan is impractical due to its high cost structure.

Table 8.1.1 Anticipated Role Sharing between the Public and Private Portions

Port and Terminal Facilities	Case 1	Case 2	Case 3
Coal Unloading Berth	ODA	ODA	Private
Coal Loading Berth	ODA	ODA	Private
Loader and Unloader	ODA	Private	Private
Breakwater and Training Dike	ODA	ODA	ODA
Coal Storage Yard	ODA	ODA	ODA
Conveyer Belt, Stacker, Reclaimer	Private	Private	Private
Landside facilities (Administration Building, Coal Mixing Equipment, Substation, Workshop, etc.)	Private	Private	Private
Dredging	ODA	ODA	ODA

Aids for Navigation	ODA	ODA	ODA
Access Road	ODA	ODA	ODA

Source: JICA Study Team

8.2. Financial Analysis

The study team simulated the financial model for the SPC established by Vietnamese and Japanese entities, with some assumptions written in following chapters. Feasibility is evaluated by calculating the Terminal Handling Charge (THC) per t, which fulfills the equity internal rate of return (IRR) of the SPC required by the public investor.

It is common to calculate a minimum rate of return on a capital investment project (hurdle rate) for investment by "capital cost plus spread between domestic and overseas interest rates". The study team set the hurdle rate as 17.2% by calculating the weighted average cost of capital (WACC) and spread between the Vietnamese and Japanese interest rates of five years average. This ratio is on the assumption that other risks of SPC, to be mentioned later in other chapters, are properly minimized.

8.3. Assumptions

(1) Description of Business

Scope of business of SPC in the financial analysis is unloading from vessels, inventory control, and loading to small barges for secondary transshipment to the coal-fired power plants (CFPPs). The secondary transshipment cost is not included in this analysis. The cost of the secondary transshipment is mentioned in Chapter 5 above.

(2) Term of the Project

The term of project is 30 years, from 2020 to 2049.

(3) Exchange Rate (reference rate in June 2014)

USD 1 ＝ VND 21,000
JPY 1 ＝ VND 205.9
USD 1 ＝ JPY 102.0

(4) Demand of Coal Handling

The coal transshipment terminal (CTT) handles all coal volume mentioned in Chapter 5. The demand from 2031 is the same as in 2030.

(5) Operation and Maintenance (O&M) Cost

As mentioned in Chapter 6 above.

(6) Land Usage Fee

As mentioned in Chapter 6 above.

(7) Tax Cost

1) Corporate Tax
   - Corporate income tax of 10% for 15 years.
   - Tax holiday of four years starting on the first year when profit is made.
   - 50% exemption for a further nine years.
2) Value-added Tax (VAT)
   - VAT 10% is included in this analysis.

(8) Capital Expenditure

- Investment plan is mentioned in Chapter 7 above.
- It is planned to expand CTT and invest in the upper infrastructure at each phase.
- Major equipment such as unloader, loader, stacker-reclaimer, dust protection wall and belt conveyer are planned to be used for 30 years. Other equipment are planned to be replaced by their deprecation period.

(9) Financing Plan

1) Equity
   - 30% of the total project cost.
2) Debt
   - 70% of the total project cost.
3) JICA Private Sector Investment Finance (PSIF)
   It is assumed to loan from JICA PSIF.
   - Interest : 3% per year
   - Currency : JPY
   - Term of loan : 20 years
   - Debt service coverage ratio (DSCR) : minimum 1.2
4) Amount of Funds and Loans

Table 8.3.1 Amount of Funds and Loans

(Unit：USD million)

	Equity	Debt	Total
Initial (2017～19)	122	285	407
2nd (2nd Phase Expansion：2022～24)		139	139
3rd (3rd Phase Expansion：2027～29)		216	216

Total	122	640	762

Source：JICA Study Team

8.4. Business Income / Terminal Handling Charge (THC)

(1) Basic Concept

Income from the project is generated from payment of THC of CFPPs in southern Vietnam. It is difficult to refer the standard level of THC in Vietnam since there is no CTT in this area; however, the level of THC has to be set to fulfill the hurdle rate of SPC, and at the same time, it has to be within a reasonable level that CFPPs can enjoy the economic benefits by utilizing the CTT compared with alternative means to import coal.

(2) THC Structure

Generally, the THC structure of CTTs in Japan consists of charges for receiving coal, storing coal, and supplying coal to CFPPs. In addition to these charges, there are other additional charges such as charge for long-term storage and secondary transportation fee depending on the distance between CTT and CFPP. However, the additional charge for long-term storage and secondary transportation cost are not considered in this study since it is difficult to set a detailed storage period required by each CFPP.

(3) Assumptions for THC

1) THC is assumed to be based on a take-or-pay mechanism, which consists of capacity charge (fixed charge for installed capacity of CFPP) and variable charge.

   A take-or-pay system is a common payment system for an infrastructure investment project with project financing, which guarantees stable income from the project.

   Take-or-pay contracts between SPC and CFPP, and payment bonds from the Vietnamese government are necessary for a private investor to make an investment in the project.

   i) The capacity charge consists of compensation for the financing cost, its interest and capital cost including dividend and tax cost, and compensation for the fixed O&M cost such as labor and periodic maintenance costs. The capacity charge guarantees the agreed income amount of SPC as long as CTT maintains a capability of its performance which is mutually agreed in advance.
   ii) The variable charge is compensation for the variable cost of CTT such as utility expenses. This charge is variable depending on the actual demand of CFPPs.

Table 8.4.1 THC Structure

	Item for Compensation	Example
Capacity Charge	Capital cost, Financing cost	Investment, interest, tax and profit
	O&M fixed charge (variable by inflation)	Labor cost (VND)

	O&M fixed charge (not variable by inflation)	Insurance (USD), Maintenance (USD)
Variable Charge	O&M variable charge (variable by inflation)	Utility cost (VND)
	O&M variable charge (not variable by inflation)	Other variable cost (USD)

Source：JICA Study Team

2) Price Adjustment Factor

THC has to be adjusted by inflation and foreign exchange fluctuation. The rule of adjustment will be agreed among related parties in a take-or-pay contract. In this financial analysis, the impacts of fluctuation of inflation and foreign exchange fluctuation are not considered since it is assumed that such fluctuation risk will be borne by CFPPs or the Vietnamese government.

3) THC by Each Phase

The CTT is supposed to be expanded by each phase, and the required investment cost and fixed cost of the CTT will be different in each phase. Therefore, the capacity charge will also be different in each phase. The capacity charge in each phase is calculated by the required income of SPC to justify the investment in each phase.

(4) THC

The THC based on the assumptions above is shown in Table 8.4.2 below. In case the coal demand in each phase will not increase during the project term, the prices in each phase as given by the table will be applied through the project term.

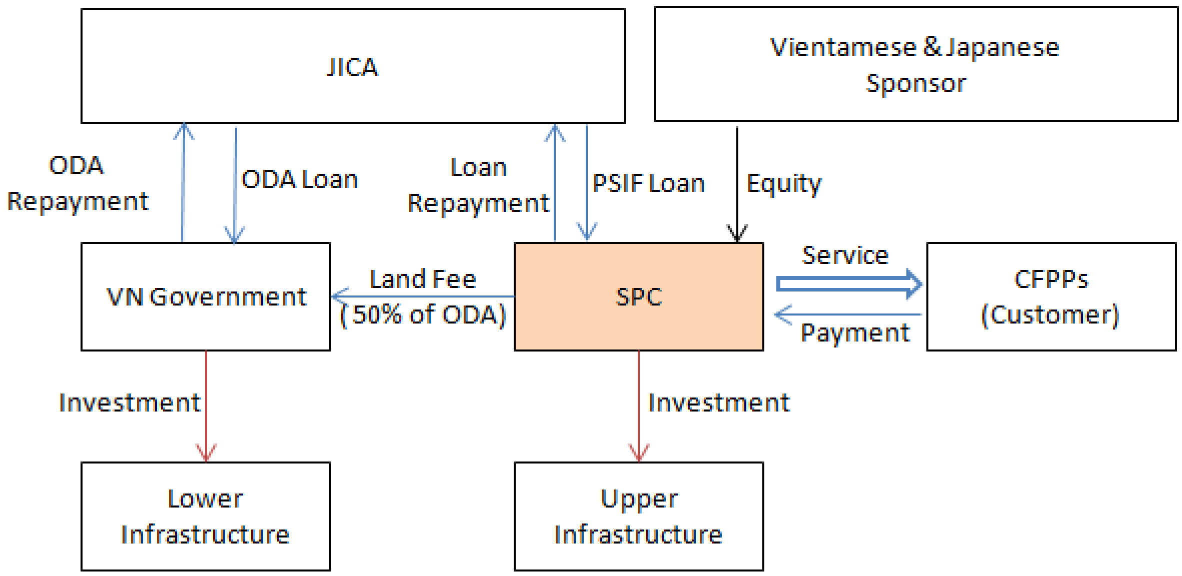
Table 8.4.2 Terminal Handling Charge (THC)

(Unit: USD million)

	1st Phase	2nd Phase	3rd Phase
Capacity charge per t	8.8	6.2	5.1
Variable charge per t	0.2	0.2	0.3
Total charge per t	9.0	6.4	5.4
Handling volume per year	8.5 million t	17.9 million t	31.1 million t

Source: JICA Study Team

8.5. Financing and Payment Flow



Source: JICA Study Team

Figure 8.5.1 Financing and Payment Flow

8.6. Objective and Method Used for Economic Analysis

The economic analysis is performed in order to analyze the effects of a public investment project from the perspective of the national economy. This analysis compares costs and benefits between the case in which the project is implemented in the future (With-project Case) and the case in which it is not implemented (Without-project Case). In this study, an economic internal rate of return (EIRR) method is used to evaluate the feasibility of this project. And, additional analyses are also performed to grasp the effects when fluctuations in investment and coal demand occur.

8.7. Assumptions of the Economic Analysis

The same assumptions as the financial analysis are basically applied to the economic analysis.

The scope of business of SPC in the financial analysis is unloading from vessels, inventory control and loading to small barges for secondary transshipment to CFPPs. The term of the project is from 2017 to 30 years after the start of CTT operation in the 1st Phase (2020), or 33 years until 2049. CTT handles all coal volume mentioned in Chapter 5. The demand from 2031 is the same as in 2030. In addition, the study team assumed that all coal will be imported from Indonesia because the usage of coal from Indonesia is more economical than from Australia in terms of transportation cost.

8.8. Examination Case

In the With-project Case, port facilities such as coal unloading berths, coal loading berths, and coal unloading machine will be installed in front of the Duyen Hai CFPP, which are developed for larger vessels, and the CTT will be also installed and operated adjacent to the power plant.

In the Without-project Case, the abovementioned facilities will not be developed. Therefore, in the case of coal from Indonesia, coal will be imported by 30,000 DWT vessels for the Duyen Hai CFPP on the assumption of usage of power plant accompanying port facilities, and be imported by vessels up to 10,000 DWT for other CFPPs due to the limitations of the Hau River Bypass Canal.

8.9. Estimation of Costs

The costs concerning this project consists of (1) Civil Structure, (2) Coal Handling Equipment, (3) Maintenance, (4) Operation, and (5) Consulting Service Fee. Specific items are shown as follows:

(1) Civil Structure

Initial dredging, port facilities (coal unloading berth and coal loading berth), CTT (soil improvement), and other facilities such as a buildings.

(2) Coal Handling Equipment

Port facilities (coal unloading machine and coal loading machine), belt conveyor,
stacker reclaimer, and other equipment.

(3) Maintenance

Maintenance dredging, maintenance of constructed facilities, maintenance of coal handling equipment, and other electromechanical equipment.

(4) Operation

Worker (direct and indirect), electricity, insurance, and other running costs.

(5) Consulting Service Fees

Design works, and construction supervision works.

8.10. Estimation of Benefits

Cost reduction of coal transport by larger vessels is one of the benefits of this project. The benefit is quantified by calculating the difference in transport cost between a 30,000 DTW vessel and a Post-Panamax or Capesize vessel in the case of the Duyen Hai CFPP, and the difference between a

10,000 DWT vessel and a Post-Panamax or Capesize vessel in the case of other power plants as described in Section 8.8.

8.11. Output of the EIRR

The study team estimated the EIRR of this project based on Sections 8.9 and 8.10.

Project feasibility is generally evaluated by whether the EIRR exceeds the social discount rate (SDR) or the opportunity cost in the target country or not. The study team applied 12% for the evaluation, which is generally adopted in the case of Vietnam in JICA's or other reports.

Table 8.11.1 shows the results of this project evaluation, which was based on estimated costs and benefits. The EIRR is 17.4%, which indicates the project will be feasible from the perspective of the national economy.

Table 8.11.1 EIRR Calculation

Year	Coal Imported			Cost				Total Cost	Total Benefit	Benefit −Cost
		Duyen Hai	Others	Construction	Equipment	Maintenance	Operation etc.			
2017				78.2	38.9	0.0	20.0	137.2		−137.2
2018				78.2	311.5	0.0	5.0	394.7		−394.7
2019				104.3	38.9	0.0	10.0	153.3		−153.3
2020	8,530	4,760	3,770	0.0	0.0	17.3	5.2	22.5	98.1	75.6
2021	8,530	4,760	3,770	0.0	0.0	17.3	9.2	26.5	98.1	71.6
2022	8,530	4,760	3,770	42.6	19.0	17.3	7.2	86.1	98.1	11.9
2023	8,530	4,760	3,770	42.6	151.9	17.3	7.2	219.0	98.1	−121.0
2024	8,530	4,760	3,770	56.9	19.0	17.3	7.2	100.3	98.1	−2.3
2025	15,000	5,950	9,050	0.0	0.0	21.4	9.1	30.5	226.4	195.9
2026	17,860	5,950	11,910	0.0	0.0	21.4	19.8	41.2	284.3	243.1
2027	17,860	5,950	11,910	58.6	29.5	21.4	12.8	122.3	284.3	162.0
2028	17,860	5,950	11,910	58.6	235.9	21.4	12.8	328.7	284.3	−44.4
2029	17,860	5,950	11,910	78.1	29.5	21.4	13.8	142.8	284.3	141.5
2030	31,090	5,950	25,140	0.0	2.5	29.8	16.6	48.8	528.5	479.7
2031	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2032	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2033	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2034	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2035	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2036	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2037	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2038	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2039	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2040	31,090	5,950	25,140	0.0	2.5	29.8	16.6	48.8	528.5	479.7
2041	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2042	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2043	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2044	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2045	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2046	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2047	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2048	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
2049	31,090	5,950	25,140	0.0	0.0	29.8	16.6	46.3	528.5	482.2
									EIRR=	17.4%

Unit: Imported coal ('000 t), Cost and Benefit (USD million)

Source: JICA Study Team

8.12. Sensitivity Analysis

The study team also conducted a sensitivity analysis in order to verify the feasibility of this project when the cost and benefit vary. The analysis is conducted for the cases in which the initial investment and the reduction cost of coal transportation by using large vessels is increased and decreased by 10% and 20%.

Table 8.12.1 shows the results of the sensitivity analysis, which demonstrates that this project can be considered to be worth implementing from the perspective of the national economy due as the EIRR exceeds 12% in every case.

Table 8.12.1 Results of Sensitivity Analysis

		Initial Investment (including all 1st, 2nd and 3rd Phases)				
		+20%	+10%	±0%	-10%	-20%
Reduction cost of coal transportation by using large vessels	-20%	12.7%	13.5%	14.5%	15.5%	16.8%
	-10%	14.1%	15.0%	16.0%	17.1%	18.4%
	±0%	15.4%	16.3%	17.4%	18.5%	19.9%
	+10%	16.6%	17.6%	18.7%	19.9%	21.4%
	+20%	17.7%	18.8%	19.9%	21.2%	22.7%

Source: JICA Study Team

8.13. EIRR in Each Stage

If coal demand were not to increase as predicted, the project would be implemented up to the 1st Phase (corresponding to Panamax) or the 2nd Phase (corresponding to Post-Panamax) without developing facilities for Capesize vessels. The study team also estimated the EIRR of such cases, which is valuable in terms of risk evaluation.

(1) Up to the 1st Phase

The EIRR is calculated as 9.1% under the assumption that coal demand would not increase after 2025. Coal imports will be around 8.53 million t.

(2) Up to the 2nd Phase

The EIRR is calculated as 16.4% under the assumption that coal demand would not increase after 2030. Coal imports will be around 17.86 million t.

Based on these results, we can conclude that this project would be feasible in terms of the national economy when demand reaches 17.86 million t, which is forecast to be achieved in 2026 and the facilities in the 2nd Phase are constructed to meet the demand.

Part 2. Scenario 2

Two scenarios of coal demand by Decision No.5964/ QD-BCT (9 Oct. 2012) as Scenario1 and the JICA Study Team estimates upon the request of the Ministry of Industry and Trade (MOIT) as Scenario 2 were used in this study. Part 2 showed the study results of case for coal demand of Scenario 2.

Chapter 9. Conceptual Design and Proposal of Optimum Planning of CTT (Scenario 2)

9.1. Coal Logistics Planning

9.1.1. Coal Logistics Planning

Coal demand based on Decision No.5964/ QD-BCT (9 October 2012) was studied in Chapter 5, but to estimate the required coal quantity of the coal-fired power plant (CFPP), it is necessary to consider three factors, namely, coal calories (kcal), energy conversion efficiency of the boiler, and operating rate of the power plant.

These three factors at each CFPP to be built in the future cannot be assumed exactly, but the study team calculated coal demand based on assumptions deemed to be more proper. According to the results of calculation by the study team, more coal demand is expected than the demand shown in Decision No.5964/ QD -BCT (9 October 2012). The assumptions that the study team set are shown in Table 9.1.1.

Table 9.1.1 Assumptions for Calculating Coal Demand

	Assumption	Remarks
Coal Calories(Kcal)	5,000 kcal	NAR base
Energy Conversion Efficiency (%)	40%	Super critical boiler
Operating Rate (%)	75%	-

Source: JICA Study Team

Based on the assumptions in Table 9.1.1, coal demand is calculated and shown in Table 9.1.2.

Table 9.1.2 Coal Demand Calculated by the Study Team (Scenario 2)

Project Power Plant		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Long Phu Power Centre												
Long Phu I	Capacity (MW)	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (Mil tons)	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Long Phu II	Capacity (MW)						1,200	1,200	1,200	1,200	1,200	1,200
	Coal (Mil tons)						3.3	3.3	3.3	3.3	3.3	3.3
Long Phu III	Capacity (MW)						1,000	2,000	2,000	2,000	2,000	2,000
	Coal (Mil tons)						2.8	5.6	5.6	5.6	5.6	5.6
Song Hau Power Centre												
Song Hau I	Capacity (MW)	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (Mil tons)	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Song Hau II	Capacity (MW)											2,000
	Coal (Mil tons)											5.6
Song Hau III	Capacity (MW)											2,000
	Coal (Mil tons)											5.6
Duyen Hai Power Centre												
Duyen Hai II	Capacity (MW)	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (Mil tons)	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Duyen Hai III	Capacity (MW)	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Coal (Mil tons)	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Duyen Hai III Expantion	Capacity (MW)											
	Coal (Mil tons)											
Long An Power Centre												
	Capacity (MW)						1,200	1,200	1,200	1,200	1,200	1,200
	Coal (Mil tons)						3.3	3.3	3.3	3.3	3.3	3.3
Bac Lieu Power Centre												
	Capacity (MW)											1,200
	Coal (Mil tons)											3.3
An Giang Power Centre												
	Capacity (MW)											2,000
	Coal (Mil tons)											5.6
Capacity/year	(MW)	4,800	4,800	4,800	4,800	4,800	8,200	9,200	9,200	9,200	9,200	16,400
Coal demand/year	**(Mil tons)**	**13.38**	**13.38**	**13.38**	**13.38**	**13.38**	**22.85**	**25.64**	**25.64**	**25.64**	**25.64**	**45.71**

Source: JICA Study Team

9.1.2. Planning of Ocean Transport

(1) Outline of Ocean Transport

The outline will be same as in Chapter 5.

(2) Ocean Freight

There is no difference of the plan itself from Chapter 5, and the reduction of ocean freight unit price is not expected. However, the merit of enlarging the vessel size shall be greater with the increase of coal volume to be transported.

Reduction of ocean freight with coal transshipment terminal (CTT) is mentioned in Table 9.1.3. Case 1 and Case 2 are the same conditions as mentioned in Chapter 5. Only volume of coal is different from that in Chapter 5.

Table 9.1.3 Reduction of Ocean Freight (Scenario 2)

Freight Table including 10,000DWT Barge

	Panamax	Handy	Barge
	70,000 - 100,000DWT	30,000 - 55,000DWT	10,000DWT
Freight from Indonesia	US$10 /MT	US$15 /MT	US$28 /MT
Freight from Australia	US$18 /MT	US$29 /MT	

<Case 1>

Reduction of Ocean freight by change from Handy to Panamax (for Duyen Hai) / from 10,000DWT Barge to to Panamax (excluding Duyen Hai)

	Annual volue of coal (for Duyen Hai CFPP)	Merit by change from Handy to Panamax	Annual volue of coal (excluding Duyen Hai CFPP)	Merit by change from 10,000DWT Barge to to Panamax	Total Merit
1st Phase	6.69 mil. MT	US$33 mil./year	6.69 mil. MT	US$120 mil./year	US$154 mil./year
2nd Phase	6.69 mil. MT	US$33 mil./year	18.95 mil. MT	US$341 mil./year	US$375 mil./year
3rd Phase	6.69 mil. MT	US$33 mil./year	39.02 mil. MT	US$702 mil./year	US$736 mil./year

<Case 2>

Reduction of Ocean freight by change to Panamax (100% from Indonesia)

	Annual volue of coal	Merit by change from Handy to Panamax
1st Phase	13.38 mil. MT	US$67 mil./year
2nd Phase	25.64 mil. MT	US$128 mil./year
3rd Phase	45.71 mil. MT	US$229 mil./year

Reduction of Ocean freight by change to Panamax (50% from Indonesia : 50% from Australia)

	Annual volue of coal	Merit by change from Handy to Panamax
1st Phase	13.38 mil. MT	US$107 mil./year
2nd Phase	25.64 mil. MT	US$205 mil./year
3rd Phase	45.71 mil. MT	US$366 mil./year

Reduction of Ocean freight by change to Panamax (100% from Australia)

	Annual volue of coal	Merit by change from Handy to Panamax
1st Phase	13.38 mil. MT	US$147 mil./year
2nd Phase	25.64 mil. MT	US$282 mil./year
3rd Phase	45.71 mil. MT	US$503 mil./year

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On the other hand, it is more difficult to charter vessels comparing with that in Chapter 5, because required number of 20,000–30,000 DWT vessels will increase from 40 (Scenario 1) to 50 (Scenario 2).

9.1.3. Secondary Transport

(1) Outline of Secondary Transport

There is no big difference in secondary transport itself from ocean transport in Chapter 5. But it will be necessary to enlarge the size of barge because the number of shipments will increase as described here in Chapter 9.

(2) Cost of Secondary Transport

Expenses per ton will not be so different between Chapter 5 and Chapter 9, but the fixed cost of barge operator(s) will be relatively smaller with the increase of total handling volume and a few percent of reduction from USD 2.20–2.40/MT is possibly expected.

9.2. Determination of Port and Terminal Layout Plan

9.2.1. Conditions for Port Layout Planning

(1) Handling Volume of Coal and Target Year

Forecast volumes of coal import shown in Chapter 9.1 are used in the planning of port facilities for the CTT. The transshipment volume of coal to the CFPPs is obtained by subtracting the transshipment volume for Duyen Hai II and III from the total volume of coal imports. Table 9.2.1 shows import and transshipment volumes of coal to examine port facilities.

Table 9.2.1 Import and Transshipment Volumes of Coal (unit: '000,000 t)

Stage	Year	Import Volume	Transshipment Volume
1st Phase	2020	13.38	6.69
2nd Phase	2025	25.64	18.95
3rd Phase	2030	45.71	39.02

Source: JICA Study Team

(2) Design Vessel

1) Vessel for Coal Importation

Vessel size for imported coal is same as Scenario 1 shown in Section 5.2.1.

- 1st Phase: vessel of 70,000 DWT to 100,000 DWT
- 2nd Phase: vessel of 100,000 DWT
- 3rd Phase: vessel of 160,000 DWT

2) Vessel for Transshipment

Vessel size for coal transshipment is same as Scenario 1 shown in Section 5.2.1.

- 1st Phase: vessel of 5,000 DWT to 10,000 DWT
- 2nd Phase: vessel of 5,000 DWT to 10,000 DWT
- 3rd Phase: vessel of 5,000 DWT to 10,000 DWT

(3) Conditions of Coal Handling

1) Capacity of Unloader and Loader

The unloader should meet the following conditions:

- Capacity: 2,700 t per hour for unloading
- Unloader Type: a continuous coal unloader
- Unloading Efficiency: 75%
- Number: two unloaders per berth

The loader for transshipment should meet the following conditions:

- Capacity: 2,500 t per hour for loading
- Loading Efficiency: 90%
- Number: one loader per berth

2) Operational Days per Year and Working Hours per Day

The principle of operational days per year and working hours per day is the same as in Scenario 1 described in Section 5.2.1. These factors are considered as follows:

- Number of operation days per year is 350 days.
- Working hours per day are set at 22 hours.

(4) Calmness of the Port

Calmness of the port is the same as in Scenario 1 described in Section 5.2.1.

- Calmness of the port: 97.5%

9.2.2. Port Facilities Planning

(1) Method for Determining the Required Number of Berths

The method for determining the required number of berths is same as in Scenario 1 described in Section 5.2.2.

(2) Required Number of Coal Unloading Berths

1) 1st Phase: Handling volume of coal is 13.38 million t per year.

Average carrying volume of a Panamax vessel in the 1st Phase is set at 70,000 DWT.

The number of required days for unloading 70,000 DWT of coal is calculated as follows. Idling time is set at 0.5 days, which includes procedures for entering and departing the port, tidal waiting time and time for mooring and unmooring, etc.

Average berthing days: 1.29 days ((70,000 / (2,700 x 2 x 0.75 x 22)) + 0.5 = 1.29)

The total number of calling vessels is calculated as follows:

Number of calling vessels per year: 192 (13,380,000 /70,000 = 191.1)

The number of berths is calculated as follows under the above conditions and the assumption that berth occupancy rate is 50%:

Number of berths: 2 (192 x 1.29 / (350 x 0.5) = 1.41)

The number of berths is two and berth occupancy ratio becomes 35.3% (calculated as (192 x 1.29) / (350 x 2)), which satisfies the advisable berth occupancy ratio by the United Nations Conference on Trade and Development (UNCTAD). The average waiting time of vessels is estimated to fall within a range of 0.09～0.18 days. To verify that two berths are appropriate, the berth occupancy ratio and average waiting time of vessels in the case of only one berth are calculated using the same method above and queuing theory. As a result, berth occupancy ratio becomes 70.5%, which exceed the criteria of UNCTAD. The average waiting time of vessels is unacceptable compared to the average berthing time. Therefore, the required number of coal unloading berths in the 1st Phase is set at two.

2) 2nd Phase: Handling volume of coal is 25.64 million t per year

Design vessel is over-Panamax, therefore the average carrying volume is set at 100,000 t. The method to determine the number of berths is the same as in the 1st Phase.

Average berthing days: 1.62 days
Number of calling vessels per year: 257
Number of berths: 3 ((257 x 1.62) / (350 x 0.5) = 2.38)

Therefore, the number of berths is three and berth occupancy ratio becomes 39.7%. In the case of two berths, same as in the 1st Phase, the berth occupancy ratio becomes 59.6%, which slightly exceeds the criteria of UNCTAD. The average waiting time of vessels is calculated to fall within a range of 0.44～0.88 days. Considering the necessity to respond to the increasing demand toward the 3rd Phase and some constraints related to the approach channel, which will be explained in Section 5.2.2 (3), the required number of coal unloading berths in the 2nd Phase is set at three. Therefore, one additional berth capable of accommodating a Capesize vessel in the 3rd Phase will be developed with specifications of an over-Panamax vessel.

3) 3rd Phase: Handling volume of coal is 45.71 million t per year

In the 3rd Phase, over-Panamax and Capesize vessels are utilized simultaneously to handle the planned volume of coal. The allotted volume of transporting coal by two types of vessels is assumed as follows for the purpose of balanced usage of two types of berths:

Over-Panamax vessel: transporting 21,400 thousand t of coal (214 vessels per year)
Capesize vessel: transporting 24,320 thousand t of coal (152 vessels per year)

Coal transported by over-Panamax vessels is to be handled at two berths already developed in the 1st Phase. Berth occupancy ratio in this case becomes 49.6%, which satisfies the criteria of UNCTAD, and the average waiting time is calculated to fall within a range of 0.26～0.53 days. Therefore, two berths for over-Panamax vessels are enough to handle the planned volume in the 3rd Phase.

The number of berths to be developed for Capesize vessels is as follows under the assumption that the berth occupancy ratio is 50%:

Average berthing time per vessel: 2.30 days
Number of berths: 2 ((152 x 2.30) / (350 x 0.5) = 1.99)

The number of berths is two while the berth occupancy ratio becomes 49.9%, which satisfies the criteria of UNCTAD. In addition, the average waiting time of vessels is in the range of 0.38～0.76 days. Therefore, the required number of coal unloading berths for Capesize vessels in the 3rd Phase is set at two, of which the one berth already developed in the 2nd Phase is to be upgraded. During actual operations, the balanced usage of two types of berths and allocation plan of two types of vessels are essential in order to avoid vessel congestion and handle the planned volume of coal smoothly.

(3) Required Number of Coal Loading Berths

The method for examining the required number of coal loading berths is the same as that used for unloading berths.

4) 1st Phase: Transshipment volume of coal is 6.69 million t per year

Idling time for a transshipment vessel of 100,000 DWT is much less compared to unloading vessels because such vessels are used for domestic shipping only. Therefore, idling time is set at around 0.11 days (around 2 hours). The number of berths is calculated as follows under the assumption that berth occupancy ratio is 50%:

Average berthing time: 0.23 days
Number of calling vessels per year: 1,338
Number of berths: 2 ((1,338 x 0.23) / (350 x 0.5) = 1.76)

The number of berths is two and berth occupancy ratio becomes 44.0%, which satisfies the criteria of UNCTAD. The average waiting time of vessels is estimated to fall within a range of 0.03～0.06 days, which is a relatively short period of time compared to the average berthing time of 0.23 days. In the case that the number of berths is one, berth occupancy ratio becomes 87.9%, which exceeds the criteria of UNCTAD. This means that the figures exceed the average berthing time so it may not be possible to cope with the demand. Therefore, the required number of coal loading berths in the 1st Phase is set at two.

5) 2nd Phase: Transshipment volume of coal is 18.95 million t per year

The number of berths is as follows under the assumption that berth occupancy ratio is 60%:

Number of calling vessels per year: 3,790
Number of berths: 5 ((3,790 x0.23) / (350 x 0.6) = 4.15)

The number of berths is five and berth occupancy ratio becomes 49.8%. This figure satisfies the criteria of UNCTAD and the average waiting time of vessels is calculated to range about 0.01 days, which seems to be relatively small compared to the average berthing time of 0.23 days. In the case that the number of berths is four, berth occupancy ratio becomes 62.3%, which slightly exceeds the criteria of UNCTAD. The average waiting time of vessels is estimated to fall within a range of 0.03～0.05 days. Therefore, the required number of coal loading berths in the 2nd Phase is set at five.

6) 3rd Phase: Transshipment volume of coal is 39.02 million t per year

The number of berths is calculated as follows under the assumption that berth occupancy ratio is 70%:

Number of calling vessels per year: 7,804
Number of berths: 8 ((7,804 x 0.23) / (350 x 0.7) = 7.33)

In this case, the number of berths is eight and berth occupancy ratio becomes 64.1%, which satisfies the criteria of UNCTAD, while the average waiting time of vessels is estimated to fall within a range of 0.01～0.02 days, which is satisfactory compared to the average berthing time of 0.23 days. In the case of six berths, berth occupancy ratio becomes 73.3%, which exceeds the criteria of UNCTAD, while the average waiting time of vessels is calculated to fall within a range of 0.02～0.05 days. Considering the usage of 2,000 to 3,000 DWT vessels in addition to 5,000 DWT vessels, the required number of coal loading berths in the 3rd Phase is set at eight.

Remarks: Average waiting time of vessels in this report is to be calculated using the computational function in the website, http://queueingtoolpal.org/. Under the assumption that distribution of the arrival ratio follows Poisson distribution and that of the berthing time follows exponential distribution or constant, computational calculation is conducted. Though no data on port activities are obtained because facilities are still in the planning stage, actual waiting time of vessels seems to fall within a range of the two figures.

(4) Approach Channel and Basin

The scale of the approach channel and basin are same as Scenario 1 described in Section 5.2.2.

1st Phase and 2nd Phase

For unloading:
- Channel width: 200 m, Channel depth: -14.5 m, Basin depth: -16.0 m.

For loading:
- Channel: the approach channel and the Hau River Bypass Canal satisfy the requirement, Basin depth: -9.0 m.

3rd Phase

For unloading:
- Channel width: 225 m, Channel depth: -17.5 m, Basin depth: -19.0 m.

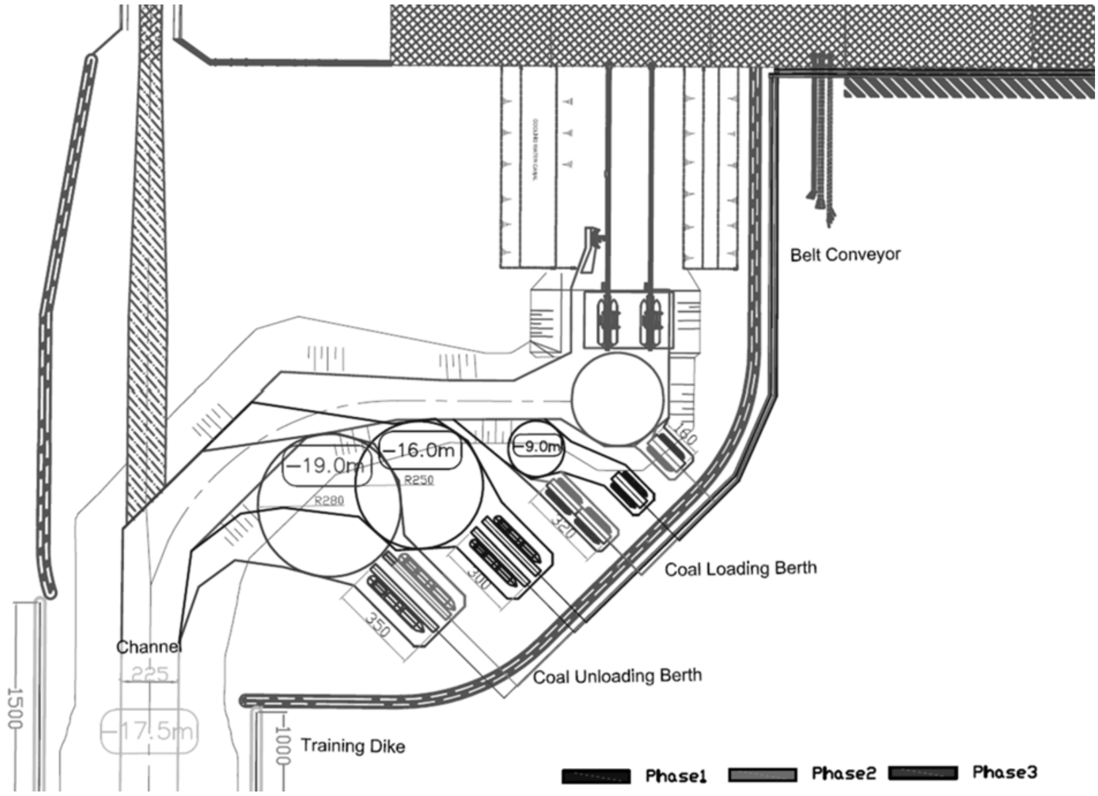
For loading:

- Channel: the approach channel and the Hau River Bypass Canal satisfy the requirement, Basin depth: -9.0 m.

(5) Alternative Port Layout Plans

Based on the above conditions, berth location of in harbor type is shown in Figure 9.2.1.

1) In harbor type



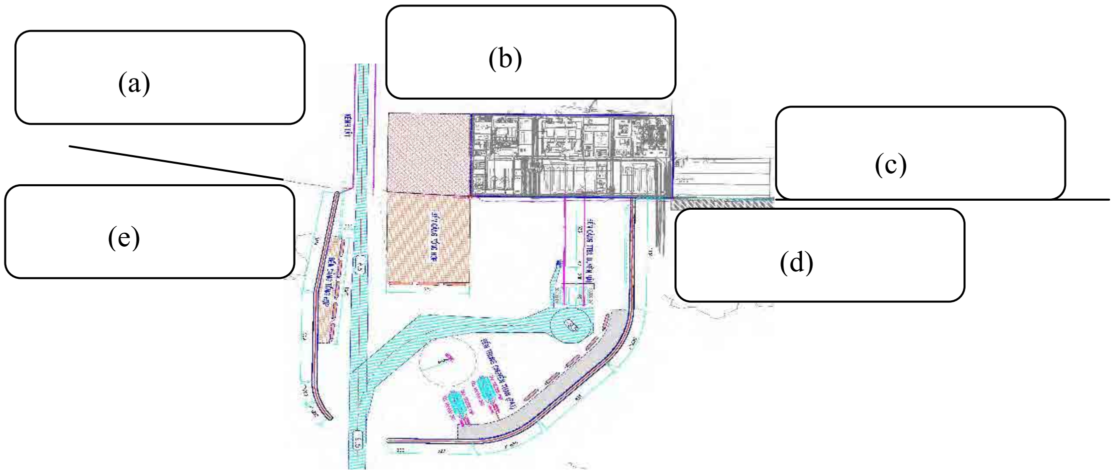
Source: JICA Study Team

Figure 9.2.1 Layout of Port of In Harbor Type

9.2.3. Preliminary Selection of the Site of the Coal Storage Yard

The same locations as Scenario 1 in Section 5.2.3 are compared for the candidate locations.

(a) West side of the Hau River Bypass Canal
(b) Landside of the power plant area
(c) East side of the power plant area (onshore)
(d) East side of the power plant area (offshore)
(e) West side of the power plant area (offshore)



Source: JICA Study Team

Figure 9.2.2 Candidate Locations of the Coal Storage Yard

The method for examining the candidate locations of the coal stock yard is the same as that of Scenario 1 in Section 5.2.3. As a result, candidate (c) is recommended for the coal storage yard. In the same way, candidate (d) might be used for the extension of the yard.

9.2.4. Terminal Planning

(1) Conditions for Terminal Planning

The following conditions for terminal planning are set up:

- Coal handling volume at terminal (stock): 39.02 million t/year
- Specific gravity: 0.9
- Yard operation efficiency: 0.75
- Unloader (continuous type): 2,700 t/h
- Ship loader: 2,500 t/h
- Stacker / reclaimer: 6,000 t/h, 2,700 t/h
- Belt conveyor (unloading): 6,000 t/h
- Belt conveyor (discharging): 5,500 t/h
- Coal stock volume at each CFPP: for 15 to 30 days

(2) Coal Stock Volumes Corresponding to Three Alternative Plans of Unloading Berth

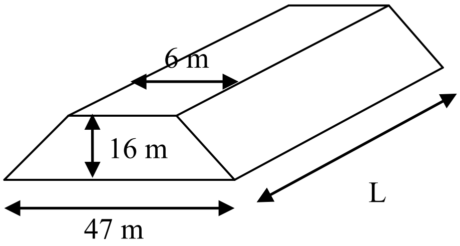
1) Inside the Breakwaters Plan

A stable coal handling toward the wave condition could be done. Therefore, the coal stock volume at the terminal is determined to be for 30 days (1 month) of annual coal handling volume. It is calculated as follows: 39.02 million t/year divided by 12 months is equal to 3.252 million t/month.

(3) Terminal Layouts Corresponding to Three Alternative Plans of Unloading Berth

The dimensions of the stockpile are the same as in Scenario 1 described in Section 5.2.4.

A＝(6+47) x 16÷2＝424 m^2.



Source: JICA Study Team

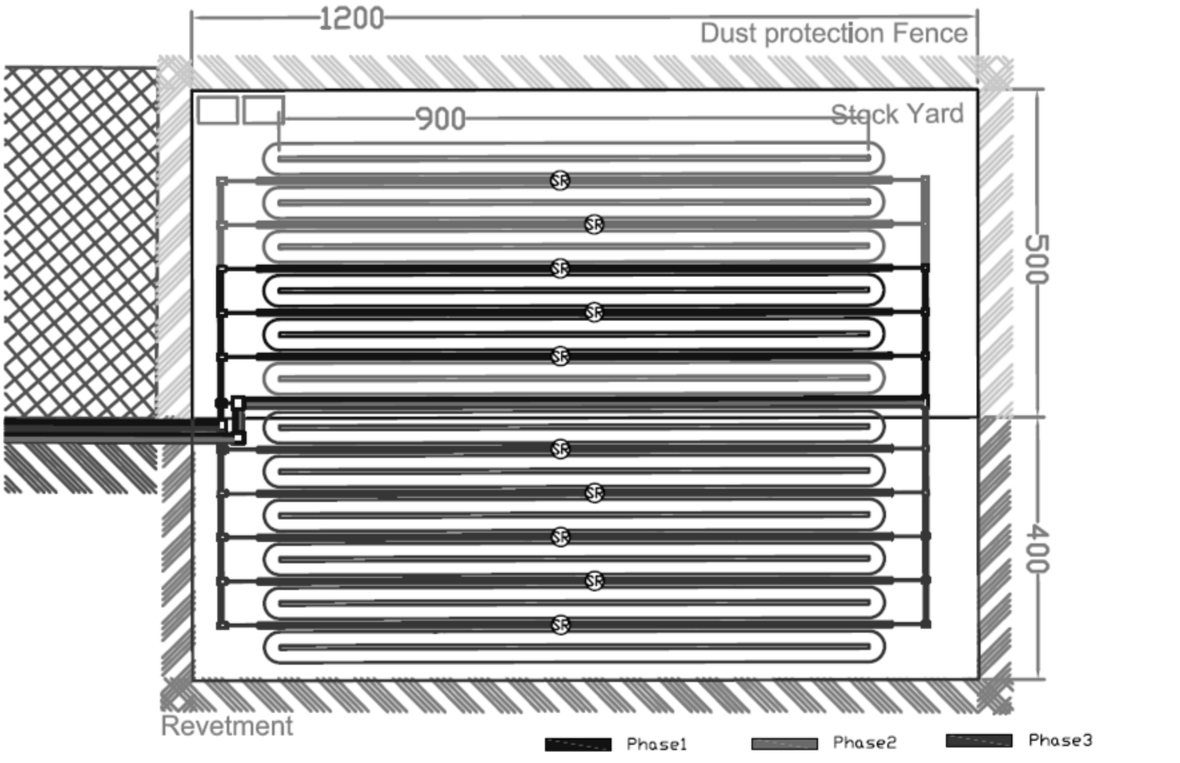
Figure 9.2.3 Dimensions of Stockpile

Coal stock volume, length and number of stockpiles and required terminal areas for in harbor plans are computed and summarized in Table 9.2.2 below. The terminal layout plan is shown in Figure 9.2.4.

Table 9.2.2 Required Terminal Areas for Alternative Plans

	Coal Stock Volume (million t)	Yard Operation Efficiency	Length of Stock Pile (m)	Number of Stockpiles	Required Terminal Area (ha)
Inside Breakwaters	3.252	0.75	900	12	108

Source: JICA Study Team



Source: JICA Study Team

Figure 9.2.4 Terminal Layout (Inside the Breakwaters)

9.2.5. Proposed Development Planning

The staged plan for port and terminal planning is proposed as follows:

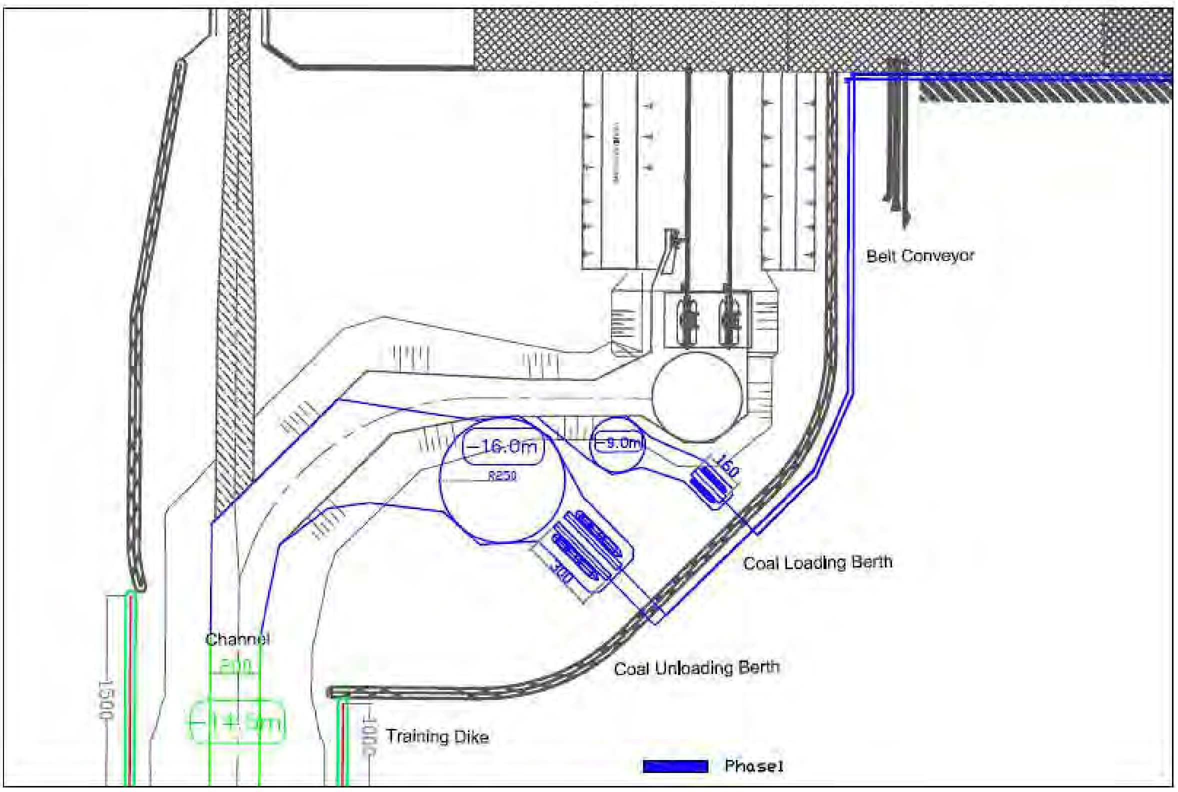
(1) Short-Term Development Plan

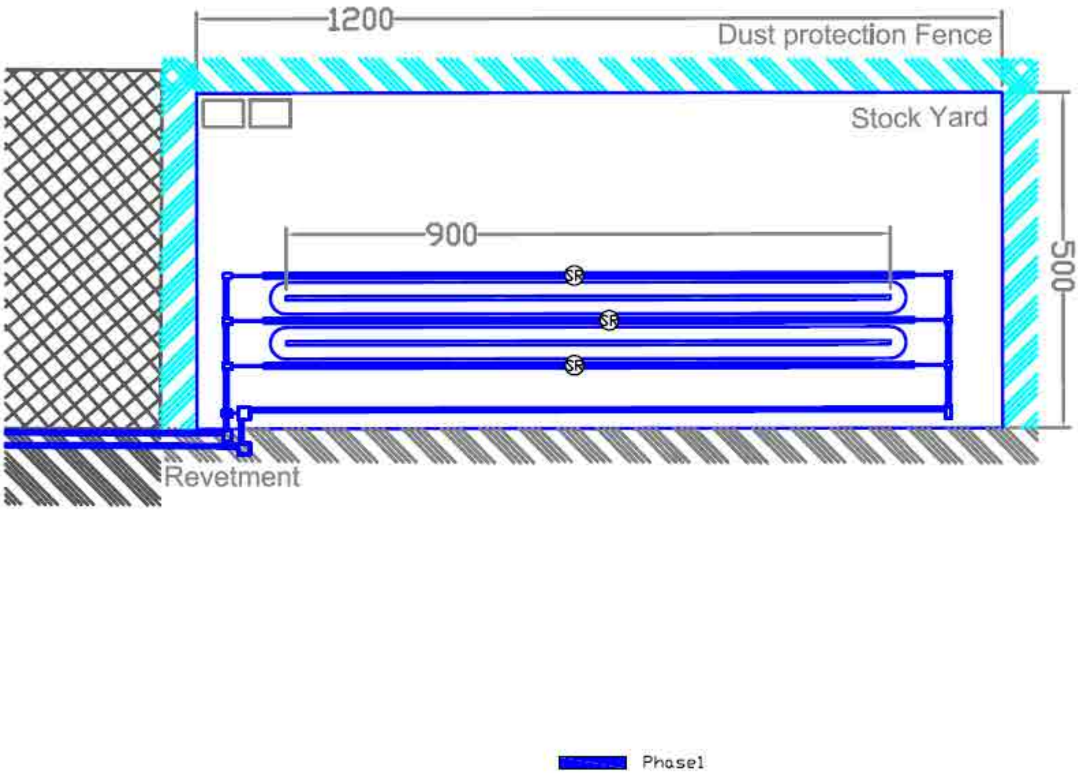
The short-term development plan, which is the 1st Phase and has a target year of 2020, is summarized in Table 9.2.3 and shown in Figure 9.2.5.

Table 9.2.3 Short-Term Development Plan

Coal Demand		13.38 million t	
Port Facility		Unloading Berth	Loading Berth
	Design Vessel	Panamax (55,000～85,000 DWT)	Small barge (5,000 DWT~10,000 DWT)
	Berth	Berth 2 berths Length 300 m/berth Depth -16.0 m	Berth 2 berths Length 160 m/berth Depth -9.0 m
	Approach Channel	Length 8,275 m Width 200 m Depth 14.5 m	Existing channel for the Duen Hai CFPP
	Turning Basin	Depth 16.0 m	Depth 9.0 m
	Handling Equipment	Unloader 4 Capacity 2,700 t/h	Ship Loader 2 Capacity 2,500 t/h
	Training-dike	Required Length 6.5 km (Both side of channel)	
Terminal Facility		Coal Stock Volume 3.77 million t, Terminal Area 22 ha	
	Yard Machinery	Stacker/Reclaimer 3 sets Capacity 6,000 t/h / 2,700 t/h	
	Belt Conveyor	For Unloading Length 14.7 km Capacity 6,000 t/h For Loading Length 9.9 km Capacity 5,500 t/h	
	Stockpile	Capacity 558,000 t Stockpile 2 piles Height of Pile 16 m Length of Pile 900 m	
	Revetment	Required length 1,200 m	
	Dust Protection Fence	Height 8 m Length 2,200 m	
Layout of Port and Terminal		Figure 9.2.5	

Source: JICA Study Team





Source: JICA Study Team

Figure 9.2.5 Layout of the Short-Term Development Plan

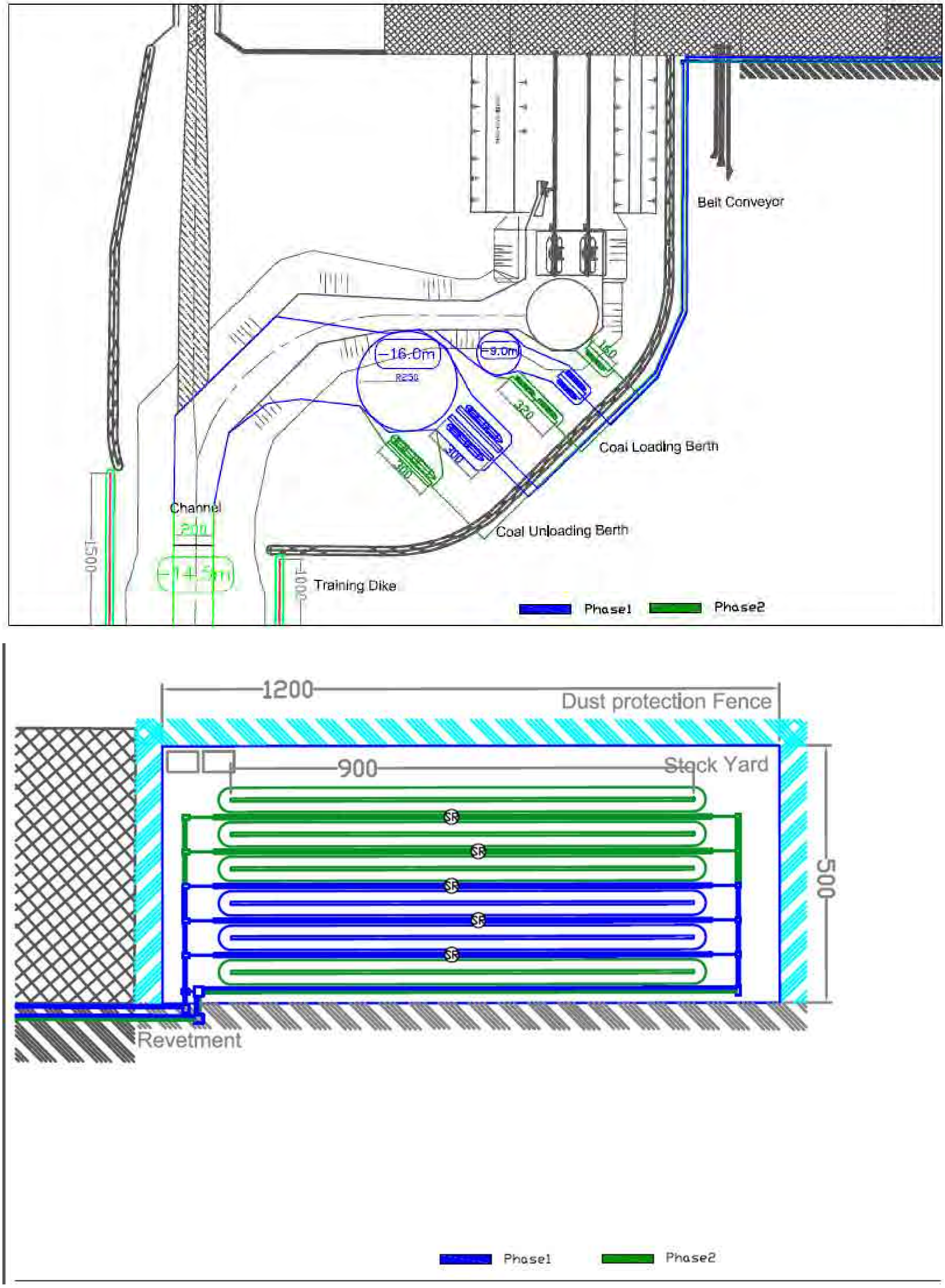
(2) Midterm Development Plan

The midterm development plan, which is the 2nd Phase and has a target year of 2025, is summarized in Table 9.2.4 and shown in Figure 9.2.6.

Table 9.2.4 Midterm Development Plan

Coal Demand		25.64 million t	
Port Facility		Unloading Berth	Loading Berth
	Design Vessel	Post-Panamax (100,000 DWT)	Small barge (5,000 DWT~10,000 DWT)
	Berth	Berth 3 berths Length 300 m/berth Depth -16.0 m (One berth is to be upgraded in the 3rd Phase for Capesize vessels.)	Berth 5 berths Length 160 m/berth Depth -9.0 m
	Approach Channel	Length 8,275 m Width 200 m Depth 14.5 m	Existing channel for the Duen Hai CFPP
	Turning Basin	Depth 16.0 m	Depth -9.0 m
	Handling Equipment	Unloader 6 Capacity 2,700 t/h	Ship Loader 5 Capacity 2,500 t/h
	Training-dike	Required Length 6.5 km (Both side of channel)	
Terminal Facility		Coal Stock Volume 18.95 million t, Terminal Area 40 ha	
	Yard Machinery	Stacker/Reclaimer 5 Capacity 6,000 t/h / 2,700 t/h	
	Belt Conveyor	For Unloading Length 23.6 km Capacity 6,000 t/h For Loading Length 15.4 km Capacity 5,500 t/h	
	Stockpile	Capacity 1,580,000 t Stockpile 6 piles Height of Pile 16 m Length of Pile 900 m	
	Revetment	Required length 1,200 m	
	Dust Protection Fence	Height 8 m Length 2,200 m	
Layout of Port and Terminal		Figure 9.2.6	

Source: JICA Study Team



Source: JICA Study Team

Figure 9.2.6 Layout of the Midterm Development Plan

(3) Long-Term Development Plan

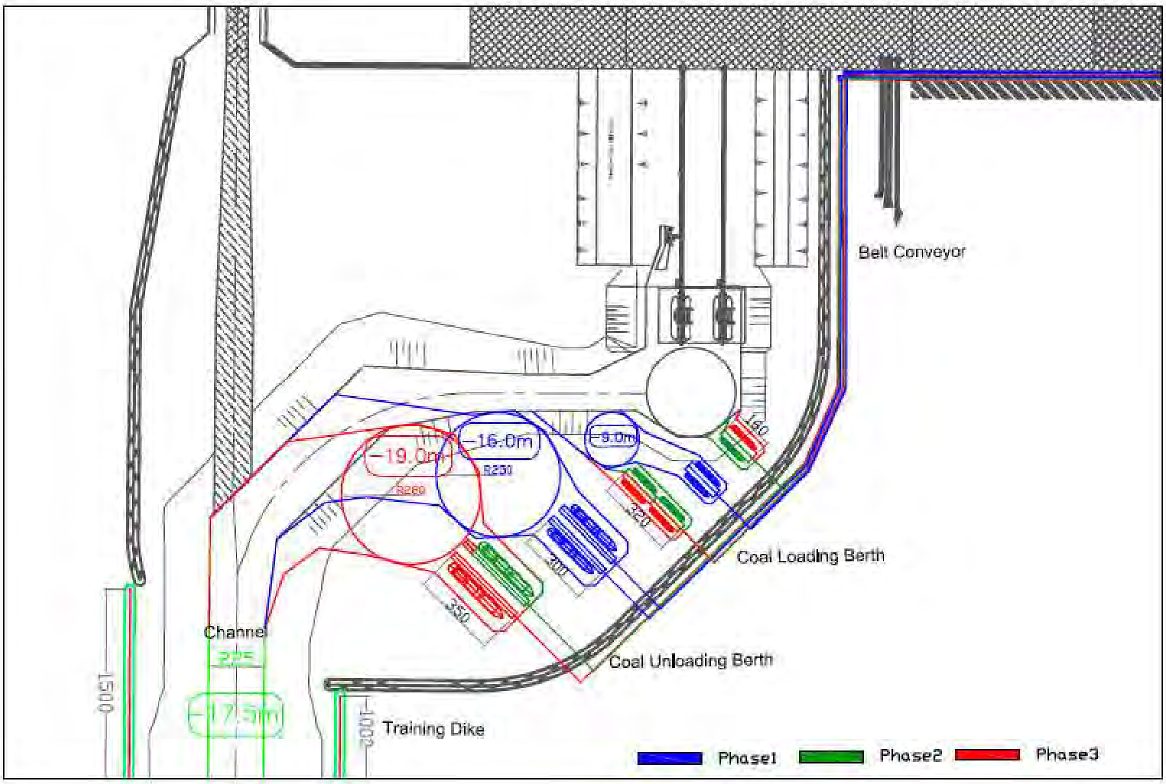
The long-term development plan, which is the 3rd Phase and has a target year of 2030, is summarized in Table 9.2.5 and shown in Figure 9.2.7.

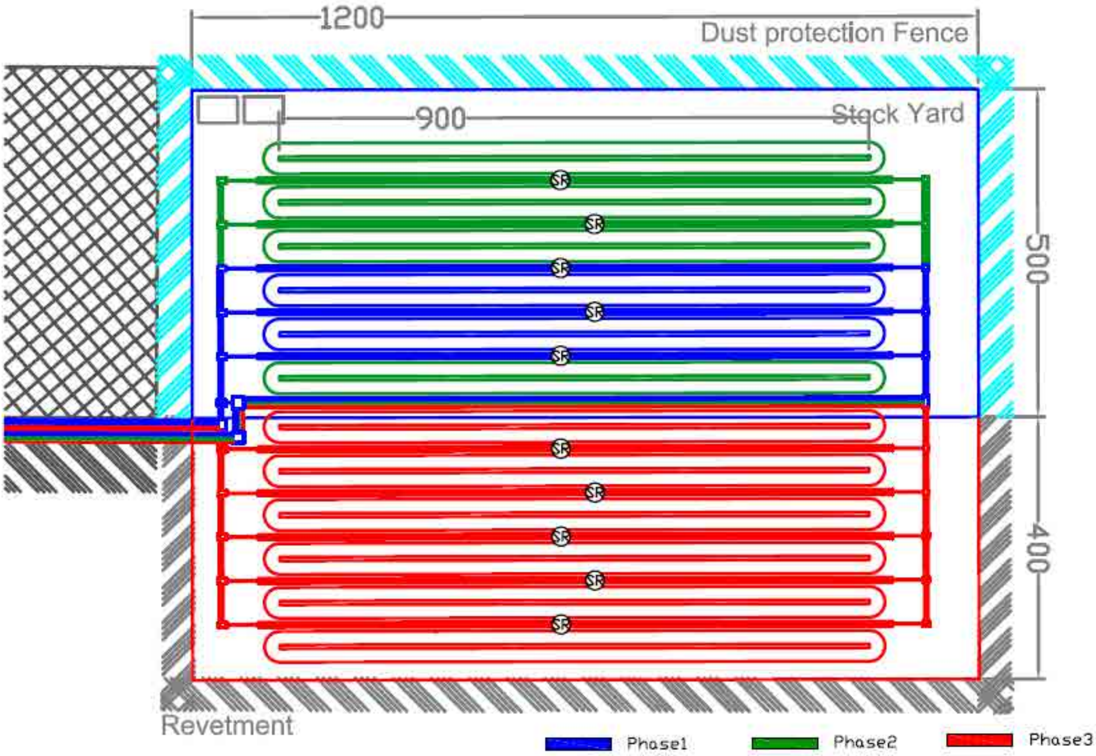
Table 9.2.5 Long-Term Development Plan

<table>
<tr><td colspan="2">Coal Demand</td><td colspan="2">45.71 million ton</td></tr>
<tr><td colspan="2">Port Facility</td><td>Unloading Berth</td><td>Loading Berth</td></tr>
<tr><td></td><td>Design Vessel</td><td>Post-Panamax (100,000 DWT)
Capesize (160,000 DWT)</td><td>Small barge
(5,000 DWT~10,000 DWT)</td></tr>
<tr><td></td><td>Berth</td><td>Post-Panamax
Berth 2 berths
Length 300 m/berth
Depth -16.0 m

Capesize
Berth 2 berths
Length 350 m/berth
Depth -19.0 m</td><td>Berth 8 berths
Length 160 m/berth
Depth -9.0 m</td></tr>
<tr><td></td><td>Approach Channel</td><td>Length 9,810 m
Width 225 m
Depth 17.5 m</td><td>Existing channel for the Duen Hai CFPP</td></tr>
<tr><td></td><td>Turning Basin</td><td>Post-Panamax
Depth 16.0 m
Capesize
Depth 19.0 m</td><td>Depth -9.0 m</td></tr>
<tr><td></td><td>Handling Equipment</td><td>Unloader 8
Capacity 2,700 t/h</td><td>Ship Loader 8
Capacity 2,500 t/h</td></tr>
<tr><td></td><td>Training-dike</td><td colspan="2">Required Length 6.5 km (Both side of channel)</td></tr>
<tr><td colspan="2">Terminal Facility</td><td colspan="2">Coal Stock Volume 39.02 million t, Terminal Area 108 ha</td></tr>
<tr><td></td><td>Yard Machinery</td><td colspan="2">Stacker/Reclaimer 10 Capacity 6,000 t/h / 2,700 t/h</td></tr>
<tr><td></td><td>Belt Conveyor</td><td colspan="2">For Unloading Length 30.7 km Capacity 6,000 t/h
For Loading Length 20.9 km Capacity 5,500 t/h</td></tr>
<tr><td></td><td>Stockpile</td><td colspan="2">Capacity 3,252,000 t Stockpile 12 piles
Height of Pile 16 m Length of Pile 900 m</td></tr>
<tr><td></td><td>Revetment</td><td colspan="2">Required length 2,000 m</td></tr>
<tr><td></td><td>Dust Protection Fence</td><td colspan="2">Height 8 m
Length 2,200 m</td></tr>
<tr><td colspan="2">Layout of Port and Terminal</td><td colspan="2">Figure 9.2.7</td></tr>
</table>

Source: JICA Study Team





Source: JICA Study Team

Figure 9.2.7 Layout of the Long-Term Development Plan

9.3. Conceptual Design of Port and Terminal Facilities

The main difference between Scenario 1 and Scenario 2 is coal handling volume. The area of the coal stock yard and handling capacity of equipment such as unloader, ship loader, stacker reclaimer and belt conveyor are changed in Scenario 2. The dimensions of the following facilities are also expected to change in this scenario:

- Unloading berth
- Loading berth
- Trestle

The load of handling equipment is expected to be larger with the increased handling capacity in Scenario 2. However, 20% more of the load of handling equipment is considered in Scenario 1 because there are differences of equipment specifications between makers. Therefore, the increase of handling equipment load is included in the excess load. As a result, conceptual designs of the cross section of the facilities are same as in Scenario 1. Conceptual designs of other facilities are also not changed because the design conditions in Scenario 2 are the same as in Scenario 1.

9.3.1. Design Conditions

(1) Natural Conditions

The site location in Scenario 2 is same as in Scenario 1. Therefore, the natural conditions can be referred to in Section 5.3.1.

(2) Conditions for Use

1) Design Vessels

Design vessels are same as in Scenario 1.

2) Handling Equipment

The dimensions of coal handling equipment are as follows:

i) Unloader

Handling capacity	2,700 t/h
Total weight	18,200 kN
Rail gauge	25.0 m
Wheel base	22 m
Number of wheels	front : 12 wheels rear : 8 wheels
Wheel span	900 mm
Unit wheel load	Table 5.3.14.

ii) Ship loader

Handling capacity	2,500 t/h
Total weight	5,100 kN
Rail gauge	14.0 m
Wheel Base	8 m
Number of wheels	6 wheels x 2 arms
Span of wheel	710 mm

iii) Belt conveyor

Table 9.3.1 Dimensions of Belt Conveyor Considered in this Design Section

	Unloading Line (offshore side)	Loading Line (landside)
Handling capacity	6,000 t/h (2 line)	5,500 t/h (2 line)
Width of belt	2,200 mm	2,000 mm
Speed of belt	240 m/min	260 m/min

Source: JICA Study Team

iv) Stacker reclaimer

Handling capacity	6,000/2,700 t/h
Coal stockpile height	16 m
Coal stockpile width	47 m
Rail span	8 m
Wheel base	10.1 m
Wheel formation	8 wheel/corner
Total weight	8,820 kN (Main body 6,370 kN + Tripper 2,450 kN)

(3) Other Conditions

Other conditions are same as in Scenario 1.

9.3.2. Port Facilities on the Sea

Design conditions of unloading berth, loading berth, trestle, breakwater, revetment and so on are the same as in Scenario 1. The structure of these facilities is also not changed.

9.3.3. Coal Stock Yard

(1) Coal Stock Yard

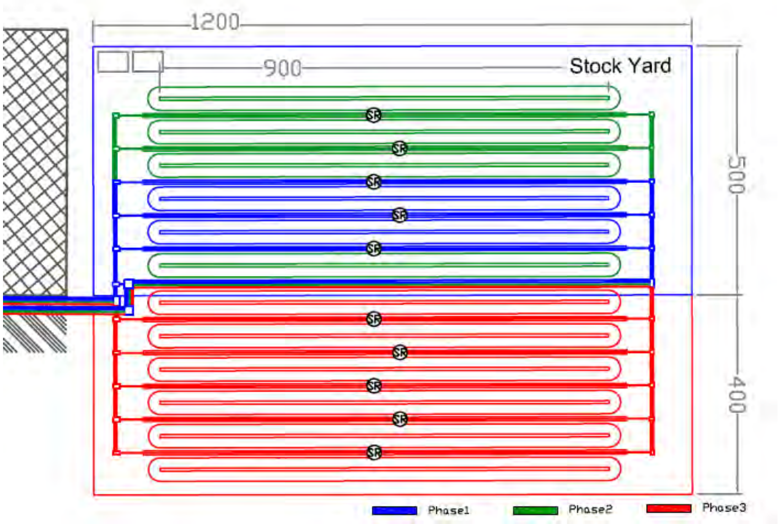
The developed plans for 1st Phase to 3rd Phase are considered. The required area of the stock yard is as follows:

1st Phase: 35 ha

2nd Phase: 60 ha

3rd Phase: 108 ha

The layout of the stock yard is shown in Figure 9.3.1. In the 3rd Phase, reclamation works are considered to expand a part of the stock yard.



Source：JICA Study Team

Figure 9.3.1 Layout of Planned Coal Stock Yard

The designed structures and facilities are shown below. The structures of these facilities are the same as in Scenario 1.

i) Reclamation
ii) Base of stacker reclaimer
iii) Soil improvement
iv) Pavement
v) Dust protection fence
vi) Other facilities such as utilities for drainage or water treatment.

9.3.4. Navigational Channel and Aids for Navigation

The navigational channel and aids for navigation are same as in Scenario 1.

9.4. Outline of Execution Plan and Schedule of Construction Works

9.4.1. Outline of the Work Items

This project is recommended to be divided into three phases as mentioned above. Construction of the facilities will be divided into three stages, namely, the 1st Phase, 2nd Phase, and 3rd Phase, according to the phasing of the project.

The outlines of work items by phase of the facilities to be constructed, coal handling equipment to be installed, and buildings to be constructed in the Coal Transshipment Terminal Project are given in Table 9.4.1, Table 9.4.2, and Table 9.4.3, respectively.

Table 9.4.1 Outline of Facilities to be Constructed

No.	Facility's Name	Unit	Quantity		
			1st Phase	2nd Phase	3rd Phase
1	Construction of Coal Unloading Berth	Berth	2	3	4
2	Construction of Coal Loading Berth	Berth	2	5	8
3	Earthworks of the Coal Storage Yard	ha	35	60	108
4	Revetment	m	2,856	4,600	6,600
5	Dredging and Disposal Works	million m^3	19	21	37
6	Channel Protection Work	km	2.5	2.5	2.5

Source: JICA Study Team

Table 9.4.2 Outline of Coal Handling Equipment to be Installed

No.	Facility's Name	Unit	Quantity		
			1st Phase	2nd Phase	3rd Phase
1	Coal Unloading Machine	Set	4	6	8
2	Coal Loading Machine	Set	2	5	8
3	Stacker Reclaimer	Set	3	5	10
4	Belt Conveyor	km	24.6	39.0	57.0

Source: JICA Study Team

Table 9.4.3 Outline of Buildings to be Constructed

No.	Facility's Name	Unit	Quantity		
			1st Phase	2nd Phase	3rd Phase
1	Administration Building	L.S.	1	1	2
2	Maintenance Shop	L.S.	1	1	2
3	Sub-Station	L.S.	1	1	2
4	Wind Protection Wall	km	2.2	2.2	2.2
5	Security Fence	km	3.4	3.4	5.0

Source: JICA Study Team

9.4.2. General Conditions of the Site

Location, access, natural conditions and social conditions are studied in this section. These conditions will be used for estimation of the work method, procedure, equipment to be used, and activity ratio of each work item. The general conditions of the site are described in Section 5.4.2 of this report.

9.4.3. Availability of Materials and Equipment

Availability of materials and equipment are described in Section 5.4.3 of this report.

9.4.4. Preliminary Execution Plan

Preliminary construction method is described in Section 9.4.4 of this report.

9.4.5. Temporary Works

Temporary works are studied in Section 9.4.5 of this report.

9.4.6. Schedule of Construction Works

In this section, the tentative construction schedule of each stage based on the terminal development plan, preliminary design and preliminary execution plan is studied. The tentative construction schedule will be prepared based on the work quantity, workability ratio and daily progress.

(1) Work Quantity of Each facility

Work quantities are calculated based on the preliminary design.

(2) Work Activity Ratio

The following work activity ratios will be applied in consideration of site conditions:

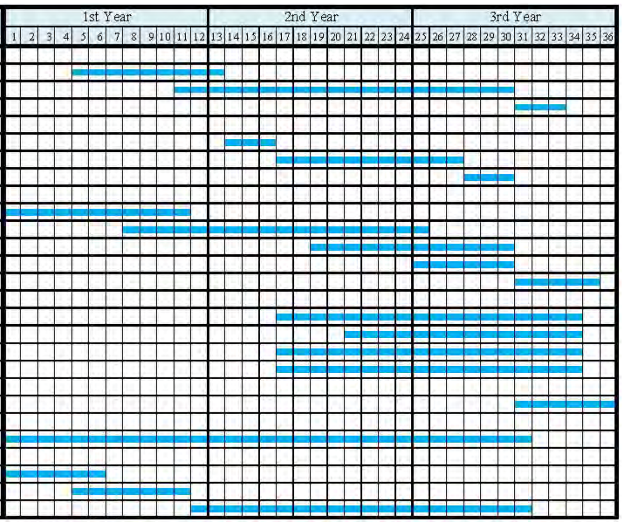
No.	Work Item	Applied Activity Ratio
1	Offshore works	0.7
2	Onshore works	0.8
3	Fabrication works	0.9
4	Other works	0.8

Source: JICA Study Team

(3) Tentative Construction Schedule

The tentative construction schedule of each stage considering the work quantities, activity ratios and assumed daily progress are respectively shown in Figure 9.4.1, Figure 9.4.2, and Figure 9.4.3.

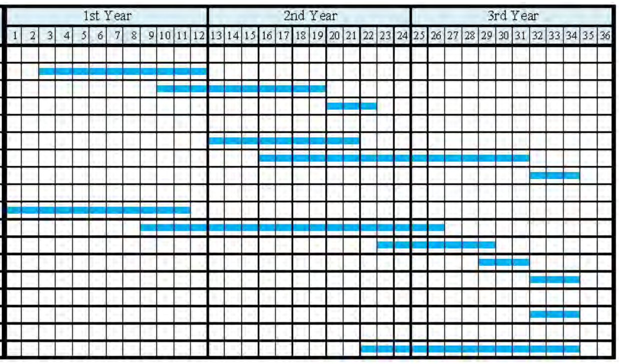
No.	WORKING ITEM	Unit	Q'ty	Productivity (/day)	Act Ratio	Duration (month)
1-1	**Coal Unloading Berth**	berth	2			
	Foundation Pile	nos	750	4	0.7	9
	Superstructure Concrete	m3	16,679	40	0.7	20
	Utility	L.S.	1			3
1-2	**Coal Loading Berth**	berth	2			
	Foundation Pile	nos	240	4	0.7	3
	Superstructure Concrete	m3	8,845	40	0.7	11
	Utility	L.S.	1			3
1-3	**Coal Storage Yard and Revetment**	ha	35			
	Reclamation	m3	2,022,400	8,000	0.8	11
	Soil Improvement	ha	35		0.8	18
	Revetment	m	2,856	10	0.8	12
	Underground Utilities	L.S.	1			6
	Pavement	ha	35	0.3	0.8	5
1-4	**Buildings**	L.S.	1			
	Administrative Building	L.S.	1			18
	Gate and Fence	m	3,400	10	0.8	14
	Wind Protection Wall	m	2,200	5	0.8	18
	Other Buildings	L.S.	1			18
1-5	**Coal Handling Equipment**	L.S.	1			
	Installation of Equipments	L.S.	1			6
1-6	**Dredging and Disposal**	m3	19,447,830			
	Dredging and Disposal	m3	19,447,830	30,000	0.7	31
1-7	**Channel Protection**	km	3			
	Sand Replacement	m3	662,500	5,000	0.7	6
	Stone work	m3	417,500	3,000	0.7	7
	Concrete Block	nos	33,000	80	0.7	20



Source: JICA Study Team

Figure 9.4.1 Tentative Construction Schedule of the 1st Phase

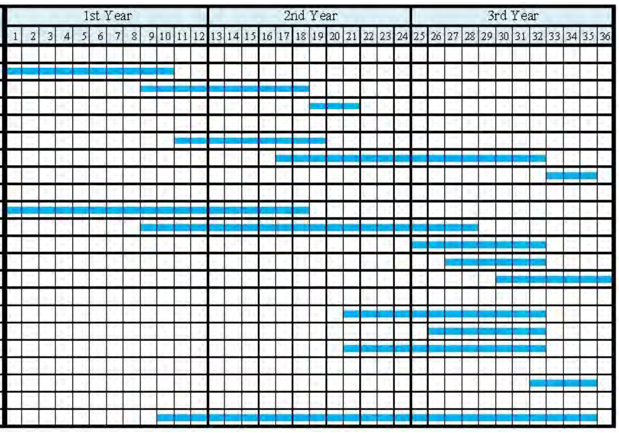
No.	WORKING ITEM	Unit	Q'ty	Productivity (/day)	Act Ratio	Year / Month
2-1	**Coal Unloading Berth**	berth	1			
	Foundation Pile	nos	440	2.0	0.7	10
	Superstructure Concrete	m3	8,340	40.0	0.7	10
	Utility	L.S.	1			3
2-2	**Coal Loading Berth**	berth	3			
	Foundation Pile	nos	360	2.0	0.7	9
	Superstructure Concrete	m3	13,268	40.0	0.7	16
	Utility	L.S.	1			3
2-3	**Coal Storage Yard and Revetment**	ha	25			
	Reclamation	m3	2,123,300	8,000.0	0.8	11
	Soil Improvement	ha	25		0.8	18
	Revetment	m	1,744	10.0	0.8	7
	Underground Utilities	L.S.	1			3
	Pavement	ha	25	0.3	0.8	3
2-5	**Coal Handling Equipment**	L.S.	1			
	Installation of Equipments	L.S.	1			3
2-6	**Dredging and Disposal**	m3	1,361,619			
	Dredging and Disposal	m3	1,361,619	5,000.0	0.7	13



Source: JICA Study Team

Figure 9.4.2 Tentative Construction Schedule of the 2nd Phase

No.	WORKING ITEM	Unit	Q'ty	Productivity (/day)	Act Ratio	Year / Month
3-1	**Coal Unloading Berth**	berth	1			
	Foundation Pile	nos	440	2.0	0.7	10
	Superstructure Concrete	m3	8,340	40.0	0.7	10
	Utility	L.S.	1			3
3-2	**Coal Loading Berth**	berth	3			
	Foundation Pile	nos	360	2.0	0.7	9
	Superstructure Concrete	m3	13,268	40.0	0.7	16
	Utility	L.S.	1			3
3-3	**Coal Storage Yard and Revetment**	ha	48			
	Reclamation	m3	3,360,000	8,000.0	0.8	18
	Soil Improvement	ha	48		0.8	20
	Revetment	m	2,000	10.0	0.8	8
	Underground Utilities	L.S.	1			6
	Pavement	ha	48	0.3	0.8	7
3-4	**Buildings**	L.S.	1			
	Administrative Building	L.S.	1			12
	Gate and Fence	m	1,600	10.0	0.8	7
	Other Buildings	L.S.	1			12
3-5	**Coal Handling Equipment**	L.S.	1			
	Installation of Equipments	L.S.	1			4
3-6	**Dredging and Disposal**	m3	16,088,104			
	Dredging and Disposal	m3	16,088,104	30,000.0	0.7	26

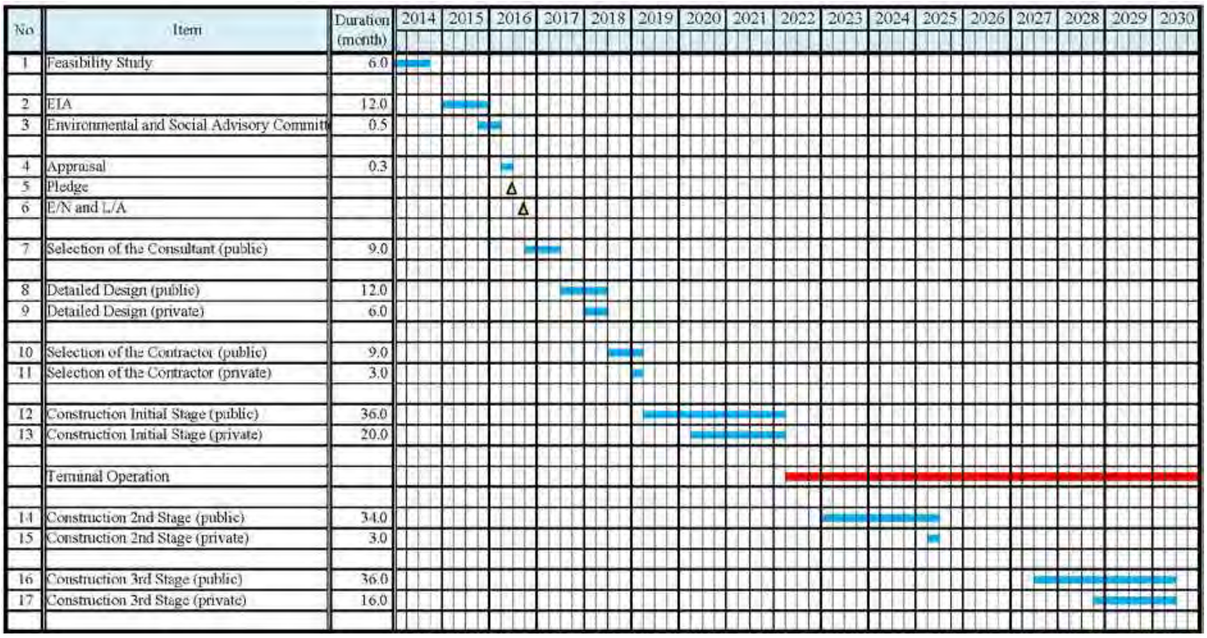


Source: JICA Study Team

Figure 9.4.3 Tentative Construction Schedule of the 3rd Phase

(4) Tentative Project Schedule

Considering the development plan of the Coal Transshipment Terminal Project and the construction schedule of each stage, the tentative project schedule is estimated as shown in Figure 9.4.4.



Source: JICA Study Team

Figure 9.4.4 Tentative Project Schedule

9.4.7. Construction Safety

Safety in any project is the most important and serious matter concerning all organizations and individuals involved. Construction safety is studied and detailed in Section 5.4.7 of this report.

Chapter 10. Terminal Management

10.1. Terminal Management Organization

Terminal management organization should be managed as the same procedure described in Chapter 6.

10.2. Running Cost of CTT Operation

(1) Personnel Expenses

Personnel expenses will be estimated as the same procedure described in Chapter 6.

(2) Utilities Expenses

Utilities expenses will be estimated as the same procedure described in Chapter 6.

(3) Water Charge

Water charge will be estimated as the same procedure described in Chapter 6.

(4) Depreciation Cost

Depreciation cost will be estimated as the same procedure described in Chapter 6.

(5) Maintenance Cost for Coal Handling Equipment

Maintenance cost for coal handling equipment will be estimated as the same procedure described in Chapter 6.

(6) Insurance Cost

Insurance cost will be estimated as the same procedure described in Chapter 6.

(7) Land Usage Fee

1) Same as in Chapter 6.

2) Same as in Chapter 6.

3) Assumed Terms and Conditions of JICA ODA Loans

i) Terms and conditions: Same as in Chapter 6.
ii) Interest rate: Same as in Chapter 6.
iii) Repayment period: Same as in Chapter 6.
iv) ODA loan amount:
Initial Debt (2020): USD 606 million
Additional Debt 1 (2025): USD 196 million

Additional Debt 2 (2030): USD 496 million
Total : USD 1,298 million

(8) Maintenance Cost for the Lower Infrastructure

Maintenance cost for the lower infrastructure will be estimated as the same procedure described in Chapter 6.

(9) Other Expenses

Other expenses will be estimated as the same procedure described in Chapter 6.

Chapter 11. Approximate Project Initial Construction Cost and Running Cost

11.1. General Description

11.1.1. General Conditions

The same general conditions described in Section 7.1.1 will be applied to estimate the project cost.

11.1.2. Construction Cost

Construction cost will be estimated as the same procedure described in Section 7.1.2.

(1) Quantity of Facilities

When coal demand of Scenario 2 is applied, the quantities of facilities are changed. The outlines of work items by phase of the facilities to be constructed, coal handling equipment to be installed, and buildings to be constructed in the Coal Transshipment Terminal Project are given in Table 11.1.1, Table 11.1.2, and Table 11.1.3, respectively.

Table 11.1.1 Outline of Facilities to be Constructed

No.	Facility's Name	Unit	Quantity		
			1st Phase	2nd Phase	3rd Phase
1	Construction of Coal Unloading Berth	Berth	2	3	4
2	Construction of Coal Loading Berth	Berth	2	5	8
3	Earthworks of the Coal Storage Yard	ha	35	60	108
4	Revetment	m	2,900	4,600	6,600
5	Dredging and Disposal Works	million m^3	19	21	37
6	Channel Protection Work	km	2.5	2.5	2.5

Source: JICA Study Team

Table 11.1.2 Outline of Coal Handling Equipment to be Installed

No.	Facility's Name	Unit	Quantity		
			1st Phase	2nd Phase	3rd Phase
1	Coal Unloading Machine	Set	4	6	8
2	Coal Loading Machine	Set	2	5	8
3	Stacker Reclaimer	Set	3	5	10
4	Belt Conveyor	km	23	37	57

Source: JICA Study Team

Table 11.1.3 Outline of Buildings to be Constructed

No.	Facility's Name	Unit	Quantity		
			1st Phase	2nd Phase	3rd Phase
1	Administration Building	L.S.	1	1	2
2	Maintenance House	L.S.	1	1	2
3	Sub-Station	L.S.	1	1	2
4	Wind Protection Wall	km	3.4	3.4	5.4
5	Security Fence	km	3.4	3.4	5.0

Source: JICA Study Team

(2) Work Quantity of Each Facility

Thee required work quantities of each facility based on the preliminary design of the 1st Phase are the same as in Scenario 1.

(3) Unit Price of the Work

The same unit prices as in Scenario 1 will be applied for estimation of the construction cost.

(4) Construction Cost

The construction cost is estimated based on the above work quantities and unit prices.

1) Direct Cost

The direct cost calculated from the work quantities and unit prices are shown in Table 11.1.4.

Table 11.1.4 Direct Cost

Facility Name	Work Item	Unit	Quantity				Unit Price	Price			
			Initial Stage	2nd Stage	3rd Stage	Total	USD	Initial Stage	2nd Stage	3rd Stage	Total
Coal Unloading Berth											
	Berth No.	berth	2	1	1	4		**52,878,700**	**30,502,000**	**30,502,000**	**113,882,700**
	Foundation Pile SPP D900	nos	462	272	272	1,006	62,500	28,875,000	17,000,000	17,000,000	62,875,000
	Foundation Pile SPP D800	nos	288	168	168	624	62,500	18,000,000	10,500,000	10,500,000	39,000,000
	Superstructure Concrete	m3	16,679	8,340	8,340	33,359	300	5,003,700	2,502,000	2,502,000	10,007,700
	Utility	L.S.	2	1	1	4	500,000	1,000,000	500,000	500,000	2,000,000
Coal Loading Berth											
	Berth No.	berth	2	3	3	8		**13,253,500**	**19,880,400**	**19,880,400**	**53,014,300**
	Foundation Pile SPP D700	nos	240	360	360	960	42,500	10,200,000	15,300,000	15,300,000	40,800,000
	Superstructure Concrete	m3	8,845	13,268	13,268	35,381	300	2,653,500	3,980,400	3,980,400	10,614,300
	Utility	L.S.	2	3	3	8	200,000	400,000	600,000	600,000	1,600,000
Coal Storage Yard and Revetment											
	Area	ha	35	25	48	108		**69,425,800**	**58,296,850**	**98,014,250**	**225,736,900**
	Land Acquisition Cost	m2	260,000	180,000	320,000	760,000	4	1,040,000	720,000	1,280,000	3,040,000
	Reclamation	m3	2,022,400	2,123,300	3,360,000	7,505,700	12	24,268,800	25,479,600	40,320,000	90,068,400
	Soil Improvement	ha	22	18	32	72	500,000	11,000,000	9,000,000	16,000,000	36,000,000
	Revetment	m	2,856	1,744	2,000	6,600	3,000	8,568,000	5,232,000	6,000,000	19,800,000
	Underground Utilities	L.S.	1	1	1	3	2,000,000	2,000,000	2,000,000	2,000,000	6,000,000
	Foundation Pile PC D600	nos	1,228	818	2,046	4,092	1,000	1,228,000	818,000	2,046,000	4,092,000
	Superstructure Concrete	m3	15,284	10,189	25,473	50,946	250	3,821,000	2,547,250	6,368,250	12,736,500
	Pavement	ha	35	25	48	108	500,000	17,500,000	12,500,000	24,000,000	54,000,000
Dredging and Disposal											
	Dredging and Disposal	m3	19,447,830	1,361,619	16,088,104	36,897,553	10	**194,478,300**	**13,616,190**	**160,881,040**	**368,975,530**
Channel Protection											
	Total length	km	2.5	0	0	3		**47,212,500**	**0**	**0**	**47,212,500**
	Stone work	m3	417,500	0	0	417,500	30	12,525,000	0	0	12,525,000
	Concrete Block	nos	33,000	0	0	33,000	750	24,750,000	0	0	24,750,000
	Sand Replacement	m3	662,500	0	0	662,500	15	9,937,500	0	0	9,937,500
	Sub total							**377,248,800**	**122,295,440**	**309,277,690**	**808,821,930**
Coal Handling Equipment											
	Unloader	set	4	2	2	8	16,300,000	65,200,000	32,600,000	32,600,000	130,400,000
	Ship Loader	set	2	3	3	8	6,200,000	12,400,000	18,600,000	18,600,000	49,600,000
	Stacker Reclaimer	set	3	2	5	10	7,900,000	23,700,000	15,800,000	39,500,000	79,000,000
	Belt conveyer for unloading line	km	14.7	8.9	11.5	35	8,000,000	117,600,000	71,200,000	92,000,000	280,800,000
	Belt conveyer for loading line	km	9.9	5.5	6.5	22	6,300,000	62,370,000	34,650,000	40,950,000	137,970,000
	Other equipments	L.S.	1	0	1	2	2,000,000	2,000,000	0	2,000,000	4,000,000
	Sub total							**283,270,000**	**172,850,000**	**225,650,000**	**681,770,000**
Building and Fence											
	Office Building	L.S.	1	0	1	2	5,000,000	5,000,000	0	5,000,000	10,000,000
	Maintenance house	L.S.	1	0	1	2	2,000,000	2,000,000	0	2,000,000	4,000,000
	Warehouse	L.S.	1	0	1	2	1,000,000	1,000,000	0	1,000,000	2,000,000
	Sub-station	L.S.	0.32	0.55	0.14	1	41,500,000	13,114,000	22,700,500	5,685,500	41,500,000
	Security house	L.S.	3	1	2	6	100,000	300,000	100,000	200,000	600,000
	Rest house	L.S.	2	1	2	5	500,000	1,000,000	500,000	1,000,000	2,500,000
	Security fence and gate	m	3,400	0	1,600	5,000	200	680,000	0	320,000	1,000,000
	Dust protection wall	m	3,400	0	2,000	5,400	1,500	5,100,000	0	3,000,000	8,100,000
	Power supply system	L.S.	1	0	0	1	22,100,000	22,100,000	0	0	22,100,000
	Water supply system	L.S.	0.5	0.5	1	2	2,900,000	1,450,000	1,450,000	2,900,000	5,800,000
	Other utilities	L.S.	1	0	1	2	1,800,000	1,800,000	0	1,800,000	3,600,000
	Sub total							**53,544,000**	**24,750,500**	**22,905,500**	**101,200,000**
	Total							**714,062,800**	**319,895,940**	**557,833,190**	**1,591,791,930**

Note: The lower infrastructure is shown in the blue-shaded area, and the upper infrastructure is shown in the gray-shaded area.

Source: JICA Study Team

2) Indirect Cost

The indirect cost consists of common temporary cost and site management cost. The common temporary cost includes the costs of temporary works, fence and gate, access road, common equipment, etc. Also, the site management cost includes the costs of management staff, office operation, accommodation, transportation, etc.

According to experience by the study team in Southeast Asia, 4.3% of the direct cost will be applied to the common temporary cost and 13.7% of the direct cost will be applied to the site management cost in this study.

3) General Cost

General cost includes costs of headquarters and/or branch of the contractor. According to experience of the study team in Southeast Asia, 9.4% of the direct cost will be applied to the general cost in this study.

4) Contingency

Contingency of 15% of the total of the direct cost, indirect cost and general cost is applied.

5) Tax

Necessary tax of 10% of the total of the direct cost, indirect cost, general cost and contingency is applied.

6) Estimated Construction Cost

The estimated construction cost including direct cost, indirect, general cost, contingency and tax is shown in Table 11.1.5. The estimated construction cost of the lower infrastructure, which is planned to be constructed by the public sector, and the upper infrastructure, which is planned to be constructed by the private sector, are shown in Table 11.1.6 and Table 11.1.7, respectively.

Table 11.1.5 Estimated Construction Cost of this Project

Work Item		Price (USD)			
		Initial Stage	2nd Stage	3rd Stage	Total
1	Civil Works	377,248,800	122,295,440	309,277,690	808,821,930
2	Building Works	53,544,000	24,750,500	22,905,500	101,200,000
3	Coal Handling Equipments	283,270,000	172,850,000	225,650,000	681,770,000
4	Sub total (Direct Cost 1+2+3)	**714,062,800**	**319,895,940**	**557,833,190**	**1,591,791,930**
5	Indirect Cost (18% of 1+2)	77,542,704	26,468,269	59,792,974	163,803,947
6	General Cost (9.4% of 1+2)	40,494,523	13,822,318	31,225,220	85,542,061
7	Sub total (4+5+6)	**832,100,027**	**360,186,528**	**648,851,384**	**1,841,137,939**
8	Contingency (15% of 7)	124,815,004	54,027,979	97,327,708	276,170,691
9	Tax (10% of 7+8)	95,691,503	41,421,451	74,617,909	211,730,863
TOTAL CONSTRUCTION COST (7+8+9)		**1,052,606,534**	**455,635,957**	**820,797,001**	**2,329,039,493**

Source: JICA Study Team

Table 11.1.6 Estimated Construction Cost of the Lower Infrastructure (Excluding Land Acquisition Cost)

Work Item		Price (USD)			
		Initial Stage	2nd Stage	3rd Stage	Total
1	Civil Works(excluding Land Acquisition Cost)	376,208,800	121,575,440	307,997,690	805,781,930
2	Building Works	0	0	0	0
3	Coal Handling Equipments	0	0	0	0
4	Sub total (Direct Cost 1+2+3)	**376,208,800**	**121,575,440**	**307,997,690**	**805,781,930**
5	Indirect Cost (18% of 1+2)	67,717,584	21,883,579	55,439,584	145,040,747
6	General Cost (9.4% of 1+2)	35,363,627	11,428,091	28,951,783	75,743,501
7	Sub total (4+5+6)	**479,290,011**	**154,887,111**	**392,389,057**	**1,026,566,179**
8	Contingency (15% of 7)	71,893,502	23,233,067	58,858,359	153,984,927
9	Tax (10% of 7+8)	55,118,351	17,812,018	45,124,742	118,055,111
TOTAL CONSTRUCTION COST (7+8+9)		**606,301,864**	**195,932,195**	**496,372,157**	**1,298,606,216**

Source: JICA Study Team

Table 11.1.7 Estimated Construction Cost of the Upper Infrastructure

	Work Item	Price (USD)			
		Initial Stage	2nd Stage	3rd Stage	Total
1		0	0	0	0
2	Building Works	53,544,000	24,750,500	22,905,500	101,200,000
3	Coal Handling Equipments	283,270,000	172,850,000	225,650,000	681,770,000
4	Sub total (Direct Cost 1+2+3)	**336,814,000**	**197,600,500**	**248,555,500**	**782,970,000**
5	Indirect Cost (18% of 1+2)	9,637,920	4,455,090	4,122,990	18,216,000
6	General Cost (9.4% of 1+2)	5,033,136	2,326,547	2,153,117	9,512,800
7	Sub total (4+5+6)	**351,485,056**	**204,382,137**	**254,831,607**	**810,698,800**
8	Contingency (15% of 7)	52,722,758	30,657,321	38,224,741	121,604,820
9	Tax (10% of 7+8)	40,420,781	23,503,946	29,305,635	93,230,362
TOTAL CONSTRUCTION COST (7+8+9)		**444,628,596**	**258,543,403**	**322,361,983**	**1,025,533,982**

Source: JICA Study Team

11.1.3. Maintenance and Operation Cost

Maintenance and operation cost which will incur after commencement of operation will be estimated in this section. This cost will be shown as an annual cost of each stage of the project.

(1) Work Item and Quantity

Maintenance and operation cost of this project may be divided into the following five items. Quantities, unit prices, and annual cost of each item are estimated as described below.

1) Maintenance Dredging

According to results of the simulation study, the expected monthly maintenance dredging volume and necessary cost are calculated. Summary of the maintenance dredging volume and cost is shown in Table 11.1.8.

Table 11.1.8 Summary of Maintenance Dredging

Cost Factor	Quantity (m3/year)			Unit Price	Maintenance Cost (USD/year)		
	Initial Stage	2nd Stage	3rd Stage	(USD/m3)	Initial	2nd Stage	3rd Stage
Maintenance Dredging - scenario2 Yard CD	1,797,323	1,797,323	2,093,113	5	8,986,617	8,986,617	10,465,567

Source: JICA Study Team

2) Maintenance of Constructed Facilities

The expected annual maintenance cost of the civil constructed facilities is calculated as 0.5% of the construction cost excluding cost of dredging works. The calculated maintenance cost of the construction facilities is shown in Table 11.1.9.

Table 11.1.9 Maintenance Cost of Constructed Facilities

Cost Factor	Construction Cost (USD) except Dredging			Ratio (%)	Maintenance Cost (USD/year)		
	Initial Stage	2nd Stage	3rd Stage		Initial Stage	2nd Stage	3rd Stage
Civil and Building Works - scenario2 Yard CD	236,314,500	369,744,250	541,046,400	0.5	1,181,573	1,848,721	2,705,232

Source: JICA Study Team

3) Maintenance of Coal Handling Equipment

The expected annual maintenance cost of the coal handling equipment is calculated as 3.0% of the purchased cost. The calculated maintenance cost of the coal handling equipment is shown in Table 11.1.10.

Table 11.1.10 Maintenance Cost of Coal Handling Equipment

Cost Factor	Construction Cost (USD)			Ratio (%)	Maintenance Cost (USD/year)		
	Initial Stage	2nd Stage	3rd Stage		Initial Stage	2nd Stage	3rd Stage
Coal Handling Equipments - scenario2 Yard CD	283,270,000	456,120,000	681,770,000	3	8,498,100	13,683,600	20,453,100

Source: JICA Study Team

4) Operation Cost

The expected annual operation cost is shown in Table 11.1.11.

Table 11.1.11 Annual Operation Cost

Cost Factor	Operation Cost (USD/year)		
	Initial Stage	2nd Stage	3rd Stage
Operation Cost	5,186,589	9,080,691	16,550,591

Source: JICA Study Team

(2) Estimated Maintenance Cost

The estimated maintenance cost in each stage is shown in Table 11.1.12. These costs include related tax.

Table 11.1.12 Summary of Maintenance Cost

Cost Factor	Operation and Maintenance Cost		
	2020-2024	2025-2030	2030-2050
Maintenance Dredging	8,986,617	8,986,617	10,465,567
Maintenance for Civil and Building Works	1,181,573	1,848,721	2,705,232
Maintenance for Coal Handling Equipments	8,498,100	13,683,600	20,453,100
Total	18,666,289	24,518,938	33,623,899

Source: JICA Study Team

11.1.4. Consulting Service Fee

The consulting services consist of design works and construction supervision works. According to current records of similar construction projects in North and South Vietnam, USD 15 million will be applied to the design cost and USD 15 million to the construction supervision cost at the 1st Phase, USD 5 million will be applied to the design cost and USD 5 million to the construction supervision cost at the 2nd Phase, and USD 10 million will be applied to the design cost and USD 10 million to the construction supervision cost at the 3rd Phase in this study.

11.1.5. Project Cost

A summary of the project costs, estimated in this section, are shown in Table 11.1.13.

Table 11.1.13 Summary of Project Costs

Cost Item	Unit	Price			
		Initial Stage	2nd Stage	3rd Stage	Total
Construction Cost	USD	1,052,606,534	455,635,957	820,797,001	2,329,039,493
Upper Infrastructure	USD	444,628,596	258,543,403	322,361,983	1,025,533,982
Lower Infrastructure	USD	606,301,864	195,932,195	496,372,157	1,298,606,216
Land Acquisition cost	USD	1,676,074	1,160,359	2,062,861	4,899,294
Maintenance Cost	USD/year	18,666,289	24,518,938	33,623,899	-
Operation Cost	USD/year	5,186,589	9,080,691	16,550,591	-
Consulting Service Fee	USD	30,000,000	10,000,000	20,000,000	60,000,000

Source: JICA Study Team

Chapter 12. Financial and Economic Analysis

12.1. Applicable Project Scheme

Same as in Chapter 8.

12.2. Financial Analysis

Same as in Chapter 8.

12.3. Assumptions

(1) Description of Business

Same as in Chapter 8.

(2) Term of the Project

Same as in Chapter 8.

(3) Exchange Rate (reference rate in June 2014)

Same as in Chapter 8.

(4) Demand of Coal Handling

The coal transshipment terminal (CTT) handles all coal volume mentioned in Chapter 9. The demand from 2031 is the same as in 2030.

(5) Operation and Maintenance (O&M) Cost

As mentioned in Chapter 10 and Chapter 11 above.

(6) Land Usage Fee

As mentioned in Chapter 10 and Chapter 11 above.

(7) Tax Cost

Same as in Chapter 8.

(8) Capital Expenditure

- Investment plan is mentioned in Chapter 11 above.
- Same as in Chapter 8.

(9) Financing Plan

1) Equity
Same as in Chapter 8.

2) Debt

Same as in Chapter 8.

3) JICA Private Sector Investment Finance (PSIF)

It is assumed to loan from JICA PSIF.

- Interest : Same as in Chapter 8.
- Currency : Same as in Chapter 8.
- Terms of loan : Same as in Chapter 8.
- Debt service coverage ratio (DSCR) : Same as in Chapter 8.

4) Amount of Funds and Loans

Table 12.3.1 Amount of Funds and Loans

(Unit：USD million)

	Equity	Debt	Total
Initial (2017～19)	139	325	464
2nd (2nd Phase Expansion：2022～24)	0	189	189
3rd (3rd Phase Expansion：2027～29)	0	236	236
Total	139	750	889

Source：JICA Study Team

12.4. Business Income / Terminal Handling Charge (THC)

(1) Basic Concept

Same as in Chapter 8.

(2) THC Structure

Same as in Chapter 8.

(3) Assumptions for THC

1) Same as in Chapter 8.

2) Price Adjustment Factor

Same as in Chapter 8.

3) THC by Each Phase

Same as in Chapter 8.

4) THC

The THC based on the assumptions above is shown in Table 12.4.2 below. In case the coal demands of each phase will not be increased during the project term, the prices in each phase below will be applied through the project term.

Table 12.4.2 Terminal Handling Charge (THC)

(Unit: USD million)

	1st Phase	2nd Phase	3rd Phase
Capacity charge per t	6.3	5.1	3.8
Variable charge per t	0.2	0.2	0.3
Total charge per t	6.5	5.3	4.1
Handling volume per year	13.4 million t	25.6 million t	45.7 million t

Source: JICA Study Team

12.5. Financing and Payment Flow

Same as in Chapter 8.

12.6. Assumptions, Method and Estimated EIRR

Same as in the financial analysis, the scope of business of the Special Purpose Company (SPC) in the economic analysis is unloading from vessels, inventory control, and loading to small barges for secondary transshipment to the coal-fired power plants (CFPPs). The CTT handles all coal volume mentioned, and all coal will be imported from Indonesia. Furthermore, the demand from 2031 is the same as in 2030. Other items including the examination case and estimation of costs and benefits are pursuant to Chapter 8.

The study team estimated the economic internal rate of return (EIRR) of this project at 21.9% (refer to Table 12.6.1), which demonstrates that this project will be feasible from the perspective of the national economy since it greatly exceeds the benchmark of 12%.

Table 12.6.1 EIRR Calculation

Year	Coal Imported			Cost				Total Cost	Total Benefit	Benefit −Cost
		Duyen Hai	Others	Construction	Equipment	Maintenance	Operation etc.			
2017				87.9	44.5	0.0	20.0	152.3		−152.3
2018				87.9	355.7	0.0	5.0	448.6		−448.6
2019				117.2	44.5	0.0	10.0	171.6		−171.6
2020	13.4	6.7	6.7	0.0	0.0	20.3	5.5	25.9	163.9	138.0
2021	13.4	6.7	6.7	0.0	0.0	20.3	9.5	29.9	163.9	134.0
2022	13.4	6.7	6.7	52.2	25.9	20.3	7.5	105.9	163.9	58.0
2023	13.4	6.7	6.7	52.2	206.8	20.3	7.5	286.9	163.9	−123.0
2024	13.4	6.7	6.7	69.6	25.9	20.3	7.5	123.3	163.9	40.6
2025	22.9	6.7	16.2	0.0	0.0	24.5	9.8	34.3	375.8	341.5
2026	25.6	6.7	19.0	0.0	0.0	24.5	20.6	45.1	432.3	387.2
2027	25.6	6.7	19.0	71.1	32.2	24.5	13.6	141.4	432.3	290.8
2028	25.6	6.7	19.0	71.1	257.9	24.5	13.6	367.1	432.3	65.2
2029	25.6	6.7	19.0	94.8	32.2	24.5	14.6	166.2	432.3	266.1
2030	45.7	6.7	39.0	0.0	2.5	33.6	17.5	53.6	777.0	723.4
2031	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2032	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2033	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2034	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2035	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2036	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2037	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2038	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2039	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2040	45.7	6.7	39.0	0.0	2.5	33.6	17.5	53.6	777.0	723.4
2041	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2042	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2043	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2044	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2045	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2046	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2047	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2048	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
2049	45.7	6.7	39.0	0.0	0.0	33.6	17.5	51.1	777.0	726.0
									EIRR=	22.0%

Unit: Imported coal ('000 t), Cost and Benefit (USD million)

Source: JICA Study Team

12.7. Sensitivity Analysis

The study team also conducted a sensitivity analysis in order to verify the feasibility of this project.

Table 12.7.1 shows the results of the sensitivity analysis, which demonstrates that this project can be considered to be worth implementing from the perspective of the national economy as the EIRR exceeds 12% in every case.

Table 12.7.1 Results of Sensitivity Analysis

		Initial Investment (including all 1st, 2nd and 3rd Phases)				
		+20%	+10%	±0%	-10%	-20%
Reduction cost of coal transportation by using large vessels	-20%	16.4%	17.4%	18.5%	19.8%	21.4%
	-10%	18.0%	19.1%	20.3%	21.7%	23.3%
	±0%	19.5%	20.6%	21.9%	23.4%	25.1%
	+10%	20.9%	22.1%	23.5%	25.0%	26.8%
	+20%	22.3%	23.6%	25.0%	26.6%	28.5%

Source: JICA Study Team

12.8. EIRR in Each Stage

The study team also estimated the EIRRs in the case of decreased demand, which is valuable in terms of risk evaluation.

The results are shown in Table 12.8.1 and indicate that this project will be feasible from the perspective of the national economy due as the EIRR exceeds 12% in all cases.

Table 12.8.1 Estimated EIRR Corresponding to Respective Phases

Up to the 1st Phase	14.2%
Up to the 2nd Phase	20.0%
Up to the 3rd Phase	21.9%

Source: JICA Study Team